

ENACTION AND ECOLOGICAL PSYCHOLOGY: CONVERGENCES AND COMPLEMENTARITIES

EDITED BY: Ezequiel A. Di Paolo, Manuel Heras-Escribano, Anthony Chemero
and Marek McGann
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ENACTION AND ECOLOGICAL PSYCHOLOGY: CONVERGENCES AND COMPLEMENTARITIES

Topic Editors:

Ezequiel A. Di Paolo, IKERBASQUE Basque Foundation for Science, Spain

Manuel Heras-Escribano, University of Granada, Spain

Anthony Chemero, University of Cincinnati, United States

Marek McGann, Mary Immaculate College, Ireland

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Table of Contents

- 05 Editorial: Enaction and Ecological Psychology: Convergences and Complementarities**
Marek McGann, Ezequiel A. Di Paolo, Manuel Heras-Escribano and Anthony Chemero
- 10 The Circularity of the Embodied Mind**
Thomas Fuchs
- 23 Ecological Psychology and Enaction Theory: Divergent Groundings**
Harry Heft
- 36 Ecological Psychology and Enactivism: Perceptually-Guided Action vs. Sensation-Based Enaction¹**
Catherine Read and Agnes Szokolszky
- 55 Mind After Uexküll: A Foray Into the Worlds of Ecological Psychologists and Enactivists**
Tim Elmo Feiten
- 65 Zoom Out Camera! The Reflexive Character of an Enactive Account**
Fred Cummins
- 77 Ecological Psychology and Enactivism: A Normative Way Out From Ontological Dilemmas**
Manuel de Pinedo García
- 87 Ecological-Enactivism Through the Lens of Japanese Philosophy**
Jonathan McKinney
- 96 Locating the Inexhaustible: Material, Medium, and Ambient Information**
Tetsushi Nonaka
- 107 Enactive Pragmatism and Ecological Psychology**
Matthew Crippen
- 120 Convergently Emergent: Ecological and Enactive Approaches to the Texture of Agency**
Marek McGann
- 130 Picturing Organisms and Their Environments: Interaction, Transaction, and Constitution Loops**
Ezequiel A. Di Paolo
- 138 Extended Skill Learning**
Edward Baggs, Vicente Raja and Michael L. Anderson
- 148 Defining the Environment in Organism–Environment Systems**
Amanda Corris
- 161 Bringing Forth Within: Enhabiting at the Intersection Between Enaction and Ecological Psychology**
Mark M. James
- 177 Levels and Norm-Development: A Phenomenological Approach to Enactive-Ecological Norms of Action and Perception**
Miguel A. Sepúlveda-Pedro

- 192** *How Enaction and Ecological Approaches Can Contribute to Sports and Skill Learning*
Carlos Avilés, José A. Navia, Luis-Miguel Ruiz-Pérez and Jorge A. Zapatero-Ayuso
- 205** *An Enactive-Ecological Approach to Information and Uncertainty*
Eros Moreira de Carvalho and Giovanni Rolla
- 216** *Dynamic Touch as Common Ground for Enactivism and Ecological Psychology*
David Travieso, Lorena Lobo, Carlos de Paz, Thijme E. Langelaar, Jorge Ibáñez-Gijón and David M. Jacobs
- 226** *Where is the Action in Perception? An Exploratory Study With a Haptic Sensory Substitution Device*
Tom Froese and Guillermo U. Ortiz-Garin
- 234** *Rediscovering Richard Held: Activity and Passivity in Perceptual Learning*
Fernando Bermejo, Mercedes X. Hüg and Ezequiel A. Di Paolo
- 248** *Scale Matters: Temporality in the Perception of Affordances*
Melina Gastelum
- 261** *Multiscalar Temporality in Human Behaviour: A Case Study of Constraint Interdependence in Psychotherapy*
Juan M. Loaiza, Sarah B. Trasmundi and Sune V. Steffensen
- 282** *Reading: How Readers Beget Imagining*
Sarah Bro Trasmundi and Stephen J. Cowley
- 294** *Being Perceived and Being "Seen": Interpersonal Affordances, Agency, and Selfhood*
Nick Brancazio
- 306** *When Affective Relation Weighs More Than the Mug Handle: Investigating Affective Affordances*
Marta Caravà and Claudia Scorolli
- 311** *Through the Magical Pink Walkway: A Behavior Setting's Invitation to Embodied Sense-Makers*
Simon Harrison
- 330** *Agency From a Radical Embodied Standpoint: An Ecological-Enactive Proposal*
Miguel Segundo-Ortin
- 343** *Enactivism and Ecological Psychology: The Role of Bodily Experience in Agency*
Yanna B. Popova and Joanna Rączaszek-Leonardi
- 359** *The Ecological-Enactive Model of Disability: Why Disability Does Not Entail Pathological Embodiment*
Juan Toro, Julian Kiverstein and Erik Rietveld
- 374** *Between Ecological Psychology and Enactivism: Is There Resonance?*
Kevin J. Ryan Jr. and Shaun Gallagher



Editorial: Enaction and Ecological Psychology: Convergences and Complementarities

Marek McGann^{1*}, Ezequiel A. Di Paolo^{2,3,4}, Manuel Heras-Escribano^{5,6} and Anthony Chemero⁷

¹ Department of Psychology, Mary Immaculate College, Limerick, Ireland, ² Ikerbasque, Basque Foundation for Science, Bilbao, Spain, ³ Center for Computational Neuroscience and Robotics, University of Sussex, Brighton, United Kingdom, ⁴ IAS- Research, University of the Basque Country, San Sebastián, Spain, ⁵ Department of Philosophy, Faculty of Philosophy, University of Granada, Granada, Spain, ⁶ Filolab Unit of Excellence, University of Granada, Granada, Spain, ⁷ Departments of Philosophy and Psychology, University of Cincinnati, Cincinnati, OH, United States

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Editorial on the Research Topic

Enaction and Ecological Psychology: Convergences and Complementarities

The past several decades in cognitive science have seen an increasing recognition of the importance of the body, and of the relationship between the body and the environment, to our understanding of the mind. Forms of this recognition have varied substantially, with some seeing it important to add a role for the body into existing computational and representational accounts of cognition (e.g., Clark, 2007; Shapiro, 2011; Barsalou, 2015), while others finding in the body a different approach altogether, one which produces quite a different picture of the mind than those accounts which have formed the mainstream and traditional forms in the cognitive sciences.

Some of these more radical forms of embodied cognitive science have developed fairly independently of one another, but nevertheless have come to share some core theoretical characteristics—accounts that emphasize the role of action for perception and that do not involve computation or representations in explanatory roles. In their place we find discussions of skilled bodily activity in providing accounts of the performance of cognitive tasks.

Two well-developed such approaches are those of ecological psychology, deriving substantially from the work of psychologist Gibson (1966, 1986), and that of enactive cognitive science, building largely on foundations laid by Varela et al. [1991; see also Thompson (2007)]. Both approaches have continued to expand and diversify in their accounts of psychological and cognitive phenomena, framing significant empirical and theoretical work within the cognitive sciences to date (e.g., Chemero, 2009; Rietveld and Kiverstein, 2014; Di Paolo et al., 2017, 2018; Hutto and Myin, 2017; Cummins, 2018; Heras-Escribano, 2019a; Turvey, 2019; Wagman and Blau, 2020).

These two approaches appear to share a number of key theoretical and methodological commitments, including a conception of cognitive activity as being performed in skilled engagement between an agent and a rich, complex world, and such accounts being couched in terms that do not depend on computational or other forms of representations for their explanatory power. Despite these shared commitments and other apparent resonances between the approaches, communication between these two groups of researchers has been surprisingly sparse, and collaboration more rare still. Though several authors (Chemero, 2009; McGann, 2014; Rietveld et al., 2018; Heras-Escribano, 2019b) have recommended some form of integration between them, just what such an integration would entail, and whether it might even be possible, has not been worked out in detail. Our primary aim in advancing this Frontiers Research Topic has been to provide a forum where such parallels, resonances, convergences, and complementarities, could be aired, and given proper consideration, in as fulsome a form as possible. That includes identifying

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Edited by:

Anna M. Borghi,
Sapienza University of Rome, Italy

Reviewed by:

Shaun Gallagher,
University of Memphis, United States

*Correspondence:

Marek McGann
marek.mcgann@mic.ul.ie

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tensions and incompatibilities and assessing whether they are merely superficial or harder to resolve. In a domain more richly illuminated by such a diversity of perspectives further work on development of either an integrated approach, or continued separate development, can be conducted with a richer understanding of the relationships between these two promising modes of cognitive scientific research.

The 30 papers that make up this Research Topic address a wide range of questions concerning ecological psychology, enactive cognitive science, and their shared domain of scientific interest. The topics broached bring to the fore a number of key points of contact between ecological and enactive thinking, and provide varying evaluations for the possibility of some kind of reconciliation, complementarity, or alignment of the two. Some authors highlight divergence, conflict, or even distinct foundations, which motivate a pessimistic prognosis on integration, noting differing views on the relationship between the agent and the world, or sometimes even the basic scientific approach. Others appear more optimistic that these are perhaps two perspectives on the same avenue of scientific advancement. Even in this latter case, however, it is clear that the differences between the two are not simply ones of appearance, but potential points of theoretical dissonance that will require real theoretical or empirical work if they are to be reconciled. In this collection of papers we see a number of potential diagnoses of differences, ranging from different starting points in examination of the agent-world relationship, to different commitments to “realism” about the world, or the role of other agents in our account of human cognition, where specific gears of ecological and enactive theories touch one another and either grind hopelessly or engage with some degree of success.

Though there are a number of themes or threads we might recognize as connecting the set of papers in this Research Topic, in what follows we outline a scheme with a few broad strands. One recurring theme is the foundational question of the relationship between the agent and the world; how it might best be understood, represented, and the varying implications that follow. A second theme is that of skill learning and the dynamics of attunement between agent and world. Regardless of how the relationship between agent and world is conceived, it is recognized as dynamic and vital. How this dynamism is to be considered and understood affects how we approach questions of cognitive science, highlighting some particularities that either strengthen or undermine the apparent consonance of ecological and enactive approaches. A third theme, unpacking that relationship in more specific terms, is the complex topic of affordances. Introduced by Gibson (1977, 1986), it has since its beginning proven to be as contested as it is useful. The frequency with which it is deployed bespeaks its value both in formulating and executing empirical research agendas as well as articulating and problematising the different ways in which different approaches formalize the agent-environment relationship. Finally, while all of these themes involve a recognition of the central role played by the active body, some contributions elaborate in more detail aspects of embodiment that are relevant to elucidating the relations between the two approaches, such as the roles of agency, of

embodied experience, and of the brain, as well as different forms of embodiment.

A key tenet that both approaches appear to share is that of a reciprocal relationship between agents and their environment. Cognition arises within that relationship, rather than, say, entirely within the head of the agent in question. The multiple and entwined circularities of this relationship are highlighted by Fuchs, who examines mutual causal and dynamical relations in the structures of situated embodiment. The dynamic, active environment that these circular relations imply is on the face of it a point of clear agreement between ecological and enactive approaches, which separates them distinctly from mainstream perspectives. A number of authors identify dissonances in the particulars of how this relationship should be analyzed and understood, and there is a clear diversity of positions taken on this ostensibly common ground, even when it comes to how such a relationship should be discussed by us scientists in our practice.

Given the foundational role of the agent-environment relationship in both approaches, it seems vital to make any differences in its conception explicit and to examine their implications. Heft notes some apparent incompatibilities based on seemingly different roles for sensation and action in the agent-environment relationship. A somewhat similar diagnosis, though with a more optimistic prognosis, is offered by Read and Szokolszky. Providing a valuable historical perspective, Feiten explores how researchers from the two approaches seem to draw from different descriptions of von Uexküll’s notion of the *Umwelt* to make sense of mutualism or reciprocity. These examinations offer key insights into how questions are framed differently by different researchers. What is more, such foundational concerns extend beyond the traditional boundaries of the cognitive sciences. If the relationship between agent and environment is as complex as ecological and enactive approaches imply, then the ramifications affect not just cognitive theory, but scientific practice more generally, explored by Cummins, as well as our conception of the person, our ethical obligations, and participation in society, an issue broached by de Pinedo García. Resources for consideration of the complementarity inherent in this mutualism between agent and environment may indeed send us further afield from mainstream cognitive science; McKinney notes the possible value of the work of various Japanese philosophers in engaging with the topic, and finding a path toward continuing fruitful interactions between the two approaches without prioritizing or undermining either.

Unpacking and systematically elucidating this concept of mutualism clearly provides plenty of work to do. Nonaka explores the inexhaustible richness of the environment, finding there a texture sufficient to account for all aspects of the contact between agent and world, in doing so, seeing off any concerns regarding “constructivism” sometimes perceived in enactive approaches. Crippen also examines this perceived incompatibility of ecological psychology’s “realism” vs. enactivism’s “constructivism.” Examination of the relationship between agent and world suggests that this dichotomy is not as threatening as it might seem. McGann similarly addresses this friction between both perspectives, and in an insight shared with several papers in the collection, notes how the complexity of

interacting processes over different timescales dissolves some of the apparent disagreement, though leaving work still to do.

While it is important to notice broad theoretical divergences, and work toward clarifying their significance and hopefully resolving them, several authors take on a more concrete stance and attempt to work out differences and complementarities between the two approaches in the case of more practical issues. One such recurring topic concerns the development and learning of action and perception skills. These involve what Di Paolo calls *transactional* couplings in his overview of pictorial representations of the relation between agent and environment, and which he identifies as being a research area of significant historical overlap between the two schools. Baggs et al. notice some tensions between the enactive and ecological conceptions of skill learning. Moving beyond perspectives that pin skills to the body, they proposed an extended unit of analysis in the organism's situated activity and the self-organization and constraints that emerge in this activity. The move is analogous to the proposal presented by Corris, who offers a developmental answer to the question of the specification of the environment, which she finds unsatisfactorily treated by both the enactive and ecological perspectives: why do certain contingencies matter and not others? The idea of a developmental niche successfully combines ecological and enactive sensitivities and serves as an example of the kinds of theoretical advances we wish to see. A complementary notion to that of the developmental niche is perhaps James's notion of *enhabiting*, the process of individuation by which the shared complex of a species-typical habitat (from the point of view of us scientists) is enacted as an Umwelt for an individual organism. Building on the work of Simondon, James describes a process akin to equilibration (Di Paolo et al., 2017) by which a specific agent-environment system brings activities at multiple timescales into coherence with one another. A similar dynamic of reconciliation or coordination is outlined by Sepúlveda-Pedro in his contribution, this time in terms of norms. He raises the question of normativity contrasting the enactive approach with the skilled intentionality framework (Rietveld et al., 2018) and their respective views that norms are enacted by agents and that agents attune to pre-existing norms. These views, again, can be reconciled by adopting a developmental perspective that appeals to the work of Merleau-Ponty. Drawing observations from cases in sports psychology, Avilés et al. also see the complementarities between enaction's attention to bodily experience and ecological clarifications of skill acquisition as calibration and the education of attention and intention. de Carvalho and Rolla also address the question of learning, this time in terms of the highly contested idea of information. Offering a distinctly optimistic view on the compatibility of different conceptions of the idea extant in the cognitive scientific literature, they provide examples of how direct learning may be understood as sensitivity to information about the likely outcome of particular actions.

Putting the focus on the microgenesis of specific skills reveals even richer links between the approaches. In their detailed analysis of dynamic touch, Travieso et al. find clear complementarities between ideas of sensorimotor contingencies and information detection through active exploration. In this

way, they touch again on the question of an agent's activity, which is also empirically explored in a sensory substitution study of haptic perception by Froese and Ortiz-Garin. Using the Enactive Torch in a double participant set-up with active and passive conditions, the authors find that the role of agency in perception appears to be only instrumental. This is in line with how self-generated activity has been conceived historically in ecological psychology. Bermejo et al. discuss this history by examining the changing reception of the work of neuroscientist Richard M. Held, who pioneered studies that revealed the importance of voluntary activity in perceptual learning. While James Gibson seemed to think voluntary activity was merely facilitatory of processes that could occur otherwise, Eleanor Gibson and colleagues working on perceptual development thought it played stronger enabling roles. Enactivists would agree and argue that they can even play constitutive roles. The authors discuss the difficulties of taking the active/passive distinction as binary, and offer a series of practical dimensions for characterizing self-generated activity.

The notion of affordance is perhaps the best known of Gibson's contributions to theory, and also the most contested. The concept, having been introduced as something that is "neither an objective property, nor a subjective property; or it is both, if you like" (Gibson, 1986, p. 129), seems to offer a means of articulating and perhaps formalizing the coupling between agent and environment. What is more, it does so in a way that motivates empirical work. In several papers here, affordances are deployed as a lens to bring certain points of contact between the ecological and enactive approaches into focus and examine them. Affordances prove useful to others more in terms of their potential to speak coherently about recurring themes in the dynamics between agent and environment that occur at different levels of analysis, or in apparently different domains. Cognitive science sprawls across the entire realm of human and non-human life, with researchers on one hand examining the relationship between moving objects and bodily motion, and moving artworks and therapeutic empathy on the other, to mention just two of innumerable possible landmarks in this rich landscape. Affordances, broadly construed, offer a means of approaching these apparently disparate domains in a coherent manner. While some are concerned this threatens to dilute the notion to the point of vacuity, others use the concept to make sense of some of the richer and more complex aspects of human existence in a way that illustrates important continuities between what are traditionally seen as distinct fields. What is more, these insights help to articulate points of tension or resonance between ecological and enactive approaches, and set out some of the work that needs to be done if the two are to come to occupy a common scientific ground.

Gastelum addresses some of the complexity regarding this range of domains from the point of view of temporality: that affordances must occur at a range of temporal scales, and be accounted for accordingly. Attentive to issues of scale, Loaiza et al. similarly examine the complexity of the domain of human activity, and use affordances to approach the interplay between temporal scales that helps make sense of their continuity. This more liberal notion of affordances would seem to offer

something akin to a theoretical invariance, a means of thinking of the agent-environment system in coherent terms whether the discussion refers to a cell in a chemical gradient or a person in a conversation. Following a multiscale perspective, Trasmundi and Cowley present an ethnographic study of the processes of reading and imagining. Their enactive-ecological approach encompasses saccadic eye movements, interaction with cognitive artifacts (such as books), vocalizations, and multimodal social interactions, demonstrating again the purchase of examining complex cognitive phenomena over a range of scales. Brancazio warns that such continuities should not be oversold, however. Also using affordances as the theoretical tool, she attempts to lever apart the domains of physical and social activity, highlighting ethical implications that must be recognized and addressed where affordances are interpersonal, distinguishing them from a more basic reading of agent-environment relation. Caravà and Scorolli's intervention suggests that the concept of affordances may be effectively deployed in the empirical study of affective or emotional aspects of life, examining the ways in which projectible properties of the visual world are encountered in terms of their social and cultural value. The role of social, cultural factors in organizing and giving valence to affordances is addressed by Harrison in his micro-ethnographic study in a commercial setting. He seeks to embed the enactive conception of sense-making within a framework informed by the ecological psychology of Barker, Schoggen, and others (see Barker, 1968; Schoggen, 1989), literally "exploring" the various forms of affordances created as part of a marketing campaign behavior setting within a shopping center in Hong Kong.

Questions about the body run through most of the contributions: the body as an active agent, the body as situated, the body in regards to others, and the embodied character of perception and experience. These are general zones of convergence between the approaches. Some contributions elaborate on these ideas. Segundo-Ortín contrasts the enactive and ecological approaches to embodied agency and argues for the benefits of adopting a dual approach that combines enactive accounts of sensorimotor equilibration with an ecological focus on how perceptual information contributes to the actualization of sensorimotor habits. The analysis of embodied agency also preoccupies Popova and Raczaszek-Leonardi, who discuss dissimilarities and complementarities between the two camps by drawing on the phenomenology of lived bodily experience. The practical implications of foregrounding agency and lived experience are well-exemplified in the ecological-enactive model of disability presented by Toro et al.. The authors demonstrate that concepts of disability are not exhausted by physiological or medical normativity, but demand the constitutive role of lived experience. Through qualitative interviews with patients with cerebral palsy, they show that their experience can demonstrate tendencies toward maximal grip, and therefore need not, in all cases, be considered as arising from a "pathological embodiment."

Insistence on the importance of embodiment has been, and continues to be, a point of contrast with neurocentric perspectives still prevalent in cognitive science. In turn, the question may be put to both enactivists and ecological

psychologists: What about the role of the brain in these theories? No one denies that the brain plays crucial roles in explaining cognition, and enactive researchers have offered explicit non-representational theories about what this role could be (e.g., Varela et al., 2001; Fuchs, 2018). Other theories, such as coordination dynamics and neural reuse, can also meet both enactivist and ecological theoretical constraints (e.g., Kelso et al., 2013; Anderson, 2014). Ryan and Gallagher discuss and compare some of these ecological-enactive proposals, in particular, apparently convergent conceptions of the brain as a resonant, rather than representational organ, and they examine whether these conceptions are metaphorical or can offer specific mechanisms. Cashing in on the resonance of these and other enactive-ecological ideas (such as that of attunement) with musical performance, they suggest that activities such as jazz improvisation provide rich case studies for combined enactive and ecological theories of brain function (and environmentally situated bodily activity).

It is clear that this and the many other questions examined in this Research Topic are ripe for further research. As with jazz performance, we are happy to observe that the contributions do not follow a single orchestrated pattern. Voices rise and recede, sometimes performing duets, sometimes trios, with attention to history but without entrenching in it, also with interesting innovations and an element of unpredictability signifying at least that the road ahead remains open. What is important, in our view, is that the conversations have started and we are certain they will continue.

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MM and ED drafted the Editorial and the rest of the authors contributed to its completion. MH-E and ED organized the workshop that triggered the preparation of this Research Topic. All the authors have worked substantially on the conception of this Research Topic and during the editing process.

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The Circularity of the Embodied Mind

Thomas Fuchs*

Phenomenological Psychopathology and Psychotherapy, Psychiatric Clinic, Heidelberg University, Heidelberg, Germany

From an embodied and enactive point of view, the mind–body problem has been reformulated as the relation between the lived or subject body on the one hand and the physiological or object body on the other (“body–body problem”). The aim of the paper is to explore the concept of circularity as a means of explaining the relation between the phenomenology of lived experience and the dynamics of organism–environment interactions. This concept of circularity also seems suitable for connecting enactive accounts with ecological psychology. It will be developed in a threefold way:

(1) As the *circular structure of embodiment*, which manifests itself (a) in the homeostatic cycles between the brain and body and (b) in the sensorimotor cycles between the brain, body, and environment. This includes the interdependence of an organism’s dispositions of sense-making and the affordances of the environment.

(2) As the *circular causality*, which characterizes the relation between parts and whole within the living organism as well as within the organism–environment system.

(3) As the *circularity of process and structure* in development and learning. Here, it will be argued that subjective experience constitutes a process of sense-making that implies (neuro-)physiological processes so as to form modified neuronal structures, which in turn enable altered future interactions.

On this basis, embodied experience may ultimately be conceived as the integration of brain–body and body–environment interactions, which has a top-down, formative, or ordering effect on physiological processes. This will serve as an approach to a solution of the body–body problem.

Keywords: embodiment, lived body, body–body problem, brain, circularity, circular causation, ecology, development

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*Correspondence:

Thomas Fuchs
thomas.fuchs@urz.uni-heidelberg.de

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INTRODUCTION

According to enactive and ecological approaches to cognition, the mind is not to be regarded as a disembodied internal representation of the external world, nor as a system of brain modules, neural symbols, and algorithms that allow us to calculate and predict the world. On the contrary, an embodied mind manifests and integrates the current state of the entire organism as it interacts with its environment. Strictly speaking, it is not a “mind” at all, if by this is meant a separate domain or entity; it is rather a bodily subject whose experience extends over the lived body, and who, via its mediation, is in contact with the world (Thompson, 2007; Fuchs, 2018; Gallagher, 2018). In other words, the subject actually inhabits the body; I am co-extensive with my body, and its movements

are literally my movements – not some external events for which the brain simply creates a suitable body phantom that I happen to experience. The body is not a mere vehicle but the very locus of the subject, the source, and the medium of its relation to the world.

If we thus re-conceptualize the disembodied mind, which is still the predominant concept of present-day Cartesian materialism (Rockwell, 2005; Knowles, 2014), then the mind–body problem has to be recast. It is no longer a question of how the mind is related to the brain but how the lived or subject body on the one hand is related to the living or object body on the other; in short, it becomes the “body–body problem,” as Hanna and Thompson (2003) and Thompson (2007) have termed it. A particularly challenging aspect of this problem is the question of whether and how we may attribute a more than epiphenomenal role to bodily subjectivity.

In what follows, I want to address this problem from several points of view. First, I will present the ontological relation between lived body and living body in terms of a *dual aspect* of the living being. Then I will use the concept of *circularity* to describe the relation and intertwinement of both aspects. As I will try to show,

- (1) Circularity characterizes the structure and dynamics of the living organism on different levels, thus giving rise to the lived body;
- (2) Circular causality, or downward and upward causation, characterizes the part–whole relation of the organism, enabling the actual effectiveness of embodied subjectivity in the world; and
- (3) The circularity of process and structure shapes the development of the living being over time. This will lead finally to a proposal as to how, in humans, this development may be increasingly determined by the embodied subject itself.

LIVED BODY AND LIVING BODY

My starting point is the circular relation between lived body and living body, or subject body (*Leib*) and object body (*Körper*). The lived body is mostly transparent to us: it is the pre-reflective background and medium of our world-directed perspective, the center from which we see, act, and live without paying attention to it. The object body appears in our experience when this perspective is turned backwards; this happens with all conspicuous bodily sensations, but in particular when fluent bodily functioning is disturbed or interrupted, be it through a mishap, clumsiness, exhaustion, or illness. In such cases, the body is no longer transparently lived as mediating our activity in the world. It becomes “an explicit part of the subject’s experiential world rather than its implicit mode of revealing that world” (Stapleton and Froese, 2016, p. 124).

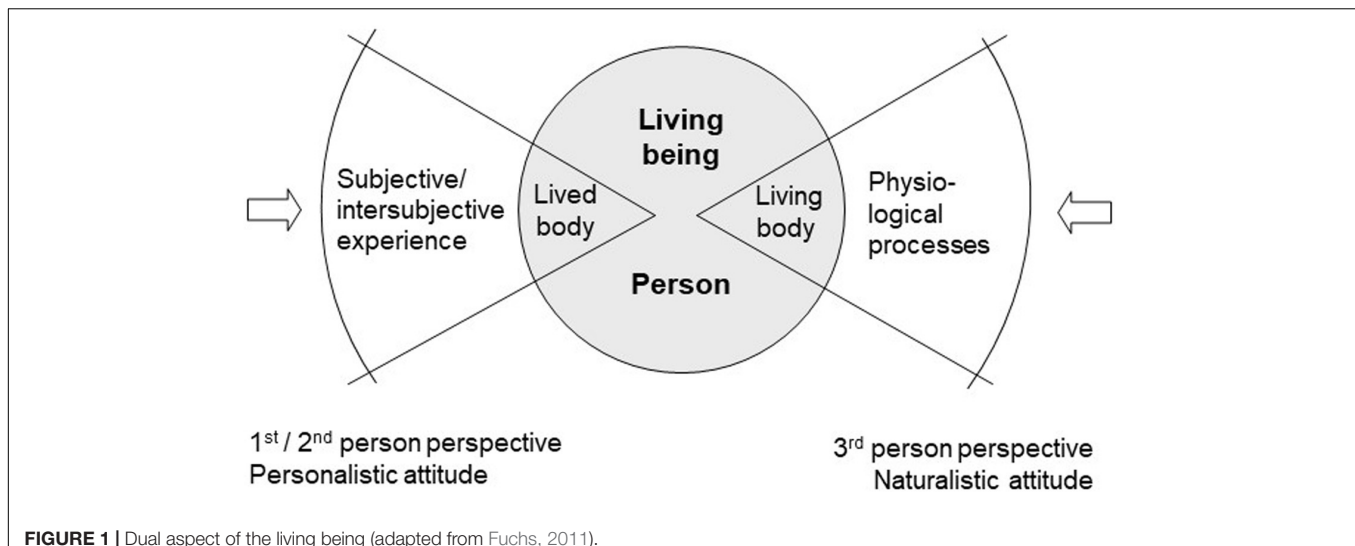
On the other hand, the living or object body (now regarded from a third-person perspective) constitutes the subject body, inasmuch as the organic functions tacitly enable the latter’s mediating role for our activities. Thus, living and lived body are in a relation of mutual concealment, because they bring forth or constitute each other, and this is what defines our embodiment.

A well-known manifestation of this reciprocal relation is the phenomenon of double touch as highlighted by Husserl (1952): if one’s right hand touches the left, the latter appears as a *palpable object* offering resistance to the right hand’s touch (i.e., as *Körper*); however, through a change of attention, it can also become a *feeling hand*, sensing the touch, that is, a part of the bodily subject (*Leib*).

This example shows that lived body and living body correspond to two different *perspectives or attitudes* between which we shift in everyday life, usually without being aware of it. Nevertheless, both perspectives are related to one and the same living being, a living being that displays two different *aspects*. This fundamentally changes the usual construal of the mind–body problem: it is generally based on the principal divide between a “mental” sphere and a “physical” sphere, the one being only accessible from within, or from the first-person perspective, the other only accessible from without, or from a third-person perspective. Instead of such a gap between two radically different ontologies (the mental and the physical), we are now faced with a *duality of aspects within embodiment* (Fuchs, 2018, pp. 77–82). The question, then, is about the relation between one’s body as a living organism and one’s body as subjectively lived. And the answer must be that processes of *living* and processes of *experiencing* (in German: *Leben* and *Erleben*) are both aspects of the organism’s life process seen from different but complementary points of view. On this understanding, the living being or animal becomes the ontological basis for embodied subjectivity on the one hand and for the objective body considered by physiology on the other. They are both complementary yet irreducible and mutually concealing aspects of the living being, like two sides of a coin (**Figure 1**).

A first consequence of this is that in order to grasp the embodied mind, we have to extend the narrow focus taken by neuroscience on the brain and take instead a wider view. *Only the living being as a whole* may be regarded as the proper subject of feeling, thinking, speaking, acting, and so forth. Neuronal activations or circumscribed brain structures are not the adequate scale at which to look for the basis of the mind. Rather, it is only through interacting with others in an empathic mode, or from a second-person perspective, that we get access to the embodied mind of the other. Narrowing the focus and getting ever closer to the physical body and its component parts mean a shift from what Husserl (1952) called the “personalistic” to “naturalistic attitude” or from the second- to third-person perspective (**Figure 1**). From this perspective, however, embodied subjectivity no longer shows itself.

On a daily basis, a doctor undertakes this change in attitudes, for instance, when greeting a patient and seeing his (friendly, anxious, or similar) gaze, yet shortly afterward taking hold of the ophthalmoscope to examine the patient’s eyes as physical organs: at this point, looking at them from too close a distance, the gaze has vanished. The embodied subject is only perceivable as a whole. The doctor may get still closer and investigate the retina – just like a physiologist or a neuroscientist may explore all the microstructures and microprocesses of the physical body, for example, the visual cortex. Yet nowhere will consciousness, mind, or life show themselves – they are *macro-phenomena*, which are



only accessible to others in coexistence, from the second-person perspective¹.

Nevertheless, both attitudes are directed to the same entity, that is, the living being or the living person. The lived or subjective body as the location of sensations and affections (fatigue, pain, hunger, etc.), as the medium of the enactment of life or of contact with others – none of this emerges as a construct in the brain, mysteriously projected into external space. Rather, this lived body *is the organism itself* under the aspect of a holistic aliveness that is manifested both subjectively and intersubjectively. We can thus consider the same entity in much the same way as a reversible figure such as Necker's Cube, in two distinct and non-transferable ways – as the lived body and as the physical body.

In sum, taking an embodied and enactive approach implies extending one's view, both with regard to space and time: looking at the wider system and how it develops over time. Then we can see both experiential and physiological processes, the lived body and the physical body as belonging to a more encompassing system, namely, the system of the living being and its environment, or of the person and her world – an ecological system that is in continuous development (Lewin, 1951; Gibson, 1979).

CIRCULARITY

I have presented a dual aspect concept of the living being, or more specifically of the human person, comprising the subjective

¹Consciousness shows itself to others only through the expressivity of the lived body (be it in emotional or verbal expression), that means, in the personalistic attitude. The same applies to life, however. One could object that the life sciences also deal with life from a third-person perspective. This is true, but when speaking of living beings, they already presuppose our coexistence or “conviviality” with life, which lets us grasp living entities in accordance with our own self-experience, namely, as moving themselves, sensing, striving, and “being up to something.” Inasmuch as the life sciences abstract, in a second step, from our self-experience of life, they conceive of living beings merely as mechanisms or machines – and thus, no longer as living or animate. “Life can be known only by life” (Jonas, 2001, p. 91); or in other words, life cannot be fully grasped from a third-person perspective.

body and the physical body. In order to further elucidate the relation between and intertwinement of both aspects, thus tackling the body–body problem, I will use the concept of *circularity*. As a first step, I will show that circularity characterizes the structure and dynamics of the organism on different levels, thus giving rise to the subjective body. In a next step, circular causality will be seen to help explain the actual significance and effectiveness of the subjective body for the self-sustainment of the living being.

Interactive Cycles of the Embodied Mind

To begin with, there are two interactive or feedback cycles that form the basis of the embodied mind (Thompson and Varela, 2001):

- (a) Cycles of organismic self-regulation, engendering a basic bodily sense of self; and
- (b) Cycles of sensorimotor coupling between organism and environment, implying an “ecological self.”

Importantly, a concept of biological embodiment implies that the sensorimotor interaction (b) is deeply rooted in the organism's internal self-regulation (a), or in phenomenological terms, the subject's “being toward the world” (ecological self) is grounded on its bodily self-awareness (basic self). Thus, the living body is not just a mechanical device of sensorimotor input and output; otherwise, it would not be distinct from a robot body as conceived in embodied AI (Ziemke, 2016). The body is rather animate, it feels and senses itself, and this self-affection is the basis of its perceiving and acting relation to the environment. This will become clearer in the following.

Cycles of Organismic Self-Regulation

As is well-known, the self-sustainment of the organism depends on homeodynamic regulatory cycles involving the brain and body at multiple levels. However, organismic regulation also has a dimension of basic self-affection or self-awareness. Affective neuroscience, represented by authors like

Damasio (1995, 1999, 2010) and Panksepp (1998, 2005), has emphasized the dependence of a *background consciousness* on the homeodynamic regulation of the entire body: various centers in the brain stem, hypothalamus, and insular and medial parietal cortices process the proprioceptive, visceral, vasomotor, endocrine, and other afferences from the internal body and integrate them into a “body landscape” that is constantly changing. This landscape includes the present state of the inner milieu (e.g., heart rate, blood pressure, blood oxygen, glucose, temperature, intestinal movements, vestibular sensations, and muscle tension). In this way, the inner milieu is continuously registered as *interoception* (Craig, 2002, 2003). Conversely, the organism’s homeostasis is constantly regulated by the brain via descending innervations (parasympathetic and sympathetic nervous system) as well as via hormone secretions from the hypothalamus and the pituitary. This results in what may be called an “interoceptive loop.”

The brain and body are therefore most intimately connected and influence each other in constant circular feedback. This interaction brings forth an interoceptive *feeling of being alive* (Damasio, 1995, p. 150): a basic self-affection with the hue of comfort or discomfort, pleasure of displeasure, relaxation or tension, or other basic moods. The feeling of being alive corresponds to a basic bodily self-affection or a *minimal form of subjectivity* (Fuchs, 2012a). Processes of life and processes of mind are thus inseparably linked: all conscious states are ultimately rooted in the homeodynamic regulation between the brain and body and, in a sense, integrate the present state of the organism as a whole. The foundation of subjectivity thus lies in the visceral or “deep body” and its vital self-regulation (see also de Preester, 2007). This may be considered as an organismic basis for the life–mind continuity thesis supported by enactivism (Thompson, 2007; Froese and Di Paolo, 2009; Kirchhoff and Froese, 2017).

A frequent objection to such an account refers to a representational and internalist concept, according to which the state of the body is mapped or modeled in the brain, thus only serving as external input. This is indeed Damasio’s position as well, for example, when he claims that the basic or protoself is constituted by “mental images of the body produced in body-mapping structures” in the brain (Damasio, 2010, p. 21). This would mean that self-awareness and consciousness are ultimately located within the brain. On the other hand, Damasio himself speaks of a continuous “resonant loop” between the brain and body (Damasio, 2010), which is hardly reconcilable with a representationalist account in the traditional sense, because “resonance” is obviously different from “internal modeling.” Elsewhere, Damasio also describes the process as

“(. . .) a looped circuit where the body communicates to the central nervous system and the latter responds to the body’s messages. *The signals are not separable from the organism states where they originate.* The ensemble constitutes a dynamic, bonded unit (. . .) this unit enacts a *functional fusion of body states and perceptual states*, such that the dividing line between the two can no longer be drawn (. . .) the signals conveyed would not be *about* the state of the flesh but literally *extensions of the flesh*” (Damasio, 2010, p. 273; my italics).

Within such a looped circuit or functional fusion, however, there is *neither place nor time for a separate representation*. There is no component within the circuit that represents another one, in the sense *that it could stand for it while it is absent* (“the signals . . . would not be *about* the state of the flesh”). The term representation suggests that the brain activities could in principle be separated from the circuit, as if they were reconstructing inside the brain what is outside². But in the functional fusion of the body and brain described by Damasio, there is no longer any inside and outside. Hence, Damasio’s representationalist account seems self-contradictory, and instead of a representative or mapping relation, we should rather speak of a *continuous mutual resonance* between the brain and body. If that is the case, then primary self-awareness can no longer be localized anywhere in the brain; rather, it is the integral manifestation of the *brain–body system*, or of the overarching process of life, which encompasses the whole organism³. The same applies to emotions: as resonant loops between the brain, body, and environment, they are no longer the brain’s representations of the body’s activity, as Damasio puts it, but rather *the feelings of the body itself* vis-à-vis a certain situation (on a corresponding circular model of embodied affectivity, see Fuchs and Koch, 2014; Fuchs, 2018, pp. 120–125).

Sensorimotor Cycles

Embodied subjectivity does not stop at the boundaries of the skin but is extended as “being toward the world” (Merleau-Ponty, 1962), mediated by the habitual functioning or the “operative intentionality” of the body. In enactive terms, this corresponds to the structural coupling of organism and environment, produced by *functional cycles of sensorimotor interaction*. Here, the lived body is pre-reflectively experienced as the point of convergence of action and perception. Interoception is the basis of exteroception; the self-affection of the deep body provides the sense of mineness, which pervades all interactions with the world⁴. In this way, basic bodily self-awareness becomes a world-directed, extended consciousness.

As is well-known, the enactive approach to cognition regards perception as a process of active *sense-making*: by interacting with the environment (moving their head and eyes, touching a surface, walking toward a goal, grasping a fruit, etc.), living beings make sense of their surroundings (Varela et al., 1991; Thompson, 2005, 2007; Di Paolo et al., 2017). Sense-making

²A representational relation in the traditional sense implies that an internal state of a system (usually the brain) “stands for” an external state of affairs. According to Piccinini (2018), this includes four elements: (i) a homomorphism between a system of internal states and their target, (ii) a causal connection from the target to the internal states, (iii) the possibility for the internal states to be decoupled from their target, and (iv) a role in action control. In other words, the computational process realizing the representation is causally connected to but in principle separable from the peripheral body or from the environment (see also Markman and Dietrich, 2000).

³On the impossibility of a “brain in a vat” modeling the world without constitutive embodiment, see also Cosmelli and Thompson (2011).

⁴In a similar vein, Gibson has pointed to the anchoring of perception in self-awareness: “This is only to reemphasize that exteroception is accompanied by proprioception – that to perceive the world is to coperceive oneself” (Gibson, 1979, p. 141). However, I prefer the term interoception here, because the basic sense of self or self-affection is derived from the deep body (visceral feedback to the brain) rather than from the proprioception of “legs, hands, and mouth” (Gibson, 1979).

has a circular structure: perception makes use of sensorimotor contingencies (O'Regan and Noë, 2001; Noë, 2004), namely, by skillfully exploring the environment (looking, touching, etc.) and then grasping the results. For this circular intertwining of perception and action to work, the body's own movement has to be *self-referential* or *self-given* through kinesthesia and through "efference copy" mechanisms⁵.

These interconnections of perception and movement include a *temporal circularity* as well. In phenomenological terms, each bodily action implies anticipations or *protentions* (being prepared for the response of the environment) that may or may be not fulfilled in subsequent perceptions (Behnke, 2009). Thus, protention and response form a temporal circle that extends into the future. Similarly, objects are always perceived as enabling possible actions, or in Heidegger's terms, as objects "ready to hand" (Heidegger, 1962). This is captured, in ecological psychology, by Gibson's term *affordances* (Gibson, 1979), which are objective structures of usefulness or viability provided by the environment. "The uses of things are directly perceived" (Gibson, 1982, p. 409), but this perception is at the same time a perception of *future possibilities* that correspond to the body's capacities and protentions. An object such as a knife can only be perceived by an embodied agent capable of somehow interacting with it, for example, by having suitable limbs to walk toward the knife, grasp it, and so forth, thus perceiving the knife as an affordance structure. In a way, the knife is a unity of present and future. Indeed the entire body (and by no means only the brain) may be regarded as a *system of expectations and "predictions,"* which make sense of the environment as a space of potentialities or affordances and their possible fulfillment⁶.

This anticipatory structure may be considered as an extension of the organismic self-regulation at the level of the deep body. Homeostasis is now achieved not just by simple set point regulation but also through external sensorimotor loops by which the organism actively establishes and ensures the conditions of its self-sustainment. The circular structure of internal self-regulation is thus extended spatially as well as temporally: through anticipating possible satisfaction or danger, living beings are able to seek preferable situations and to avoid precarious ones – a crucial mark of their adaptivity (Di Paolo, 2009). As this goes beyond internal homeostasis, Sterling (2012) and Vernon et al. (2015) have introduced the suitable model of *allostasis* to describe a mode of self-regulation by anticipating needs and preparing to satisfy them *before* they arise. Allostasis is related to the future as a realm of possibilities and values. For these

extended loops, drives and emotions play a crucial role: distant goals require a striving (or aversive) anticipation. "The animal has to span a gap that represents in time what the gap between itself and the relevant objects represents in space. The latter gap is provisionally spanned by perception, the former is by emotion" (Jonas, 2001, p. 104). Thus, hunting is motivated by appetite, desire, and aggression, whereas flight is driven by fear. Through emotions, affordances are perceived as *valuable*, for instance, as attractive or as repulsive.

Circularity of Affordances

The account of sense-making given so far also allows us to see affordances as having a dual aspect, as Gibson has suggested:

"[A]n affordance is neither an objective property nor a subjective property; or it is both if you like" (Gibson, 1979, p. 129).

The concept of circularity can be applied to this dual aspect of affordances, which are neither purely physical properties nor subjective mental projections:

- On the one hand, the living being makes sense of the environment as affording certain possibilities of action, namely, on the basis of needs and desires of the *lived body*; this is the subjective aspect of affordances.
- On the other hand, the environment objectively offers precisely these possibilities of interaction, thus providing a suitable "niche of affordances" for the *living* or *object body*. In the course of a concrete action, these affordances and their sensory flow continually define the body's further sense-making activity (Fultot et al., 2016).

In other words, there is a circular interrelation between the needs of animals and the corresponding affordances in the environment, which are disclosed by these needs. This relation itself is an objective feature of the ecological system. Affordances are real, regardless of whether they are currently perceived or used. Thus, the structural coupling of organism and environment renders affordances *objective relational properties* in the world (see also Chemero, 2003). The dual aspect of lived body and living body allows us to consider these relations from both complementary perspectives.

The Role of the Brain

I have spelled out the animal's sense-making in terms of spatial and temporal loops extending into the environment. It is obvious that these loops are not produced by the brain alone; they are crucially mediated by the whole body and its protentions. The brain functions rather as an *organ of suitable dispositions*: Through its networks, it provides *open loops* of possibility that are closed by suitable complements in the environment and thus become functional cycles of interaction (Fuchs, 2011, 2018). For example, there are so-called canonical neurons in the premotor cortex that are activated both when handling tools and when only looking at them (Grafton et al., 1997; Gallese and Umiltà, 2002). This means that the knife is perceived as "ready to hand" in an embodied sense, because the motor system and the hand are already involved in its perception as open loops. The same

⁵These are feedforward mechanisms that inform the sensory system of imminent self-movements (Holst and Mittelstaedt, 1950). In this way, for example, the movements of the eyes are taken into account by the sensory system, because otherwise, the perceived surroundings would start to sway with every eye movement. Circularity is thus found already on the subpersonal level.

⁶The currently fashionable concepts of the brain as a "prediction machine" (see, e.g., Clark, 2013; Hohwy, 2013) restrict and reduce the potentiality of the whole organism-environment system to an internal computing mechanism. However, the anticipatory structure of the perception-action cycle is crucially based on the movable body as well as on the affordance profile of the environment; the brain only connects and mediates these properties and potentialities of the system. For an enactive critique of the "predictive coding" concept, see also Gallagher (2017, pp. 15–20).

is demonstrated by handled objects priming the according reach and grasp actions (Masson et al., 2011).

However, the anticipatory structure of the action–perception cycle involves the *entire body* interacting with its environment and may not be reduced to a “predictive brain.” Open loops are neither “hypotheses” nor “predictions” about the world but rather dispositions of neural and bodily activity (shaped in the course of earlier sensorimotor experiences) that mediate the skillful coping with situations and objects. As long as their anticipatory structure is fulfilled, the functional cycles run smoothly (usually without conscious attention); if there is a mismatch, then an irritation or surprise results, now requiring conscious reorientation and adaptation. Therefore, neural processes should be described neither as internal representations nor as models or predictions but rather as dispositional patterns that participate in dynamic sensorimotor cycles involving the whole organism–environment system. The cycles run through the brain, body, and environment, leaving no separate “inside” and “outside” for representations to work. A more adequate concept would be based on the notion of *resonance* between the brain, body, and environment⁷.

Hence, if I skillfully handle a knife to carve a piece of wood, there is no boundary in the action that would separate the brain from my body, nor my body from the environment. Neural networks; muscular movements of my hand, knife, and wood synergically work together; and the whole resonating brain–body–environment system creates my experience of agency. Being able to carve is obviously a capacity not of the brain but of an embodied subject coupled to an environment that provides the necessary complements. This corresponds to the subjective experience of embodying the knife or any other tool into one’s body schema: I am not a pure consciousness outside of my own action but an embodied and “ecological self” whose borders do not stop at my skin (Neisser, 1988). Hence, consciousness may not be localized in any one place; it is the “integral” of the ongoing interaction and resonance between the brain, body, and environment⁸.

As we can see, from an enactive approach, *the phenomenology of bodily being in the world corresponds to the ecology of the organism in relation to its environment*. Lived body and physical body are both complementary aspects of the same life process that connects the living subject and the world, or the brain, body, and environment in circular interactions⁹.

⁷On this, see Fuchs (2018, pp. 145–155) and Kevin and Shaun (2020, this issue). Gibson also speaks of the sensory system *resonating* with global changes in the perceptual field: “In the case of the persisting thing, I suggest, the perceptual system simply extracts the invariants from the flowing array; it resonates to the invariant structure or is attuned to it” (Gibson, 1979, p. 249).

⁸In algebra, the integral enables the calculation of an area that is bounded by a function over a certain basis. I use it as a metaphor to signify the integration that consciousness achieves over an extended basis, without being separable from that basis as a system of “representations.”

⁹It is also through the functional sensorimotor cycles that the object body is constituted in experience. Whereas the basal feeling of being alive corresponds to the internal, deep body or “body-as-subject,” that is, the endogenous source of experience that cannot itself become an object, the body re-appears on the level of directed, sensorimotor relations to the environment, namely, as an *object* of proprioceptive, tactile, and visual perception, or as “body-as-object” (a special object though, as it remains always present). Hence, the internal body conveys the

Circular Causality of Living Systems

As shown above, the basic self-awareness arising from the deep body forms the core of the body-as-subject. This core is extended as bodily “being toward the world,” where the body functions as medium of our sensorimotor interactions with the environment. Both the basic bodily self-awareness and the extended lived body may be regarded as the *integral* of the brain–body and the brain–body–environment cycles, respectively. The next question is whether these higher-level phenomena of bodily subjectivity also have an effectiveness of their own, or whether they are only epiphenomena of processes on the microlevel. Does the bodily experience of hunger or anxiety actually lead to the actions required to satisfy the hunger or avoid the anticipated threats?

A concept that is suitable for establishing the significance of the lived body is known as *circular causality*, also termed downward/upward causation or global-to-local/local-to-global causality (Haken, 1993; Thompson, 2007; Murphy et al., 2009; Vernon et al., 2015). Circular causality obtains between higher- and lower-level processes, or between the whole and the components of a system. Thus, a living being may be regarded as a system that continuously reproduces the components of which it consists (organs, cells, biomolecules, etc.), whereas these components reciprocally sustain and regenerate the system as a whole. The whole is the condition of its parts but is in turn realized by them.

Such a structure, for instance, characterizes the relations between genes and the organism: the genetic structure of an individual cell nucleus controls the necessary production of specialized cellular organs and functions (=upward or local-to-global causation). Conversely, the entire configuration and function of the organism are involved in defining which genes of the individual cell attain any relevance at all for its development, specialization, and regulation (=downward or global-to-local causation). Another example is as follows: an emotional state such as a patient’s anxiety can be treated pharmacologically, that is, by directly influencing the transmitter metabolism in the brain (upward). On the other hand, this can also be achieved by calming talk, that is, on the higher level of social interaction, which changes the patient’s perception of his or her situation (downward). As such, intersubjectivity corresponds to an integral level of organism–environment interactions that feeds back into lower-level (neuro-)physiological processes.

This type of causality is often criticized and rejected, on the grounds that it either presupposes unknown physical forces, thus contradicting the laws of physics, or that it is superfluous and falls prey to Occam’s razor (Craver and Bechtel, 2007). However, by no means are we obliged to restrict the notion of causality to effective causes (*causa efficiens*) as in the model of billiard balls acting on each other. Macrostructures may well develop

background state of being-directed-toward something – the body as medium – whereas the external body is the body that we become conscious of, or that we can use like an instrument. Whereas the body-as-subject is primarily constituted on the level of subcortical brain structures coupled with the visceral body, the body-as-object requires cortical structures connected with the sensorimotor body (cf. also Solms, 2013; Fuchs, 2018, p. 117f.).

formative or organizing effects with regard to the microelements in which they are realized, in accordance with Aristotle's *causa formalis* (Juarrero, 1999, pp. 125–128). This does not mean that new forces emerge that would contradict physical laws. Rather, macrostructures are in a position, thanks to their form and configuration, to *select* specific properties and behaviors of their components and *block* others (Campbell, 1974; Moreno and Umerez, 2000).

Thus, these components acquire *emergent* properties, for instance, iron incorporated in hemoglobin. Normally, iron exposed to oxygen and humidity rusts, as it binds oxygen irreversibly. The process of respiration, however, crucially requires that the iron is in a position to incorporate oxygen reversibly, which would never happen in inorganic nature. This purpose is served by hemoglobin, a macromolecule consisting of about 10,000 atoms, with the sole purpose of enabling iron to release its oxygen in the necessary areas of the organism. For this to occur, no physical “miracle” is required, but only a superordinate organizational structure (in this case hemoglobin) that selects and “enslaves” its own compositional elements (Haken, 1993; Kelso, 1995), that is, integrates them into specific behavioral patterns. Generally, the molecular processes within a living cell are so constructed that they produce chemical reactions and molecules, which defy the odds of natural occurrence by many orders of magnitude (Deacon, 2006). Thus, the form, configuration, or topology of a living system constrain the *range of possibilities* in the system's phase space.

Analogously, mental processes, as embodied and integral acts of a living organism, can be effective in that organism's physical behavior. Of course, subjectivity does not affect physiological processes as an external force but rather exerts a top-down formative influence over them. If I, for instance, speak a sentence, the muscles of my tongue and larynx display organized patterns of movement. Their proximate or efficient cause is the release of acetylcholine at the motor endplates of these muscles. Nevertheless, it is equally correct to say that my tongue and larynx move in these ways *because I am speaking these words* and I am intentionally directed toward their content. This “because,” however, no longer signifies an efficient, but a higher-order *selecting and forming cause*: the muscles are always ready for excitation, they could contract in manifold other ways, but they are drawn into a selective, superordinate dynamics. Thus, the organizing cause of the muscle actions is my speaking (*downward*), which in turn is realized by a complex but constrained dynamics of physiological mechanisms (*upward*).

However, the same applies to the neuronal activity in motor and other areas of my brain: there is no place where an efficient-causal chain of “speech events” would begin. Rather, the neuronal processes proceed in this precise way because *I am speaking* these words, consciously spanning the intentional arc of the sentence over time, and roughly anticipating the meaning of the sentence and the next words to come. In other words, my embodied intentions and protentions are able to organize their physical implementation with the potential *to even achieve a future state that does not yet exist*. On a more basic level, such temporal loops also enable the *allostasis* mentioned above,

by which conscious organisms regulate their needs in advance (Sterling, 2012). The coupling of an organism's protentions and the corresponding environmental affordances act as a higher-order cause of the respective interaction. As overarching and future-directed enactments of life, conscious processes may thus be effective in the behavior of a living being without “acting on brain processes” in an external way.

In order to avoid any connotation of such efficient cause, one could also speak of an “implicational causality” (de Haan, 2020, p. 119): *by way of* thinking or speaking, I – as a living being – also realize certain organized processes in which ordered activities of neurons and muscles are implied; this happens inadvertently, as it were, similar to water molecules being drawn into a whirlpool that nevertheless consists of them. The whirlpool as form or order *implies* their specific movements without acting upon them. Thus, the complete cause of my speaking is neither my tongue nor my brain, but *I am this cause myself as a living being*. In each conscious action – walking, speaking, writing, or thinking – the living being as a whole acts as the forming, selecting, and organizing cause.

Again, circular causality does not mean external causation nor an interaction of mind and body but a relation of implication or global-to-local encompassing. Let us take the example of anxiety once more. A threatening situation, for example, an imminent loss of my job, induces growing anxiety, and this anxiety is obviously motivated by my former experiences and my subjective view of the current situation. On the other hand, changing from the personalistic to naturalistic stance, a neuroscientist might examine my brain in an fMRI scanner, zooming in, so to speak (de Haan, 2020), and find an increased activity in my amygdala. This activity is not the *cause* of my anxiety, however. The neuroscientist only turns to the physical aspect, with a narrow focus on the specific brain activity involved, leaving aside the circular interaction of the brain, body, and environment. Only the wider view, namely, considering the aspect of embodied subjectivity, its situatedness, and its history, provides a full explanation of my anxiety. On the other hand, it is not my anxiety that *causes* my amygdala to get activated – at least not in the usual sense of causality where cause and effect may be separated, one following the other. Much more is it that embodied subjectivity *constrains* or orders the patterns of brain activity involved.

Hence, there is no external causal relation between the experiential and neurophysiological aspects, because each refers to one and the same life process, looked at with a wider or a narrower focus. When I am anxious, there is no causal impact from either my brain activity to my experience or the other way around: rather, my having this experience *implies* certain brain activities, by way of circular causality or implication. Brain processes certainly enable my experience (upward causation), but the experiential aspect is wider with regard to both space and time. Only my relation to the current situation as a whole and my history of interactions with similar situations can explain my anxiety and the neural processes connected to it (downward causation). And only my anxiety as a future-directed subjective experience is able to motivate and organize the physical actions required for avoiding the threats I anticipate.

Hence, via circular causation, embodied subjectivity as the integral of the brain–body–environment system is actually effective in the world, for it encompasses the physical processes necessary for its effect.

Diachronic Circularity of Process and Structure

The impact of embodied subjectivity on the course and formation of physical processes and structures becomes even more obvious if we turn to the diachronic aspect, that is, the *development* of the individual human being. This may be described as a continuous *incorporation* of lived experience, in the sense suggested by Merleau-Ponty (1962, p. 192): “The body is solidified or generalized existence, and existence a perpetual incarnation.” In other words, existence as lived experience leaves its traces in the structure of the body, in particular in its neural structures. Development, learning, and memory formation may thus be conceived as a circularity of living *process* and solidified *structure*, continuously modifying each other. I will describe this diachronic circularity in more detail.

As research into neuroplasticity has amply shown, each bodily experience or behavior induces changes in the highly plastic matrix of the brain, mediated by epigenetic alterations of cellular functions and resulting in more adaptive dispositions and patterns of neural activity. This includes changes in the synaptic structure of neural networks, in the connectivity strength between brain regions, or even an anatomical enlargement of brain areas involved (McClung and Nestler, 2008; May, 2011). Thus, motor exercise, musical training, memorizing, meditation practice, and psychotherapy have been shown to durably change brain structure and activity (Goldapple et al., 2004; Draganski et al., 2006; Vestergaard-Poulsen et al., 2009; Dayan and Cohen, 2011; Ker and Nelson, 2019). In all these cases, the incorporation of experience in the form of altered neural dispositions results in an ever smoother performance, in acquired skills or habits.

Importantly, *conscious attention* obviously plays a crucial role for these top-down structuring effects. This was shown, among others, in a study by Recanzone et al. (1993) who trained monkeys to pay discriminative attention to either sound or touch

stimuli presented to them simultaneously. After 6 weeks of the trial, a differential result emerged: in the monkeys attending to the sounds, the auditory brain area expanded, whereas the somatosensory area increased in monkeys attending to touch (for a similar experiment on the effect of discriminative attention in rats, see Polley et al., 2006). Conscious experience and attention thus act as “order parameters,” differentially constraining the current patterns of neural activation and thus also determining the long-term structuring of brain networks.

The extent to which the mammalian brain is already formed by interactive experience during early ontogeny has been impressively demonstrated by Mringanka Sur and his research team who induced a far-reaching cortical reorganization in newborn ferrets (Melchner et al., 2000; Sur and Rubenstein, 2005). They severed one of the ferrets’ optic nerves, so that the stump grew together with the part of the thalamus that usually transmits impulses from the auditory nerve to the auditory cortex. Now, visual stimuli, in dependence on the ferret’s motor activity, reached a brain region that usually processes acoustic signals. Surprisingly, the brain adapted to the sensorimotor patterns produced by the organism–environment interaction: in the course of several weeks, the auditory cortex became a visual cortex. It even developed orientation-selective cells that are characteristic of the visual cortex, so that the ferrets were finally capable of seeing with the eye concerned.

As it turns out, it ultimately depends on the sensorimotor interaction and its specific patterns of neural excitation, which task a cortex region ultimately takes on. Similar cortical reorganizations can also be observed in humans after brain lesions or strokes where patients can re-learn major skills by continuous exercise and training; language and orientation functions can even be taken over by the other hemisphere (Dimyan and Cohen, 2011). All this may be expressed by the principle “form follows function”: *consciously interacting with the environment induces the development of the neuronal structures necessary for ever smoother interaction and experience.*

This is the basis of learning, memory, and development from birth on: a downward effect of the superordinate body–environment system, corresponding to the subjective experience,

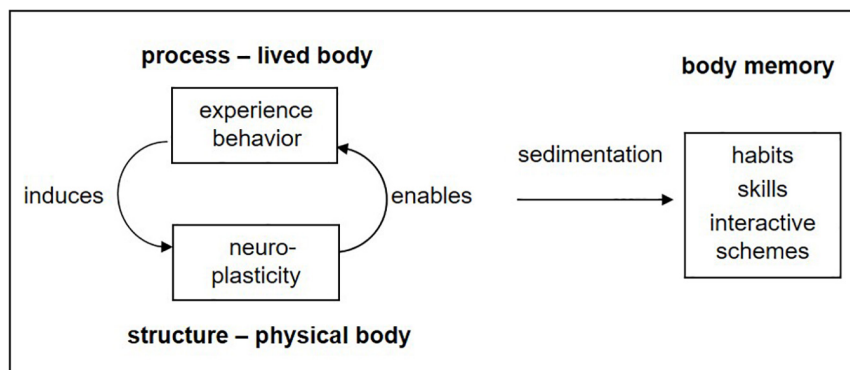


FIGURE 2 | Circularity of process and structure: learning as transformation of experience or behavior into organic (in particular neural) dispositions (adapted from Fuchs, 2018, p. 140).

induces adaptive changes in the neural substrate, which in turn enable improved functioning (Figure 2). It may also be described as a continuous circularity between *experiential process* and *organic structure*, or in other words, between *lived body* and *physical body*. Over time, repeated experiences are sedimented or incorporated in what may be termed *body memory* (Fuchs, 2012b, 2018), namely, the totality of dispositions, habits, skills, and interactive schemes acquired by an individual in the course of his or her development.

Of course, there are no two separate processes going on, one experiential and one physiological, which would somehow act on each other. Rather, we are looking at two aspects of one and the same process: the one implying the lived interaction within the wider system of organism and environment and the other having a narrower focus on the physiological processes and the continuous reorganization within the brain, which turns process into structure. Hence, there is circular causality, downward influencing, and upward enabling but no causal interaction between the aspects.

Switching between both aspects in the diachronic sequence, we can also speak of a *spiral-shaped development*: lived body and organic body, each considered as aspects of the life process, mutually influence and modify each other. As superordinate processes, the lived body's interactive experiences become organic dispositions, which in turn enable new forms of experience. The dialectics of *Leib* and *Körper* unfold in time and become the dynamics of lived (present) and sedimented (past) experience, or of process and structure mutually turning into each other – which is precisely what we call *learning and development*.

In the diachronic dimension, then, the two-dimensional circle of body–environment interaction actually becomes a *three-dimensional spiral* (it only appears as a circle when viewed from above, neglecting its diachronic axis; cf. Figure 3). Experience turns into the organism's altered dispositions (O_1, O_2, O_3, \dots), which change the perceived environment and its selected affordances (E_1, E_2, E_3, \dots), thus in turn enabling new experiences, and so on. Perceived affordances are thus shaped by the history of the structural coupling of organism and environment¹⁰. In early childhood, for example, objects take on special relevance once infants acquire certain manipulatory skills. As Eleanor Gibson has shown, sensorimotor learning is based on the infant's exploratory activity and environmental feedback, leading to a continual increase in perceiving what is doable (Gibson, 1991, 2000). Every acquisition of new motor skills – reaching, walking, swimming, driving, sewing, and handwriting – produces new affordances throughout life (Adolph and Kretch, 2015).

This is obviously not a merely individual development – most capacities, customs, and cultural techniques are acquired in the course of *embodied social practices* such as imitation, joint attention, and cooperative learning. The social and cultural environment with its shared practices becomes the decisive “ontogenetic niche” for scaffolding the infant's development and

selecting appropriate neural structures (Tomasello, 1999; Kendal, 2011). The embodied mind is thus intersubjectively formed from birth on. To give one example, infants have a universal potentiality for speech and articulation, which through acquiring the mother tongue is gradually restricted to a culture-bound pattern. Therefore, in the first months of life, babies can still distinguish more phonemes than the adults of their culture (Markowitsch and Welzer, 2009, p. 160–164). Via implicational or downward causality, the plastic matrix of their brains is shaped by the higher-order patterns of social interactions (Kuhl, 2010). These interactions restrict and determine what now appears to the baby as meaningful social affordance, namely, familiar verbal sounds, whereas foreign sounds remain meaningless. Of course, the latter may still serve as affordances, yet only for babies from another culture. This is just one example of the spiral of process and structure that characterizes childhood development as a whole and continues later on – as the constant incorporation of experience or “perpetual incarnation of existence” (Merleau-Ponty, 1962). The cultural environment serves as a higher level system that scaffolds, selects, and constrains the formation of individual brain functions and corresponding capabilities.

A similar “spirality” can also be found in the *phylogenetic* development of *homo sapiens*: human culture gradually formed a new ecological niche, which acted as a superordinate formative field that favored and selected appropriate organic structures, including the higher structures of the human brain (Sterelny, 2010; Sutton, 2015). Another example is the evolution of the

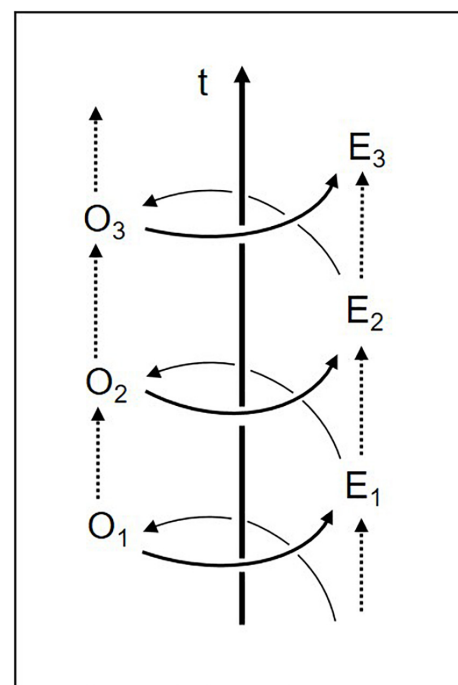


FIGURE 3 | Co-evolution of organism (O) and environment (E) over time (t) (adapted from Fuchs, 2018, p. 103).

¹⁰In enactive terms: “What constitutes the world of a given organism is enacted by this organism's history of structural coupling” (Varela et al., 1991, p. 202).

human larynx, which adapted to the cultural development of language: compared with other primates, it descended to a lower position, thus opening a unique resonance space for the differentiation of vowels and allowing the human tongue to move more freely, to the advantage of our phonetic repertoire (Fitch, 2000). Even though the crossover of the respiratory and digestive tracts resulting from the lowered larynx is dysfunctional in another respect (it may lead to choking and lethal aspiration), the further development of language obviously outweighed the disadvantage. Thus, in human evolution, we find again an analogous relation of *process and structure*: on the one hand, intercorporeality and interaction increasingly developed toward symbolic communication; on the other hand, these social processes shaped the structure of the human organism, although of course within an evolutionary, phylogenetic time frame.

This results in a *spiral of cultural and biological evolution*, and in the inherent connection of embodiment, social interaction, and culture (Durt et al., 2017). Humans create their own specific environment, consisting not only of material products of culture such as tools or artifacts but also of shared ways of sense-making and interaction that are established as symbols, codes, rituals, and habits. This constitutes a universe of novel, *cultural affordances*, which impregnate and structure the individual ontogeny. The “material culture” (Malafouris, 2013) and the symbolic culture have to be appropriated and incorporated by every new generation; this is crucially mediated and enabled by the “encultured brain” (Lende and Downey, 2012), which adapts to the cultural scaffolding on the basis of circular causality.

Self-Formation: Modifying the Spiral

The processes of circularity and development mentioned so far were mostly involuntary; learning, habit, and skill formation were considered as part of the overall process of enculturation. However, it is characteristic of the human species that its members increasingly take ownership and responsibility for this development themselves. By their decisions and actions, by choosing a certain way of life and environment, individuals shape their own development, because the chosen way of life and environment feed back on their own becoming. Humans not only live their lives but also *lead* them, and through this, they form and cultivate themselves. This means that the spiral of process and structure is *deliberately* modified and directed to an anticipated goal.

There are two presuppositions for this individual self-determination:

- a) *Relationship to oneself*: Based on the capacity of self-reflection, the individual is in a position to take a stance toward his or her own development. He or she is no longer determined by the higher-order system of cultural socialization but can detach himself or herself from the current situation and anticipate and evaluate possible alternatives of life.
- b) *Embodied freedom*: As shown above, in each conscious action, the living being as a whole acts as the forming, selecting, and organizing cause – in accordance with the principle of downward causation. In humans, this principle is raised to a higher potential by the possibility

of autonomous decision making. Free will should not be regarded as a purely mental feat, however; making a choice and acting according to it are rather the result of an “embodied freedom,” which integrates the entire bodily, affective, and cognitive situation of the person in each decision and its execution (see Fuchs, 2018, p. 236–243, for further explanation).

Objections to a concept of genuine human freedom are mainly rooted in latent dualistic intuitions, assuming this kind of freedom to rest on an immaterial mind steering the activities of neurons. By contrast, the concept of embodied freedom is based on circular or implicational causality; it regards decisions as superordinate, intentionally directed enactments of life performed by an embodied person – enactments that are enabled but not determined by the neuronal processes involved. Of course, the problem of free will cannot be discussed here in detail (cf. Banks et al., 2006; Gallagher, 2006; Murphy et al., 2009); suffice it to emphasize the fundamental change brought about by human freedom in the top-down processes of enculturation. All a person’s experiences and actions leave behind traces in the organism and thus change his or her dispositions, skills, and potentialities. A person’s being is continually becoming, but *this becoming is increasingly his or her own doing*. Through their decisions and actions, human persons shape their own development.

This new level of freedom creates a particularly human spirality, which we find already expressed in Aristotle’s concept of *hexis*, that is, a personal habitus and character that is continuously shaped through self-forming actions:

“The virtues we get by first exercising them, as also happens in the case of the arts as well. For *the things we have to learn before we can do them, we learn by doing them*, e.g., men become builders by building and lyreplayers by playing the lyre; so too we become just by doing just acts, temperate by doing temperate acts, brave by doing brave acts. [...] This is why the activities we exhibit must be of a certain kind; it is because the states of character correspond to the differences between these. It makes no small difference, then, whether we form habits [*hexis*] of one kind or of another from our very youth” (Aristotle, 1925; my italics).

The italicized passage describes precisely the spiral of human learning, namely, shaping the body’s dispositions, skills, and habits through one’s actions, which are in turn increasingly enabled by these dispositions. This circularity extends to the sphere of moral actions: in the course of mental development, they become more and more self-determined, and through repetition and habitualization, they form a “virtuous” character. One might conclude that embodied subjectivity most clearly proves its effectiveness or its non-epiphenomenal character *when it directs its actions on itself* and thus produces a lasting self-forming and self-changing effect. This may be considered the highest stage of the principle of circularity.

CONCLUSION

In this paper, I have studied the interrelation of lived or subject body (*Leib*) on the one hand and living or object body (*Körper*) on

the other. Both were considered as complementary, irreducible, mutually constituting, and also mutually concealing aspects of the living being. They correspond to two different attitudes that we may adopt: in the personalistic attitude, we experience our own lived body from a first-person perspective or the other's lived body from a second-person perspective. In the naturalistic attitude, we observe or investigate the physical body from a third-person perspective. Whereas the personalistic attitude and its corresponding aspect require a holistic view of the living being or the person, the naturalistic attitude allows for focusing on increasingly narrow sections and details of the physical body, albeit at the price of losing the phenomena of life and mind. A person, that is, a living, embodied subject, can only be perceived as such by another embodied subject in the personalistic attitude.

In order to further investigate the relation of both aspects and the “body–body problem,” I have interpreted the intertwinement of subject body and object body on the basis of the concept of *circularity*. First, embodiment shows a circular structure, because it is based (a) on the cycles of homeostatic self-regulation between the brain and body and (b) on the sensorimotor cycles between the brain, body, and environment. The first cycle is the foundation of the feeling of being alive, or the pre-reflective background feeling of the body itself. The second cycle is the basis of bodily “being toward the world” (Merleau-Ponty), or of situated, enactive subjectivity. Here, in terms of ecological psychology, living beings and their surroundings constitute an interactive system, with each constituent being reciprocal to the other: what we perceive are not objects as such but objects to deal with, or the functional relations between self and world. In other words, there is a mutual interdependence of the bodily dispositions of sense-making and the affordances of the environment disclosed by these dispositions.

In both kinds of cycles, the ongoing circularity of the processes involved does not allow for an internalistic account on the basis of representations in the brain, which could in principle be separated from their source. There is no component within the cycles that represents another component, in the sense that it could stand for it while it is absent; “inside” and “outside” are functionally coupled and may not be separated. Hence, bodily self-awareness as well as conscious being-in-the-world can no longer be localized in the brain; instead, they are the *integral manifestation* of the brain–body–environment system, or of the overarching process of life encompassing the whole organism. This conception unites the first-person phenomenology of the lived body with a systemic approach provided by both enactivism and ecological psychology.

In order to establish the effectiveness of embodied subjectivity, I have further used the concept of *circular causality*, which characterizes the relation of parts and whole within the living organism as well as within the organism–environment system. Downward causation enables an account of embodied subjectivity as being equivalent to an ordering or forming cause of a living being's actions, while avoiding dualistic assumptions of the “mind acting on the body.” It is a causation by global-to-local implication, not a separate mental activity or impact. Importantly, this kind of causation includes the possibility of achieving future states anticipated by embodied intentions and protentions. Hence, only the wider view of the subject as

embodied and situated, with both regard to space and time, is able to fully explain a person's experience and behavior.

As a next step, I have described the interrelation of lived and physical body as a *circularity of experiential process and (neuro-)physiological structure* underlying development and learning. Here, the circular causality of higher- and lower-level processes is considered as unfolding in the *diachronic* dimension, based on the plasticity of the brain. Subjective and intersubjective experience constitutes a process of sense-making that includes cerebral processes so as to form modified neuronal structures, which in turn enable altered future interactions. Only conscious experience contains the intentional and meaningful relations to the environment whose correlates are functionally and morphologically inscribed in the brain throughout the course of socialization. This results in a *spiral-shaped development*: lived body and organic body mutually influence and modify each other. This is not only an individual development, however; the social and cultural environment with its shared meanings, habits, and artifacts constitutes the crucial *ontogenetic niche* for the individual formation of the brain. Analogously, human culture has also provided the decisive scaffolding for the *phylogenetic evolution* of the organic (in particular, neural) structures of the human being.

A final step is reached with the possibility of *shaping one's own development*, which arises with the relation to oneself and the autonomy of the person. This is the circularity of freedom: by choosing one's actions and way of life, one also shapes the body's dispositions, skills, and habits which increasingly favor those actions. Individuals are not just the result of the organic, social, and cultural conditions, which have contributed to their development; instead, they take control and responsibility of their own becoming by choosing the experiences, actions, and situations that feed back on their development. This self-determination is based on circular causality as a presupposition of free decisions and actions, and on the human capacity for taking a stance toward one's own being and becoming.

In conclusion, the proposed – yet certainly not exhaustive – solution to the body–body problem may be summarized as follows:

- a) Lived body and living body correspond to two complementary, irreducible, but intertwined *aspects of the living being*, regarded from two different perspectives or attitudes.
- b) The *living body as a whole* is the constitutive basis of the subjective lived body; or in other words, the latter is equivalent to the integral experience that we have as living organisms in relation to our (physical, social, and cultural) environment. The brain is not the locus of subjectivity but only a mediating component of the cycles of self-regulation, sensorimotor, and social interaction, in which the life of a human person consists.
- c) The lived body or embodied subjectivity has a top-down, ordering, and constraining effect on the physical body and its processes, and over time, a formative effect on its (neuro-)physiological structures. These effects are mediated by *circular causation* or by way of *implication*.

- d) Accordingly, lived body and living body, *Leib* and *Körper*, mutually enable and constitute each other. This is what defines our embodiment as human persons.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Ecological Psychology and Enaction Theory: Divergent Groundings

Harry Heft*

Department of Psychology, Denison University, Granville, OH, United States

Both ecological psychology and enaction theory offer an alternative to long-standing theoretical approaches to perception that invoke post-perceptual supplemental processes or structures, e.g., mental representations, to account for perceptual phenomena. They both do so by taking *actions* by the individual to be essential for an account of perception and cognition. The question that this paper attempts to address is whether ecological psychology and enaction theory can be integrated into a stronger non-representational alternative to perception than either one can offer on its own. Doing so is only possible if most of the basic tenets and concepts of ecological psychology and enaction theory are compatible. Based on an examination of the role that sensations play within each approach; the manner in which each treats the concept of information; and how each conceptualizes an organism's boundaries, it is concluded that a synthesis of the two approaches is not possible. Particular attention is paid to the concept of sensations, the limitations of which were an impetus for the development of ecological psychology.

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Jelle Bruineberg,
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*Correspondence:

Harry Heft
heft@denison.edu

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INTRODUCTION

Most explanations of visual perception that have been offered in recent centuries, and in particular those following the tradition of British Empiricist philosophy, adhere to a common meta-theoretical template: sources of stimulation in the environment innervate sensory receptors, which give rise to elementary sensations that function as the basic components of perceptual experience. Because the character of the environment as experienced by the perceiver cannot be explained with reference to those sensations alone owing to their limitations, additional psychological processes beyond perception are deemed necessary that supplement, enrich, and organize them. These post-perceptual processes are assumed to be latent in the perceiver owing to inheritance or prior experiences or both. Since the emergence of cognitive psychology in the 1960s, these post-perceptual processes have often been claimed to be based on 'mental representations' of the environment.

The ecological approach to perception and enaction theory are distinctive among perceptual theories for advocating a theoretical approach that rejects an appeal to mental representations or post-perceptual processes to account for experience of the environment. Furthermore, both approaches assume that an adequate account of psychological processes other than perceiving, such as thinking, remembering, and communicating symbolically, requires as a first-step a satisfactory account of perceiving. For this reason, both agree that 'getting one's account of perceiving right' from the outset matters a great deal for psychological theory broadly considered.

Because both ecological psychology and enaction theory attempt to establish a framework for a non-representational approach to psychological theory, and because presently both are in a

minority position with respect to the field of perceptual psychology overall, it might seem as if a joining of forces as it were – or at least a partial synthesis – would make for a stronger joint alternative to the representational theories that have dominated psychology and the philosophy of mind for so long. That is only possible, however, if most of the basic tenets and concepts of ecological psychology and enaction theory – that is, their grounding concepts – are compatible. In this brief paper, I will argue that they are not.

Fultot et al. (2016) previously offered a comparative analysis of these two approaches and also reached a similar conclusion. The initial draft of the present paper was written prior to examining their analysis in order to develop an independent assessment. More importantly, since the appearance of Fultot et al. (2016), two major contributions to enaction theory have appeared: *Sensorimotor Life* (DiPaolo et al., 2017), and *Linguistic Bodies* (DiPaolo et al., 2018). The present paper draws mostly on the former as a basis for comparing ecological psychology and enaction theory.

It is recognized that not all investigators who self-identify as enactivists necessarily adhere to each of the features of the framework developed by DiPaolo and his colleagues. The purposes of this paper is not to survey the varieties of enactionism, however. Because that framework bears most of the conceptual characteristics of this approach overall, and because at present it appears to be the most influential in addition to the seminal work by Varela et al. (1991), this paper focuses primarily on those three books.

STARTING POINTS

In order to examine the areas of difference between ecological psychology and enaction theory, it will be useful here at the outset to recognize that the starting points in the formulation of these two approaches differ. On the one hand, ecological psychology is rooted in James Gibson's account of perception which emphasizes the role that perceiving plays for the organism in the control of action, and conversely, the significance of action in the organism's detection of properties of the habitat (Gibson, 1958, 1966, 1979). Perceiving supports adaptive functioning by making it possible for the organism to 'stay in touch' with the environment in the course of everyday actions. The formative image underlying enaction theory, on the other hand, is the living cell operating as a far-from-equilibrium, dynamic system that strives to maintain stability in the face of possible perturbations (DiPaolo et al., 2017, 2018). It does so by way of its network of interdependent within-system processes and through continuous exchanges with the surround beyond its boundaries.

It is the case that these differences in their starting points can ultimately be reconciled. Adherents of each approach have independently argued how ecological psychology and enaction theory considered on their own terms are compatible with dynamical systems thinking (e.g., Chemero, 2009; DiPaolo et al., 2017, respectively). But reconciling them in this regard will not be sufficient for their rapprochement. This is because the lines of thought in ecological psychology and enaction theory

beginning with their most basic concepts led to noteworthy divergences between them. Reconciliation would require non-trivial modifications in the conceptual structure of one approach or the other. A simple melding of the two will not do.

It is also critical to emphasize here at the outset that a central feature of the framework developed from the ecological psychology perspective – indeed, its essential commitment – is one that would *not* be embraced by enaction theory. Advocates of ecological psychology maintain that their approach to perception provides grounds for the claim that the environment is *directly perceived*. Direct perception means that perception of the environment – that is, the detection of its relational structure by means of perceptual systems – is not mediated by non-perceptual processes such as stored memories, mental representations, and the like. Ecological psychology offers a conceptual basis for embracing the epistemological position of *direct realism* (Gibson, 1967). When enaction theory extrapolates the image of the living cell as a dynamic, far-from-equilibrium system to an account of perception, it also sees no need to appeal to stored memories and mental representations. In spite of that, as we will see, one would be hard-pressed to describe its account of perceiving as direct, nor would one characterize its epistemology as that of direct realism. This difference will emerge at several points below.

The present discussion will mostly be limited to considerations of visual perception. In order to explicate their areas of disagreement, it will be necessary to review what may be quite familiar ground for some readers. Doing so is intended, in part, to inform those committed to one or the other approach about its counterpart. While my own training stems from an ecological approach, I trust that proponents of enaction theory will consider my account of their views as being accurate as far as it goes.

Three points of difference between the two approaches will be discussed here: (1) the role that *sensations* play within each approach; (2) the manner in which each approach treats the concept of *information*; (3) the way each approach conceptualizes an *organism's boundaries*. To some extent, these differences hinge on matters of terminology and the way particular concepts are defined. But these terminological and definitional differences are far from trivial. They are indicative of fundamentally dissimilar approaches to perception.

In brief, ecological psychology characterizes perceiving on the part of the individual as a process of perception-action involving the pickup of *information* in the environmental surround that is *available* to the perceiver and that *specifies* properties of the environment. Enaction theory claims that the perceived environment is realized, comes into being, is 'enacted' for an individual by means of an interdependent dynamic network of *sensorimotor* processes within the boundaries of the organism. Obviously, these two claims require a great deal of elaboration, but they are sufficient as places to begin our discussion because they bring to the foreground a few notable differences in terminology employed in each approach. Ecological psychology takes as a core concept 'information'; whereas central to enaction theory is the concept of 'sensorimotor processes.' As we will see, each concept as used in the respective theories would be rejected by its counterpart approach on grounds to be explained. The differences between ecological psychology and

enaction theory could not be more clearly revealed than when we compare their respective treatments of information and sensorimotor processes.

THE ROLE OF SENSATIONS IN PERCEPTION

As already discussed, the standard approach to explaining perception takes sensations as its starting point and develops an account of perceptual processes from there. The ecological psychology concept of information, and ultimately the ecological approach to perception itself, was developed by James Gibson in large measure *because* he came to the realization after many years that a functionally adequate account of perception – that is, one that describes the process by which organisms function in the environment in the course of everyday activities – could not be formulated based on what are conventionally taken to be ‘sensations.’ That point cannot be overemphasized. To the extent that sensation in this conventional sense corresponds to how the term is employed in the expression ‘sensorimotor’ in enaction theory, this difference sets ecological psychology and enaction theory on diverging paths from the outset.

Conceptual Limitations of Sensations From the Standpoint of Ecological Psychology

Following Turvey (2019, pp. 166–167), sensations are conventionally assumed to have the following characteristics: they are *anatomically specific* products of sensory receptor stimulation, and as such they are *biological correlates* of physical energy variables originating in the environment. As biological correlates of receptor stimulation, they are *private*, occurring ‘in’ the organism. Importantly, owing to their origins in individual receptor functioning, sensations are assumed to be *discrete* as well as *transient*.

In contrast, perceptual experience tends to have the qualities of *patterns* and ordered or semi-ordered *structure* rather than discrete bits of sensation. Further, features of perceptual experience, such as objects, tend *not to be transient*: even when they *go out of sight* they usually are not experienced as *going out of existence* [see Gibson (1979) treatment of dynamic occlusion (Chap. 11); Heft (2020)]. They have a phenomenal permanence to them (excepting somewhat less common cases such as disintegration of matter and evaporation of liquid.) Finally, features of perceptual experience typically are ‘felt’ to be located in a *public domain* beyond the body boundaries – and as such, they are taken to be qualities that, in principle, others can experience as well, rather than being exclusively private.

The recurring challenge for perceptual theorists has been how to explain this apparent ‘gap’ between properties of sensations, on the one hand, and perceptual experience, on the other. Ecological psychology and enaction theory offer alternative accounts. Enaction theory offers an account of perceiving whereby system processes incorporate sensations into a sensorimotor loop, by means of which perceptual experience of the environment is

realized (‘enacted’). Ecological psychology, in contrast, rejects the assumption that sensations play a role in perceiving; instead they are considered to be incidental to perceptual experience. Instead of a sensation-based account, ecological psychology offers an ‘information-based account of perceiving.’ That is, ecological psychology, unlike enaction theory, dispenses with sensations in its account of perceiving. What is directly perceived is the environment. For this reason, the proximal-distal distinction found in most modern accounts of perception collapses. Although this step is unorthodox among theories of perception, it is not entirely novel, having been previously proposed by Reid (1785) and James (1890, Chap. 17).

Enaction Theory and Sensations

In their seminal book for enaction theory, Varela et al. (1991) hold that “the enactive approach consists of two points: (1) perception *consists in* perceptually guided action and (2) cognitive structures emerge from *recurrent sensorimotor patterns* that enable action to be perceptually guided” (p. 173, emphasis added). Perceptual experience, that is, is a resultant of linkages between sensations and motor activities rather than solely based on the deliverances of sense. They appeal to sensorimotor patterns rather than sensations as such, not because of the characteristics mentioned above, but because sensations change in the course of ongoing activity.

The point of departure for the enactive approach is the study of how the perceiver can guide his actions in his local situation. *Since these local situations change as a result of the perceiver’s activity*, the reference point for understanding perception is the sensorimotor structure of the perceiver (the way the nervous system links sensory and motor *surfaces*) (Varela et al., 1991, p. 173, emphases added.)

For that reason, perception necessarily must stem from action patterns in relation to sensations, or a network of sensorimotor linkages.

But can sensations, even when they are embedded in a sensorimotor loop, carry correlates of environmental structure that are sufficiently ‘informative’ about the nature of the environment so as to allow for adaptive functioning? In other words, can sensations as conventionally understood (see above) carry the conceptual weight needed for an account of perceiving the world *beyond the system’s boundaries*? Even allowing for the possibility that perceptual experience is dependent on sensorimotor linkages ‘in’ the system, the sensations must carry *some* qualities of the environment beyond the system’s boundaries so that the organism is not ‘free-floating’ wholly detached from the surround. While a sensorimotor account may address how a system itself strives to maintain stability, does it also allow for a means by which the organism can stay in touch with and anchored to the environment? (How the environment is conceptualized is a related contentious issue, as we will see below).

Recognizing that the question of what makes a particular sensorimotor pattern informative requires attention to other aspects of their framework to be taken up later, here we focus on the ‘sensory’ part of the sensorimotor loop. In that regard how do

enaction theorists describe the character of the ‘sensory’ facet of a sensorimotor structure? As far I have been able to determine, the qualities of sensations are rarely described with much specificity in the enaction theory literature. To the extent that they are, they would appear to be referred to as the products of sensory receptor stimulation. DiPaolo et al. (2017) describes the sensorimotor approach as taking “*the raw and quantifiable variation of sensory and motor surfaces of the organism as a departure point*” (p. 32, emphasis added). They continue that the focus is on the way in which “*the sensory stream changes*” with movements of the agent; on how “*the agent guides its movements in relation to sensations*” (p. 34), and with “*co-variations of sensory stimulation, neural, and motor activity*” (p. 43; emphases added). As this sampling shows, references to ‘the sensory stream’ in enaction theory writings are rather general in nature. If the ‘sensory’ in sensorimotor activity is intended to refer to something other than sensations in a conventional manner, namely, as the products of receptor activity, then it is incumbent for enaction theorists to be more specific here.

Perhaps the most detailed account of the experience of sensations offered in the initial chapters of DiPaolo et al. (2017) concerns the hypothetical case, previously suggested by Myin (2003), of how an individual might identify by touch alone the property of the sponginess of “a small spongy ball. [when it] is held between thumb and forefinger.” Squeezing the ball (an action) produces a felt pressure on the finger tips, as well as “proprioception, and the sense of effort required to maintain a certain grip” (p. 58). As we will see in the next section, this felt pressure produced through action occurs in relation to background knowledge of other possible sensations that *might* arise in this case. Here we limit our attention to sponginess as a ‘proximal property’ stemming from the immediate contact between a source of stimulation and receptor surfaces. As a proximal property, the experience of sponginess does not ‘reach’ distally into the surround beyond the body boundaries. The fact that the object is even a *ball*, for example, is not discernible based on that sensation, obviously.

Other examples of sensations offered include the flow of stimulation that results from movement relative to the environment. If, for example, I move my eyes, sensory patterns due to light projecting on the retina sweep, albeit discontinuously due to saccades, across the retinal surfaces. The flow of stimulation can only be determined to be contingent on movement owing to the correspondence between sensory and motor effects; but the sensory stimulation itself, even in the context of a sensorimotor loop, provides no ‘information’ *about the environment*. All that one can discern is a *proximal* retinal flow and whether or not the perceiver herself caused it. It has no ‘distal’ referent.

DiPaolo et al. (2017) write: “The primary correlation that is available to an agent is the manner in which the sensory stream changes as a function of its own actual movement and its possibilities and dispositions for movement.” They continue: “From this perspective, agency is about enacting effective sensorimotor relations. *These are the relations that the agent helps to create and which are immediately available to it*” (p. 32; emphasis added). It is by means of a mastery of sensorimotor

regularities that one comes *to perceive the world* and the self, or in their phrasing, one engages in “sense-making.”

But is the world beyond proximal sources of stimulation even accessible to the perceiver in such an account? To return to the examples, sponginess versus solidity, or retinal flow produced through self-motion are, at best, proximal experiences – qualities that are limited to the immediate contact of physical stimulation and sensory receptors. But perceptual experience is much more than that. We experience a world that surrounds and extends ‘away’ from us. That is, we have ‘distal’ experiences. The evolution of vision (as well as audition and olfaction) quite likely is due to the functional value of detecting features of the environment at a distance from the perceiver. The language of ‘sensations’ would seem to trap enaction theory within the dynamic system that is the organism. Experience of the environment is claimed to be realized by way of sensorimotor linkages, but how is that realized experience connected to the environment as such?

To get beyond system boundaries involves, as we saw above, what enaction theorists call sense-making – the enactment of the perceived world. That may be assumed to take the perceiver beyond proximal ‘contact’ with the world; but ultimately the ‘distal’ sources of sensations would seem to be conjured up by some means other than ‘direct’ contact because sensations are inadequate to do the necessary work. It is for this reason enaction theory has the appearance to some critics as being a form of Idealism, although its proponents would surely reject that attribution because it would seem to remove the approach from the realm of natural science.

From the point of view of enaction theory, the preceding criticism concerning the limitations of sensations might well be viewed as a ‘straw man’ argument, because the enaction approach invokes sensorimotor networks rather sensations alone. But will sensorimotor networks overcome the conceptual limitations of sensations? What perceptual work revealing the world beyond the body boundaries is the *sensory facet* of sensorimotor networks supposed to be able to contribute? Absent a more detailed account of what is meant by the products of sensory stimulation, it appears to be an exceptionally impoverished concept on which to build an account of perception of *the environment* even after embedding them in the notion of a sensorimotor structure. Recall that it was because of such conceptual limitations of sensations that Gibson turned away from them in his efforts to develop an account of perceiving. The ecological approach to perceiving is built on entirely different grounds. We will sketch that out next, and in doing so compare how the approaches employ the notion of information.

INFORMATION FOR PERCEIVING

Ecological Optics: Information-as-Specification

At the heart of an ecological approach to visual perception is Gibson’s proposal and exposition of *ecological optics*. It appears to me, at least, that Gibson’s framework is often misunderstood because ecological optics is not given adequate attention by commentators, including those working from an

enaction perspective. Gibson (1966) envisioned ecological optics as a piece of an overall, and still developing, ‘ecological physics’ which considers the physical energetic properties of the world *relative to active organisms taken as a whole*, rather than in relation to the more reductive level of sensory receptors. In other words, he is attempting to offer a description of the environment in relation to animal life rather than the world from the standpoint of an animal-free domain of physics. Gibson saw the historical inclination of philosophy and psychology to begin the consideration of perception with terms developed within conventional physics, and in turn with the stimulation of receptor cells giving rise to sensations, to be the basis for many enduring theoretical and philosophical problems in psychology (Reed, 1988; also see, Dreyfus and Taylor, 2015).

To be more specific, an ecological approach to the study of visual perception among terrestrial organisms begins not with a micro-consideration of light in a classical physical vein (e.g., light traveling in waves of different periodic frequencies and intensities or as photons), but instead with a consideration of the illuminated environment taken at the level of the active organism as a whole – that is, with a consideration of the *habitat*. From an ecological/evolutionary stance, animals adapt to their habitat as whole organisms, not merely piece-meal (Lewontin, 2000). For this reason, an examination of the ecological possibilities for perceiving the habitat should be taken at a level of analysis commensurate with the organism considered as a whole. Broadly considered, then, the habitat for a terrestrial species includes the ground surface layout; detached and attached objects on those surfaces; and events transpiring over a perceptible duration (see Gibson, 1979, Chap. 3).

Ecological optics is an on-going research field that considers how light from a radiant source (e.g., the sun) interacts with surfaces, such as inanimate and animate features and the ground. When surfaces are illuminated, some of that light is absorbed, and some is reflected by them. Owing to such things as the reflectance character of surfaces due to, e.g., pigmentation and texture, as well as their orientation relative to the light source, *reflected light* takes on some of the character of these surfaces. To offer a simple example, white surfaces reflect more light than dark surfaces; and surfaces perpendicular to the ‘lines’ of light radiation reflect more light than those oblique to them. Adjacent perpendicular and oblique surfaces produce a discontinuity in reflectance or an edge. As these simple cases illustrate, reflected light is rarely homogenous, but structured even in these minimal ways. The continuous, instantaneous scattering of reflected light due to the abundance of surfaces present in most places results in a ‘steady state’ of reflected light intersecting at, in principle, an infinite number of potential observation points. These potential observation points can be temporarily occupied by a perceiver, and more commonly, individuals move along a path of observation points (Gibson, 1966). The scattering of reflected light is *ambient* with reference to an individual: it surrounds the individual, rather than being considered solely as light rays that project onto a picture plane (i.e., the retina) as it is in standard accounts of visual perception.

A detailed analysis of the structure of reflected light *to a particular point of observation* shows that some properties of the

terrestrial environment and its features, such as surfaces that extend away from the viewer and the perception of relative object size, can be carried in or conveyed in the structure of reflected light (Gibson, 1950). When the structure of reflected light is considered *from a moving point of observation*, rather than from a single observation point, information specifying object shape and self-motion become available to a potential perceiver. Detailed accounts of ecological optics can be found in numerous sources, such as Gibson (1966) and Sedgwick (1986). On-going research considers various abstract geometric systems that might be best utilized to describe patterns of reflected light to an observation point (see, Warren, 2020).

The structure in ambient light that *specifies*, e.g., surface layout, is referred to by Gibson as *information*. Information in the available array of reflected light corresponds to or *specifies* properties of the habitat, and is often most readily detected from a moving point of observation. Through the detection or ‘pick up’ of this structure (sometimes the metaphor ‘resonate’ is invoked), organisms perceive the layout of the habitat. In order to distinguish this use of ‘information’ from how the term information is employed in other psychological theories (see below), we will refer to this as ‘information-as-specification’ following Turvey (2019).

Let us consider in a bit more detail the manner in which structure in ambient light can function as specifying information. Gibson distinguishes between *invariant structure* and *perspective structure* in the ambient array of light, both of which are revealed from the point of view of an active perceiver. Also, invariant structure can be detected from a temporary stationary position, with, e.g., displacements and rotations of objects. *Invariant structure* refers to those patterns in ambient light that do not change in the context of change. For example, the perceived shape of an object is experienced as remaining constant even as one walks around it; and this constancy can be attributed to invariant relationships in the reflected light. These invariant relationships that are perceived over time remain the same across changing points of observation, and they have been described geometrically for several cases (see Johansson, 1964; Johansson et al., 1980; Runeson, 1994).

Perspective structure is the flow of reflected structure in the ambient array of light that is generated by a moving perceiver in relation to surface layout when adopting different but continuous points of observation (e.g., optic flow). In the previous example, the visual experience of oneself moving around the object is conveyed by perspective structure. Movement toward an object is specified by an optic flow of structure, and parameters within that flow specify the direction and rate of movement. A great deal of supportive research has been carried out to describe mathematically the changing structure of reflected light from a moving point of observation (e.g., Lee, 1976; Johansson et al., 1980; Warren, 1998; Fajen, 2005).

Sensation-Less Perception

An especially vivid contrast between an approach to perceiving based on sensations and an information-based approach are cases of so-called ‘sensation-less perception.’ Here we can consider if sensory stimulation is even a necessary constituent of perceiving

in all cases. Gibson (1966, 1979) has argued that it is not, and in support of this assertion he offers instances when features of the environment are perceived in spite of the fact that those features cannot give rise to any sensations because those features are temporarily out of sight. Take, for example, instances when objects or portions of objects are temporarily hidden from view, such as when an object visually occludes the surface of another object in the line of sight. **Figure 1** is a pictorial representation of such a case. (Because of its static nature, **Figure 1** is merely suggestive of an effect that is readily experienced dynamically; see below.) A horizontal bar juxtaposed over a vertical bar is not typically described by perceivers as three separate objects, but rather two objects, with one partially occluding another. The partially occluded surface is typically experienced as a single vertical bar as if the surface that is presently occluded *persists* even though it cannot be fully viewed from one observation point – there are no sensations specific to these hidden portions of the surface given the current line of sight. Consistent with these observations are studies that show young infants will track the position of an object as it passes behind an occluder (Gibson and Pick, 2001, pp. 122–125; also see Van der Meer and van der Weel, 2020). Their actions suggest an awareness of its *persistence* in experience even though there are no sensations possible when the object is passing behind the occluder.

How are these phenomena to be explained from an ecological perspective? Recall that the ecological approach claims that perceiving is a process of detecting information. Is there information that specifies a surface going out of sight (as opposed to going out of existence)? When a perceiver moves relative to the two object surfaces located at different distances from him but in the same line of sight – or alternatively, when one surface moves relative to the other, e.g., an animal passing behind a tree – what occurs is a gradual ‘covering up’ over time of once visible portions of the occluded object at the ‘leading edge’ of the occluding object; and a gradual ‘revealing’ over time of once hidden portions of the occluded edge at the ‘trailing edge’ of the occluding one. (Refer to an experimental film made by Gibson to demonstrate of this compelling effect

dynamically from a fixed viewing position¹.) The event of gradual occlusion/disocclusion of the more distant (occluded) surface at the leading/trailing edge of the closer (occluding) surface is information in the ambient reflected light of, respectively, portions of the more distant object temporarily going out of sight, while other portions once out of sight are revealed. This information is only perceivable over time; and notably, for our discussion of sensation-less perception, those portions of the more distant object that are currently out of sight are experienced as persisting. The important point for our purposes here is that there is perception (experience/awareness) of the persistence of the occluded object in the absence of sensations.

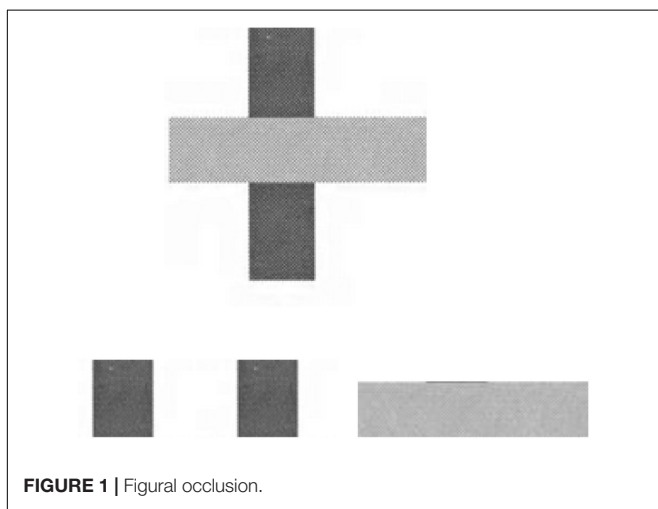
Although I have not found reference to the occluding edge phenomenon in the enaction literature, it could be accounted for within their approach as well. And yet the manner in which they would approach this phenomenon surely would be quite different from that of ecological psychology. These differences illuminate how the two approaches are at variance. Presumably from the point of view of enaction theory, because of learned (or perhaps innate) contingencies linking sensory and motor patterns – that is, because of the sensorimotor loop that is in place – the sensorimotor system ‘enacts’ or gives rise to the perceptual experience of a complete vertical bar partially occluded from view by the closer horizontal bar. This would be an instance of the ‘sense-making’ possibilities of sensorimotor processes. Because it is assumed that sensations are constituents of perceiving, and because in the case of an occluded object there are no sensations available, that which is out of sight presumably must be *enacted* via sensorimotor processes.

One may argue that both accounts amount to much the same thing – and in terms of outcome this may be the case. Both attempt to explain how it is that a perceiver can be aware of an object or a portion of an object presently out of sight. And yet how each gets there conceptually is quite different, and that difference matters a great deal from the standpoint of theory. As Turvey (2019) puts it:

Does perception create or constitute its own objects, so that the environment perceived by an organism depends on the organism’s act of perceiving? Or is the function of perceiving to acquaint an organism with the objects composing its environment as they exist independently of perceiving? (p. 29).

Occlusion transpiring at an edge serves as information that specifies an object going out of sight rather than going out of existence. Disocclusion at an edge, where an object gradually comes into sight, specifies an object previously hidden. Occlusion has a prospective quality; disocclusion a retrospective quality. This account is consistent with the claim that perception is direct; its qualities are specified by information that is available to be perceived, and one need not appeal to any mediating processes (e.g., a concept of object permanence that supplements perceiving).

An enaction explanation wouldn’t appeal to mediating processes either, and yet without grounding the phenomenon in specifiable information – information that can, in principle, be



¹https://www.youtube.com/watch?v=6QXqz_UJPWM

described with precision – the ‘enactment’ of currently hidden surfaces (i.e., sense making) seems nearly magical. At best, they are describing the phenomenology of the event, but because they begin with sensations, they miss the information that specifies it. After all, in the ecological account, occlusion at an edge transpires in the dynamic *relationship* between environment and perceiver, and what is perceived can be anchored in specifiable change in the ambient light, i.e., information-as-specification. Even if we take ‘enactment’ or sense-making as indicating an emergent event, *where* does it event occur? It would seem to be realized within the sensorimotor loop which is solely within the boundaries of each *individual* system. This difference illustrates one way that an ecological approach would embrace a direct realist stance and enaction theory would not. We will return to this implication in the final section of this paper where we discuss the matter of the organism’s boundaries.

Conceptual Limitations of Ecological Optics From the Standpoint of Enaction Theory

Enactivists identify what they see as two related short-comings of the ecological approach to perceiving. Their first objection is that ecological psychology appears to take the perceived character of the world, or at least the information that specifies it, as “pre-given” in the environment prior to the presence of a perceiver. Presumably, at least part of the concern here is the apparent absence of an account why the environment appears as it does in the absence of the organism’s role in the act of perceiving. The second objection is that little is offered in the way of explaining what the individual contributes to perception – that merely stating that information is available to be detected or picked up by a perceiver is insufficient. Taken in combination, the claim is that without indicating how the individual contributes to perceiving, the available information would seem to be simply “pre-given,” and as a result perceptual experience would not have the transactional character – rather than a linear functional approach – that a dynamic approach to psychological functioning that *both* adopt would suppose. These criticisms initially offered by Varela et al. (1991) have continued to be repeated by advocates of enaction theory. They strike me as reflecting an inadequate understanding, first, of the relational character of ecological psychology; and, second and most critically, of the manner in which the environment is conceptualized from an ecological perspective (also, see Fultot et al., 2016).

Is Information ‘Pre-given’?

Is the environment “pre-given” prior to the presence of a perceiver? If so, that would undermine the relational commitment of ecological psychology. In certain respects, this is a rather straight-forward question that can be answered in the negative. The very definition of an environment implies a possible animal. That definition is foundational to the ecological sciences and its notion of a habitat, and it is foundational to ecological psychology as well. Gibson begins his 1979 book by taking up “the environment to be perceived” (p. 5), and he defines the environment in the first sentence of Chapter 1 as

“the surroundings of those organisms that perceive and behave, that is to say, animals” (p. 7). He draws the distinction between the “animal environment” and the physical world, with the latter referring to a domain taken independent of any animal, whereas “the words animal and environment make an inseparable pair” (p. 8). What *can be* an environment – rather than the physical world considered apart from animals – by definition implies a possible animal. The surface of the sun, for example, is part of the physical universe, but it is not an environment. Logically, an environment cannot pre-exist an animal because *what can be an environment* is defined in relation to an animal. Likewise, the information available to be perceived from the standpoint of ecological optics is to be taken relative to a possible perceiver.

In this same vein, the identification of a habitat implies a particular animal group or species. By definition, habitats are not empty slots to be filled by organisms, but they reflect the reciprocity of environment and a way of living. The environment does not pre-exist an animal when it is defined in relation to animal, as it is in the ecological sciences.

To indicate, however, that animal and environment ‘make an inseparable pair’ does not mean that in the case of perception – that is, when we are operating in the psychological domain – that the features of the environment cannot ‘exist’ independently of an animal in other respects. There is a particular sense in which an environment is ‘pre-given.’ These issues have long been points of confusion (see, Heft, 2001, pp. 132–135). How can features of the environment be independent of the individual at some times and also not independent given the mutuality of animal and environment? Consider the case of the chair in the next room that affords the possibility of sitting-on for me if I were to move from my desk chair where I am presently to that room. It is independent of me in the respect that it is in the next room; nothing that I do from here will affect it. But it only exists as an affordance possibility relative to me (or some other person). Contra Berkeley, ‘to be’ is not to be perceived; but rather ‘to be’ is to offer the possibility of being perceived by some individual for whom the environment is taken in relation. An affordance, such as the chair in the example, is defined relative to a prospective individual, but it is not necessarily perceived by that individual at all times. There are always places and features in the environment that are not necessarily in view at a given time. (See, for example, the discussion of sensation-less perceiving above.) The environment to be perceived is *an environment of possibilities* considered relative to a perceiver.

How are we to understand such cases? How does this state of affairs come about? Briefly, the environment, or better the habitat, exists separately from an animal’s actions and experience because the *histories* of each are different. This way of formulating the nature of perceptual experience can be found in William James’ philosophy of radical empiricism (James, 1912; also see Heft, 2001). Immediate experience stems from the intersection of processes in the environment and processes of the perceiver. Referring to the *immediate experience* of a room in which his reader might be located in, William James writes: “the experience is a member of diverse processes that can be followed away from it along entirely different lines. One of them is the reader’s personal

biography, the other is the history of the house of which the room is a part. [That latter history includes] a lot of previous physical operations, carpentering, papering, furnishing, warming, etc” (pp. 173–174). Structure ‘on the environment side’ of relational, immediate experience (i.e., the perceiver-environment relation) is ‘already there’ available to be perceived when taken at the level of analysis of and in relation to a perceiver. Note that the environment, in this passage from James, is identified by following a set of relations away from immediate experience; that is, it is taken relative to the perceiver.

A particular place that an individual enters has already had a prior history that accounts for *why it is as it is* at the moment the individual encounters it (Heft, 2018). Its character is ‘already there’ for an individual who might encounter it; and yet only those features taken relative to a possible perceiver matter from a psychological standpoint. Let’s take the comparatively simple case of a building – and it is simple because we can have a complete understanding of its history. When an individual enters a building, its structure is indeed pre-given in the sense that it was already there upon entering. Why is that? Because designers, clients, contractors, among others, all had a hand in constructing it, and they did so with its intended purposes relative to possible users in mind. Needless to say, intentionally altering environments is an action that all organisms engage in for adaptive purposes (Odling-Smee et al., 2003). How the individual comes to detect the building’s structure, and in the end can find her way around in it as well as utilize its affordances, is a matter of exploration and discovery. Its potential structure taken relative to a perceiver is already available to be perceived. Environments like individuals have a history.

What is the case with a building, which is constructed by human efforts, is also the case with aspects of environments that bear less indication of human intervention – so-called ‘natural environments.’ Because our species lineage evolved in relation to particular features of the environment, such as ground surfaces and graspable objects, environments offer particular possibilities for action for *Homo sapiens*. In a sense these structures do pre-exist – they have a history – when considered relative to our species, but they don’t come into existence when a particular individual is present. They are ‘permanent possibilities’ for perceiving for an individual understood within the framework of ecological optics.

Gibson (1966) points out that the phrase ‘permanent possibilities’ for perceiving is a variation on John Stuart Mill’s hypothesis of the “permanent possibilities of sensation.” But the difference between these two phrases stems from Mill taking sensations as the starting point for an account of perceiving, as I suggest enaction theory does. As a result, “[h]e believed that their grouping constituted the basis for our *belief* in the external world, but this is far from asserting that the possibility of detecting stimulus invariance is the basis for *contact* with the external world’ (Gibson, 1966, p. 223). Does ‘belief’ in this context mirror enaction theory’s notion of sense-making?

The Perceiver’s Contribution

Turning to the second objection cited above that ecological psychology gives short shrift to what the individual contributes to

perception, Varela et al., 1991) argue that this approach “leads to a research strategy in which one attempts to build an ecological theory of perception entirely from the side of the environment” (p. 204). What is found to be missing in ecological psychology from the enaction perspective is a consideration of the organism’s role in perception. This is a common criticism of ecological psychology, although unlike most others, enaction theorists rule out that this role would involve providing non-perceptual mediating additions to the flow of sensory activity. Still, this criticism typically reflects a limited reading of Gibson’s writings, and in particular a cursory reading at best of Gibson (1966).

Most enactivists are familiar with ecological psychology through Gibson’s last book (1979) and later writings by other ecological psychologists; but the truly breakthrough work that launched ecological psychology is *The Senses Considered as Perceptual Systems* (Gibson, 1966). As its title indicates, that book reformulated perceiving conceptualized as a reception of stimulation and the imposition of sensations as instead a process whereby the individual engages an information-rich, structured environment through action. The visual perceptual system, for example, includes, in addition to the retinal receptors and the neural optic tract, the possibilities for action provided by the body (e.g., movements of the eyes, neck, and the entire body). Perceiving is an activity of the body, not merely the sensory tracts. Through perception-action, invariant and perspective structure is revealed that specifies environmental layout and self-movement. That is, *action generated by the individual* plays an essential role in revealing environmental structures, and in doing so supports exploration and discovery. That claim is central to the entire framework of ecological psychology. To assert that environmental psychology attempts to build an account of perceiving “entirely from the side of the environment” overlooks these essential facets of the framework invoked by the concept of a *perceptual system*.

Other and no less important ‘contributions’ on the perceiver side could be pointed to as well, such as changing attunement to available information through *perceptual learning and development*, and actions of directed attention on particular occasions. To take Gibson (1979) as reflecting ecological psychology in its entirety is to fail to take into account a great deal of other literature pertinent to ecological psychology not only by J. J. Gibson and those who followed him, but perhaps most especially, E. J. Gibson’s contributions. Her seminal book *Principles of Perceptual Learning and Development* (1969) – which in my view should be required reading for anyone interested in perception – as well as the later *An Ecological Approach to Learning and Development* (Gibson and Pick, 2001), are rarely mentioned by enaction theorists when criticizing ecological psychology in this vein. As Gibson (1966, p. 271) pointed out, the elaboration of their differentiation theory of perceptual learning (Gibson and Gibson, 1955) which is to be found in Gibson (1969) is an essential facet of the ecological approach. As he plainly indicated, that book “will take up the story where mine leaves off” (Gibson, 1966, p. viii).

Likewise, as Turvey (2019) recently stated about ecological optics, the hypothesis of information as specification “does not constitute a complete theory of perception. At this juncture, our

concerns remain fairly modest and it suffices that we can identify a theory of direct perception as a theory whose distinguishing mark is the [information as specification] hypothesis” (pp. 30–31). What the availability of specifying information accomplishes, paraphrasing Turvey, is to negate the need for psychological factors that either transform or produce perceptual experience, *while still leaving ‘plenty of room’ for how psychological factors might affect how the organism ‘exploits’ available information.* Gibson consistently described the ecological approach as one whose development was on-going. This initial step of framing perceiving as the pickup of information takes us quite far epistemologically, because it would seem to undercut theories that assume perceptual experience to be mediated necessarily by non-perceptual processes, and hence necessarily indirect. But there remains much work to be done from a *foundation* of information-as-specification.

Recall that from the perspective of ecological psychology, perceiving supports adaptive functioning by making it possible for the organism to ‘stay in touch’ with the environment in the course of everyday actions. In the case of tactile perception or touching (as well as tasting), individuals can stay in touch with environmental structures proximally by means of literally feeling and manipulating surfaces. In order to stay in touch with the environment more distally, as is the case with seeing, hearing, and smelling, what is needed is a *medium* that carries structure specifying features at a distance from the perceiver. The essential place of the medium for perceiving from an ecological perspective has no counterpart in enaction theory. Presently, ecological optics is the most well-articulated framework to account for how it is possible that perceivers stay in touch with the environment through vision. Ecological optics and the concept of information-as-specification which requires a medium are critical to ecological psychology’s claim that perceiving even of features quite distant from the body surface is direct, that is, unmediated (For a discussion of the medium in ecological psychology and its antecedents, see Heft, 2001, pp. 225–232; also see, Nonaka, 2020).

In light of the enaction theory criticism of information in the ecological approach, we might ask inversely what makes a particular sensorimotor pattern informative from the enaction perspective? The results of sense-making must have some adaptive relation to the surround in which the system operates. That is, it must be meaningful in relation to the surround, or risk being disconnected from that surround and consequently have questionable adaptive value.

What Makes Sensorimotor Activity Informative in the Enaction Approach?

Our previous discussion of enaction theory was mostly limited to a consideration of the ‘sensory’ facet of sensorimotor structures; and in doing so we omitted a central feature of the approach. To reiterate, proponents of enaction theory are clear that the sensory stream of activity alone is not the basis for perceiving the environment if for no other reason than actions of the individual cause changes in the sensory stream. Consider optic flow. The perceiver must have a means of distinguishing between changes

in sensory activity due to occurrences in the environment, on the one hand, and sensory changes produced through self-action, on the other. Because there is sensory change in each case, i.e., change of retinal stimulation, what makes a particular instance of change *informative* as to its basis? Is it due to movement in the environment or movements of the eyes? From the enaction perspective, embedding sensations in a sensorimotor loop, with the latter considered in relation to a network of related sensorimotor linkages, results in one particular experience to be realized (enacted) for the individual rather than some other.

In order to understand what makes a particular sensorimotor loop *informative*, it must be considered relative to “the set of all possible sensory dependencies on motor states, for a particular type of agent and a particular environment. Whatever specific behavior the agent exhibits, its sensorimotor projections will always be found *within this set*” (DiPaolo et al., 2017, p. 53; emphases added). These authors call this set the ‘*sensorimotor environment*.’ However, we are cautioned that the sensorimotor environment, which would seem to be a state space within the system, “is not to be confused with the environment for the agent” – the latter presumably referring to the character of the surround beyond the boundaries of the system. (Because of this possibility for confusion, it might have been prudent to have utilized terms other than environment and, as we will see, habitat in these instances.)

They go on to distinguish between the ‘*sensorimotor environment*’ and the “*sensorimotor habitat*.” Whereas the former refers to all possible trajectories in this state space, the latter refers to “the set of all sensorimotor trajectories (i.e., movements in a sensorimotor space) that can be generated” by a *particular agent* (p. 54). To do this, one must take into account “internal dynamics’ of the perceiver, in addition to constraints from the sensorimotor environment. “In other words, although the SM environment limits the possible [SM] habitats, there are still an infinite number of ways in which an SM environment can be ‘inhabited’” (DiPaolo et al., 2017, p. 54). Without going into further detail here, which would require a discussion of, e.g., “sensorimotor coordination” and “sensorimotor schemes” (see, pp. 55–58), it will be useful to examine these claims more closely in order to understand what makes any particular sensorimotor activity informative from this perspective. In other words, what makes sensorimotor activity A indicative of circumstance X (e.g., eye movement) or Y (e.g., movements in the environment) in that the visual ‘sensations’ are assumed *the same* in each case?

Any particular instance of a sensorimotor activity is informative relative to that set which could be generated by a particular agent. To return to the object property of sponginess, DiPaolo et al. (2017) ask us to imagine that one is “a worker whose daily task is to sort out 1000s of sponges into soft and hard” (p. 61). As I understand their argument, the present sponge can be identified as soft or hard because of the amount effort employed to depress it and reciprocally the force of return resistance one experiences through tactile sensations *in relation to a prior set of possible sensorimotor patterns.* The present sponge is experienced, for example, as soft but not hard;

and it is so because it is informative as to “what it is not but might have been.” That latter phrase comes from Gibson (1966, p. 245) brief discussion of the concept of information as it is employed in communication theory developed by Shannon (1948). Gibson’s discussion here was an effort to clarify the difference between his concept of information (what we called above following Turvey ‘information-as-specification’) and information as developed by Shannon. Gibson regularly expressed frustration that some critics confused the two. Shannon’s concept of information was adopted and applied to the psychology of perception, most prominently by Attneave (1959) and Garner (1962).

I have not found any reference to Shannon’s ideas in my admittedly selective examination of the enaction literature; but the manner in which DiPaolo et al. (2017) treat the role of sensorimotor activity in sense-making – e.g., the realization of one sensorimotor pattern within a set of sensorimotor trajectories – appears to be similar to that line of thought. To explain, Shannon’s influential treatment of information was developed post WWII for the field of electronic communication. The prototypical problem for communication theory is how a signal transmitted by a ‘sender’ that is informative of something, as opposed to, e.g., mere ‘noise,’ can be recognized by a ‘receiver.’ Imagine an individual (sender) speaking into the microphone of a telephone, and a listener (receiver) camped out at the other end of the line. Absent any pre-established background structure in the receiver relative to the signal being sent (e.g., the receiver doesn’t speak the same language as the sender), the signal would be uninformative. But with some pre-established background structure on the part of the receiver, a signal can be recognized as being informative at the receiver end. According to Shannon information theory, this is done not by registering the signal as such because, as we saw in the case of a language, some background is needed on the receiver side of things. Instead, the signal is rendered as being informative by ruling out what it isn’t with respect to some prior background (i.e., what is already known.) What makes a signal informative is that it rules out *prior* possibilities as to what it could be. In other words, and critically, that which is informative reduces uncertainty for an individual.

How are we to understand this difference in how ‘what is informative’ is treated in ecological psychology and enaction theory? We already tried to ground information qua ecological psychology in an analysis of structure through ecological optics taken in relation to a perceiver. What about the enaction approach? The latter like most 20th century perception theories appears to assume that organisms operate in a psychological domain of possibilities. The sensorimotor environment is the set of “sensorimotor projections” within which a particular behavior exhibited by an agent on any particular occasion will be found. This set is narrowed further when the individual’s “internal dynamics” are added into the account, resulting in a sensorimotor habitat. Perceiving qua sense-making appears to be realized in relation to this background set of possibilities. What is perceived is realized among a set of other different possibilities within a particular domain.

(Although it is not to be minimized, we set aside here the important question of the origin of the background possibilities – the SM environment – against which a particular sensorimotor correspondence is assessed. If the informative character of a particular sensorimotor activity is established relative to a field of possibilities, how does that field of possibilities itself come about? One cannot merely assume that the necessary background for rendering an instance of sensorimotor activity is in place without explaining its origins. Articulating the requisite developmental history is needed. I cannot speak to how adequately enaction theory carries this out.)

In contrast, and as we saw above, from an ecological perspective, the perceiver engages a surround that, in principle, has infinite nested informational structure; and continuing exploration may reveal ever greater subtleties or higher-order patterns in any particular domain. On-going discovery of ever finer structures is, for example, the basis for connoisseurship in some area of activity. The training of a sommelier (a wine expert), for instance, consists of hours and hours of comparative wine tasting, in the course of which distinctive relational differences *in* the chemical make-up of the wine are revealed to the perceiver. To reiterate, the differences are to be found *in the wine*, and reciprocally, with continued exploration, the taster’s acuity is heightened. As Gibson (1969) proposed, what differentiates A from B is a relational difference, and that difference is discoverable through exploration of the array of available information.

For their part, enaction theorists criticize ecological psychology on the grounds that “*the origin* of the particular motor patterns that bring about the invariant revealing transformations is not always considered relevant; instead, what matters in many case is simply *the structure of movement-induced flows*” (DiPaolo et al., 2017, p. 74, emphasis added). But, to continue the example above, acts of discovery through wine-tasting do not involve merely imbibing and allowing the movement of liquid to flow across receptors surfaces. Swirling the wine in one’s mouth and other acts of exploration in order to reveal its informational structure are critical (Gibson, 1966, pp. 138–144). The actions are relevant for the purposes of perceptual differentiation and discovery, but “origins of the particular motor patterns” in this case would not seem to be.

What accounts for the route taken in enaction theory, or at least, by DiPaolo et al. (2017)? Why treat a given sensorimotor pattern as being informative relative to a set of possibilities? My supposition is that it is traceable to the concern raised in the first part of this paper – their reliance on sensations, even when embedded in sensorimotor activity, on which to develop an account of perception. Sensations tend to be equivocal in relation to their environmental sources. The environment, as a consequence, is in principle an unknowable Kantian “thing-in-itself.” But an unknowable world for Kant was world of apart from human experience, and a pre-Darwinian one at that – not a habitat from the point of view of the ecological sciences with which organisms need to ‘stay-in-touch.’ The best one can do from an enaction stance is to ‘enact’ a perceived world through sense-making, but that would seem to put the perceived world ‘within’ the organismic system.

System Boundaries and the Region of Exchange

One of the requirements that marks agency in a biological structure, according to DiPaolo et al. (2017), is “system individuation.”

“The enactive approach suggests that agents are systems that *actively define themselves as individuals* and may be identified as such without arbitrariness. Only systems that manage to sustain themselves and distinguish themselves from their surrounding, and in so doing define an environment in which their activity is carried out, are considered as candidate agents in this approach” (p. 112).

This point of view is certainly one that would be congenial to the ecological psychology perspective, although the way it is further developed within each approach adds to a divide between them.

To account for system individuation, DiPaolo et al. (2017) invoke the notion of *operational closure*, which refers “to a network of processes whose activity produces and sustains the very elements that constitute the network” (p. 112). The interdependencies among the system’s constituents give rise, as a matter of course, to a boundary that distinguishes this network of interrelations from those things that lie outside of it. “[T]he boundaries between an autonomous system and its environment emerge as a result of how an autonomous system is organized” (DiPaolo et al., 2018, p. 27).

That said, it is obvious to enaction theorists that the system cannot be wholly independent of the surrounding environment. Because it is a far-from-equilibrium system, it must remain sufficiently open to the surround to allow needed resources beyond its boundaries to participate in the necessary workings of the system. At the level of cells, we find semi-permeable membranes that allow, e.g., nutrients to enter into the system to participate in and maintain its functions. Critically for our purposes here, there is *region of exchange* between the environment and the system; and that region is where the organism ‘ends’ and the environment ‘begins.’ In this biological case of the cell membrane, that region of exchange is *proximal* – at the physical body boundary.

When we shift our level of analysis from the cell to the organism as a whole, and adopt a higher-order *psychological* focus, we also find some instances of a proximal region of exchange between the organism and the environment, as in the case of tactile perception (see above). But also, and particularly striking, are those commonplace experiences when *the region of exchange* between the organism and the surround is experienced as being located at places distant from the physical body boundary. In those cases, the body is experienced as being extended *distally* into the environment.

To offer two obvious examples: when individuals use a tool, such as a stick to probe a surface or a screwdriver to tighten a screw, they invariably report that the environment is experienced as beginning at the end of the tool – at the surface and at the screw notch, respectively – and that *the body is experienced as if it extends to that point*. Exchanges with the environment as

mediated by tools are typically reported as being felt at some distance from the biological boundary of the body.

With their roots partially in phenomenological writings, both ecological psychology and enaction theory recognize this phenomenon. But how readily can each approach begin to account for it? DiPaolo et al. (2017) differentiate in an *ad hoc* manner among different levels of complexity of sensorimotor agency, from those of “minimal sensorimotor engagement,” such as habits, to “open sensorimotor agency” whereby “sensorimotor agents have the adaptive capacity to learn new sensorimotor schemes and integrate them in the overall network” (p. 170). This latter integration would seem possible in their account because the system is open to temporary ‘enabling relations’ with factors outside of it. Notably, however, *these factors do not enter into the system’s interdependencies*. Although they “do not belong to this network [they] enable processes within the network; but they remain external because they themselves do not depend for their operation on processes in the system” (DiPaolo et al., 2018, p. 25).

However, if these temporary enabling relations do not belong to the network of system interdependencies, how can an enaction account of perception go beyond the boundaries of the system in the ways that *the experience of tool use* suggests? As we just saw, enabling relations only serve “to enable processes within the network.” Can these enabling relations function to extend the network experientially? Presumably, it is assumed that they can, but how they might do so is not explained. Most important for our discussion, by setting ‘enabling relations’ outside of the network system, the primary unit of analysis that is in evidence here is the individual system rather than an organism-environment relation.

An alternative way of conceptualizing the experience of the extended body that accompanies tool use is to adopt a relational view with the organism-environment as our unit of analysis. The network of interdependencies at work would encompass the organism and the environment as coupled features on any particular occasion. The animal-environment relation is the unit of analysis for ecological psychology; and it is characteristic of the focus inherent in the ecological sciences rather than biology as such.

The study of ecology takes the organism in relation to a system of environmental interdependencies. Enaction theory while recognizing the tight interdependencies within the organismic system seems to underplay the interdependencies of an organism-environment system. Conceptually in the ecological sciences, what is needed from the standpoint of an organism’s functioning is a means of ‘staying in touch’ with circumstance in its habitat. Over the course of species’ evolution, perceptual systems were selected for in order to make this possible. These perceptual systems offered a selective advantage for organisms because by means of them, they could exploit the information that was available in the surround in order to maintain the necessary *coupling* between on-going environmental change and dynamic organismic processes.

Turvey (2019) points out: “what makes a theory of perception a theory of direct perception at its most fundamental level is an enriched entailment structure” (p. 40). By the latter he

means an account of the information available to be detected that specifies the environment. In spite of enaction theory allowing for so-called ‘enabling relations’ between the system and factors external to it, in the absence of an account of the environment from an ecological perspective, and available information to specify the environment, is hard to imagine how the enaction approach can account for the experience of the extended body other than merely stating that it is enacted, and leaving the matter at that. A *coupling* between on-going environmental change and dynamic organismic processes requires an entailment structure on the side of the environment, as just noted.

Holt (1931), a student of William James and one of Gibson’s graduate school mentors (Heft, 2001) proposed that every action of an organism has a quality of ‘adience’ by which he meant the quality of ‘reaching toward’ a source of stimulation – that is, it has a quality of external reference. That sort of intentional stance is shared by both enaction theory and ecological psychology. But Holt goes a step farther and helps set the stage for the relational stance of ecological psychology by arguing that these actions can only be adequately described with reference to factors outside of the organism beyond the body boundaries (Holt, 1915). In this way distant features function as *constituents* of action. They are enfolded within the action itself. According to Holt, it is only when we recognize the adient quality of action that we are led *from the study of biological processes to the study of psychological functions* (Heft, 2014).

Arguably, however, sensory activity (in sensorimotor activity) cannot conceptually ‘carry’ the properties of ‘distant objects’ (see above), and for this reason, those ‘distant objects’ cannot function as ‘constituents of the behavior process’ from an enaction perspective. Organismic processes accordingly seem to remain encapsulated within system boundaries. In contrast, Holt offers a relational perspective: “The knower is a concrete material body in a concrete material environment and the cognitive relation exists between the two” (Holt, 1931, p. 51).

A relational view requires an account of ‘both sides’ of the environment-person duality. In Gibson’s ecological approach, his formulations of ecological optics, on the one hand, and perceptual systems, on the other – both of which are introduced in Gibson (1966) – make a relational perspective for psychology feasible. An account of the potential ‘environment’ side of the relation allows us to take our *psychological* analysis beyond the organism considered solely with respect to its *biological* boundaries.

CONCLUDING COMMENTS

It has been argued that ecological psychology and enaction theory, in spite of their considerable commonalities, remain at variance because of differences over several basic issues: first, the role that sensations play within each approach differs, with enaction theory taking these products of receptor activity to be the initial basis for ‘contact’ with the surround, while

ecological psychology considers sensations as being incidental at best for perceiving.

Second, they differ in the manner in which each treats the concept of information, with enaction theory seemingly conceptualizing information in a manner similar to that employed in Shannon’s account of communication, with its model being a sender and a receiver in possession of possible states of realization; while information within ecological psychology refers those structures in the medium for perceiving that specify properties and features of the environment (i.e., information-as-specification). The latter meaning of information stems from Gibson’s development of ecological optics. Criticisms of ecological psychology from the point of enaction theory often reflect a failure to recognize the place of ecological optics in this approach.

Third, the way in which each approach conceptualizes the organism’s boundaries differ. Enaction theory’s focus on ‘system individuation’ gives rise to an emphasis on the organism’s boundary that distinguishes its network of interrelations from those things that lie outside of it. This image stems from considerations at a biological level of analysis such that individual systems, such as a cell, while dependent on exchanges with the surround, are considered mostly apart from it. Ecological psychology adopts as its unit of analysis the organism-environment relation in keeping with the orientation of the ecological sciences. From that perspective, the boundary or region of exchange between the organism and the environment – that is, where the organism ‘ends’ and the environment ‘begins’ – is fluid on functional and psychological grounds.

The common thread running through all of these differences is, in fact, the first one – the place of ‘sensations’ in ecological psychology and enaction theory. Recall that it was the conceptual inadequacies of sensations for developing an account of perception that eventually led Gibson to reject sensation-based approaches to perception and in their stead to offer an information-based approach. From this historical vantage point, enaction theory in spite of its valuable incorporation of new ideas from dynamical systems thinking for perceptual theory, brings along with it old ideas that have not served perceptual theory particularly well in the past.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Ecological Psychology and Enactivism: Perceptually-Guided Action vs. Sensation-Based Enaction¹

Catherine Read^{1,2*} and Agnes Szokolszky³

¹ Plant Biology, Rutgers University, New Jersey, NJ, United States, ² Department of Psychology, Ithaca College, New York, NY, United States, ³ Department of Cognitive and Neuropsychology, Institute of Psychology, Szeged University, University of Szeged, Szeged, Hungary

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*Correspondence:

Catherine Read
ceread@sebs.rutgers.edu

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Ecological Psychology and Enactivism both challenge representationist cognitive science, but the two approaches have only begun to engage in dialogue. Further conceptual clarification is required in which differences are as important as common ground. This paper enters the dialogue by focusing on important differences. After a brief account of the parallel histories of Ecological Psychology and Enactivism, we cover incompatibility between them regarding their theories of sensation and perception. First, we show how and why in ecological theory perception is, crucially, not based on sensation. We elucidate this idea by examining the biological roots of work in the two fields, concentrating on Gibson and Varela and Maturana. We expound an ecological critique of any sensation based approach to perception by detailing two topics: classic retinal image theories and perception in single-celled organisms. The second main point emphasizes the importance of the idea of organism-environment mutuality and its difference from structural coupling of sensations and motor behavior. We point out how ecological—phenomenological methods of inquiry grow out of mutualism and compare Gibson's idea of visual kinesthesia to Merleau-Ponty's idea of the lived body. Third, we conclude that Ecological Psychology and varieties of Enactivism are laying down different paths to pursue related goals. Thus, convergence of Ecological Psychology and Enactivism is not possible given their conflicting assumptions, but cross-fertilization is possible and desirable.

Keywords: Ecological Psychology, Enactivism, direct perception, sensation based perception theories, retinal image theory, ecological mutualism, James J. Gibson, Francesco Varela

The seemingly paradoxical assertion will be made that perception is not based on sensation. That is, it is not based on having sensations... but it is surely based on detecting information.

James (Gibson, 1966)

...partly because of the difficulty of Merleau's rhetoric..., and partly because he needed a theory of perception that didn't then exist and now does, I have concentrated rather on trying to understand and expound Gibson than on trying to bring the American and the French thinker together.

Marjorie (Greene, 1995)

INTRODUCTION

After a brief account of the parallel histories of Ecological Psychology and Enactivism, we cover three main points about the relations between them. First, perception is distinct from sensation.

¹ Publications by Dent, C., Dent-Read, C. and Read, C. are by the same author.

This idea is elaborated by examining the biological roots of work in the two fields, concentrating on Gibson in Ecological Psychology and Varela and Maturana in Enactivism. We cover critical assumptions about perception and about methods of study. The second main point emphasizes the importance of the idea of organism-environment mutuality, and the differences between the ecological idea of mutuality and the enactivist idea of autopoiesis or self-creation. Third, we conclude by contrasting the two approaches, pointing out areas that each has yet to develop. We conclude that a convergence of Ecological Psychology and Enactivism is not possible given their conflicting assumptions, but that cross-fertilization is possible and desirable.

Ecological Psychology is the oldest radical challenger of classical representationist cognitive science with its seven-decade-long history. The germinal books for this approach are James J. Gibson's *The Senses Considered as Perceptual Systems* (1966) and *The Ecological Approach To Visual Perception* (1979, 2015). During these decades (between the 1970's and the 1990's) ecological psychologists kept elaborating, theoretically and empirically, its core idea: that perceiving—acting organisms are in direct epistemic contact with their environment via ecological specification and affordances. In the meantime, Ecological Psychology has branched out from its core experimental studies on action and perception into diverse contexts including human development, movement science, social dynamics, ecological robotics, and other cognitive topics such as language and metaphor use.

The enactive approach is based on work by Maturana and Varela (1988), and was succinctly articulated for the wider audience in the early 1990's, in the germinal book *The embodied mind: Cognitive science and human experience* by Varela et al. (1993). In this book Varela et al. launched their own challenge to the cognitivist paradigm, with the core idea that cognition is an embodied, lived process, based on self-organizing and recurrent sensorimotor patterns. Enactivism quickly became influential, and gradually three main versions appeared: autopoietic, sensorimotor, and radical enactivism (cf. Ward et al., 2017). However, they all are conceptual descendants of the enactivist program, as defined by Varela et al. (1993).

In *The embodied mind* Varela et al. acknowledged, but also firmly criticized, Ecological Psychology claiming that Gibson understood environmental structures as objective, pre-specified properties to which the organism must respond (Varela et al., 1993, pp. 203–204). Clearly, this was a one-sided and largely inaccurate reading of Gibson's theory, as pointed out later by others (e.g., Fultot et al., 2016), and it disallowed taking the Ecological program as a partner to engage with. Not until recently did representatives of Ecological Psychology react to this criticism and engage in discussion with Enactivism. Perhaps a “a full-blown” post-cognitivist science of the mind might need both ecological and enactivist insights (Heft, 2001; Chemero, 2009; Rietveld and Kiverstein, 2014; van Dijk et al., 2015; McGann, 2016; Hutto and Myin, 2017; Bruineberg et al., 2019).

An important step was a dialogue in the 2016 Special Issue of *Constructivist Foundations*. The target article by Fultot et al. pointed out the misreadings of Ecological Psychology by Varela et al. and critiqued Enactivism on the basis of being, in the final

analysis, internalist and concluded that enacting a world seems to be “constructivism in the most traditional sense” (par.50). Now it was on the enactivist side to claim this as an “uncheritable” reading (Stapleton, 2016).

Difficulties for clarification abound as neither Ecological Psychology nor Enactivism comprises a fully developed, homogeneous set of views. As apparent in recollections by ecological scientists², in the early decades of Ecological Psychology cognitive science presented a hostile cognitivist environment. Under these circumstances Ecological Psychology focused “inwards” and worked on turning basic insights by James J. Gibson into a full blown theory of action and perception and workable empirical research programme.

In the exchanges between Ecological Psychology and Enactivism some significant questions and critiques have surfaced on both sides. In a simplified summary, the major questions about Ecological Psychology on the enactivist side are the following (based on the target article and the commentaries in 2016 Special Issue of *Constructivist Foundations*): (1) Ecological Psychology puts too much load and emphasis on symmetry principles in organism—environment mutuality; (2) Thereby Ecological Psychology does not do justice to the autonomy, subjectivity, perceptual consciousness, historicity of the agent side, which is necessary to account for an active agent with a self; (3) In Ecological Psychology descriptions of the environment (affordances, specification) refer to pre-existing structures that are not dependant on experience and, therefore, are not truly relational; (4) Ecological Psychology ignores the subpersonal level of emergent processes, that is, the level of the physical basis of perceptual experience (on the distinction between personal and subpersonal see Thompson and Cosmelli, 2011; Roberts, 2018). The major questions on the ecological side are the following: (1) Enactivism embraces subjectivity and constructive processes and thereby opens up the door to dualism; (2) Enactivism takes sensorimotor functioning as the starting point which retains the idea of the “poverty of the stimulus” and does not explain how meaning emerges from something non-meaningful; (3) Thereby Enactivism also fails to establish how the organism/agent is in direct epistemic contact with its environment; (4) Enactivism does not treat the organismic level as a distinguished level of analysis, and, thereby, does not satisfy truly ecological mutualism.

Issues and questions exist, however, not just concerning the “other side,” but also about “own sides.” Fundamental questions are still being tackled within each framework. Versions of Enactivism lay out different ideas about agency, embodiment, or sensorimotor contingencies (cf. Ward et al., 2017). Whereas within the framework of Ecological Psychology serious discussion continues regarding the interpretation of such fundamental concepts as the environment, information, and

²Interviews with Eleanor Gibson (Szokolszky, 2003), with Ulric Neisser (Szokolszky, 2013); further unpublished interviews by Agnes Szokolszky conducted in 1997, with Rober E. Shaw, Michael Turvey, Nancy Rader, Claudia Carello, William M. Mace, Reuben Baron, David Lee, Alan Costall, Sverker Runeson, Claes von Hofsten, and Gunnar Jansson.

affordances (see e.g., Chemero, 2009; Read and Szokolszky, 2018; van Dijk and Myin, 2019).

We take the above questions as opportunities for reflection. Earlier we briefly discussed the Enactivism-Ecological Psychology relationship (cf. Szokolszky et al., 2019). We highlighted basic strategic and conceptual differences in their ways of explaining animal–environment mutuality; however, we concluded that a dialogue benefits both parties. This time we continue the dialogue by focusing on some of the ecological questions about Enactivism, but also on some critical questions related to Ecological Psychology.

In this paper we focus on two main points of difference between Ecological Psychology and Enactivism. Our first main point is to emphasize that perception is not sensation-based. We will elaborate the argument against sensorimotor capacities and contingencies as the foundation for a psychology of perceiving and knowing. Along with others committed to Ecological Psychology we claim that this is a fundamental point of difference that needs to be squarely addressed (cf. Szokolszky et al., 2019). We agree with Michaels and Palatinus (2014, p.19) that Ecological Psychology comes “as a package deal”: the major principles of Ecological Psychology are “deeply connected and intertwined. To subscribe to some and discard the others always entails contradiction.” We elaborate this distinction between perception and sensations by examining the biological roots of work in the two fields, concentrating on Gibson in Ecological Psychology and Varela and Maturana in Enactivism. Here we go over two prototypical topics: the retinal image theory of vision, and perception by single-celled organisms. We cover critical assumptions about perception and about methods of study.

The second main point emphasizes the importance of the idea of organism-environment mutuality and how it is more than organism-environment interaction or coupling. Ecological Psychology has developed the concept of mutuality and Enactivism has focused on individuals (usually conscious human beings) interacting with the world. These two concepts are radically different and should not be confused.

In the final analysis, we conclude that the concepts of sensorimotor action, -agent, and -life are profoundly different from the concepts of ecological action, -agent and -life. These profound differences must be recognized and acknowledged. This does not mean, however, that there is no point to the dialogue. Both Enactivism and Ecological Psychology are developing enterprises that still need to give elaborate answers to questions regarding brain level processes, knowing and feeling, consciousness, and phenomenological experience. Ecological Psychology has a coherent account of contact with the environment, however, the role of experience in perceiving/acting, or even the importance of experience, has not been developed in ecological work to date (see related points in Kadar and Effken, 1994, 2006). This even though Gibson drew on experiences (that anyone with a functioning perceptual system can share) to develop his theory of how the structure of the surround is detected³. Enactionism draws heavily

on phenomenology, but its assumptions on the sensorimotor foundations of agency are not compatible with Ecological Psychology. The paper concludes that the goal is not to seek convergence, but to keep attending to each other and leaving open the possibility for potential cross-fertilization.

FIRST MAIN POINT: PERCEPTION IS NOT BASED ON SENSATION

A fundamental difference exists between Ecological Psychology and Enactivism regarding the interpretation of the role of sensation and perception as the foundation for action. Although they both share an emphasis on action, Enactivism takes sensorimotor capacities and contingencies as the basis for action, whereas for Ecological Psychology perception is not constituted by sensation and, therefore, perceiving/acting based on affordances of the surround is the cornerstone of cognitive functioning. Therein lie deep differences in the concept of “enaction” and ecological perception/action.

Varela et al. (1993) claim (p. 173) that enaction means that: (1) perception consist of perceptually-guided action; and that (2) cognitive structures emerge from the recurrent sensorimotor patterns that enable action to be perceptually guided⁴. On the other hand, Gibson claims that having sensations is not perception, rather, perception is the functioning of perceptual systems that include the whole organism. Clearly, these are two thoroughly opposing views. At stake is the very foundation on which a viable alternative to representationism can be built. Why and how the two approaches come to build on these different foundations and what are the consequences? This is a complex question that needs attention.

Both approaches have roots in biology, but their starting points and paths of development are diametrically opposite. We are looking for answers by exploring the biological roots of enactive and ecological explanations.

The Biological Roots of Direct Perception Ecological Explanations and Sensation Based Enactive Explanations

The roots of the ecological approach to perception (Gibson) and the embodied approach to the mind (Varela and Maturana) extend into biology, but in very distinct ways. In the service of understanding the contrasts and relations of these two approaches we now briefly compare the biological basis and assumptions of the two theories by considering early work in biology by Varela (1997) on patterns of life and by Maturana et al. (1960), Maturana et al. (1960) on vision in the frog. In contrast, we review work by Gibson (1979) countering the retinal image theory of perception and by Pittenger and Dent (1988) on a direct perception account of bacterial chemotaxis.

(1982), for accounts of some aspects of phenomenology in relation to Ecological Psychology.

⁴It is Sensorimotor Enactivism (Ward et al., 2017) in the first place that elaborates these points in the most detail. However, sensorimotor explanations are endorsed by other enactivist theories as well.

³For example, the decisive test of reality is whether one can discover new details by scrutiny (1979, p. 257). See Kadar and Effken (1994, 2006), and Glotzbach and Heft

Varela equates living organisms with living systems and, consequently, gives organisms the qualities of what he defines as natural systems. Organisms are a process of constituting an identity and identity refers to coherence; identity is not a structure, but a process, and it is not mentalistic or personal (Varela, 1997). In describing autopoiesis, Varela takes the example of the bacterial cell which has the capacity to produce all the components that comprise a distinct, bounded unit. How a natural system differentiates is not considered, nor is reproduction. The latter is seen as a process that is an “added complexity superimposed on a more basic entity” (p. 75).

Note the contrast to Gibson’s (1979) focus on what might be called “conditions of life.” Gibson begins with a perceiving organism, not a natural system, and especially not one that is self-made. If one starts from the point of view of a system, and the formal logic of systems, then the organism tends to become “just” a system, or an aspect of a system. If one starts with the organism, then how it moves, lives, reproduces, and dies in its conditions/surrounds leads to different research questions (e.g., Sheldrake, 1981; Gilbert and Sarkar, 2000). The organicist approach leads to questions of mutualism, adaptation, and affordance, however those are defined. And it leads to very different questions and assumptions about perception.

Maturana, who researched the frog visual system, is an example of a theorist who accepts and assumes the mentalist account of perception (e.g., Lettvin et al., 1959; Maturana et al., 1960). Some of the assumptions about perception that the researchers hold are evident from their description of the process of frogs seeing and catching prey. For example, frog vision is described as using visual clues, that the objects toward which the frogs act have certain features, such as movement, size, contrast, color. The analogy to human reading is used to characterize frog recognition of appropriate prey:

“Just as we are able to read and to recognize shapes under the most varied conditions, so are frogs able to see their prey and to feed upon it under the bright light of midday or under the twilight of morning or evening, whether this be in their natural environment or in a small cage in the laboratory” (Maturana et al., 1960, p. 129).

They ask how a frog recognizes prey or enemy and assert that:

“To survive, a frog needs to react rapidly, either to catch a prey or to escape an enemy. To do this, the pattern of light and dark that is the original image formed on the retina has to be analyzed, sooner or later, to select it the features which define the universals” (Maturana et al., 1960, p. 1).

This constitutes a straightforward and clear statement of the retinal image theory of vision, a theory that is assumed to pertain to any organism with (chambered) eyes. How does this theory with its set of assumptions about what constitutes perception coordinate with the type of studies conducted and the conclusions drawn from the studies? The authors argue that if the retina “performed the analysis” behavior could be quicker and more adaptive. “Thus, for anatomical reasons, the retina should be expected to perform the first step in the analysis of

the visual image and to transmit the abstracted information to the visual centers” (p. 130). Therefore, the retinal cells are “mapped” for their patterns of activation in terms of a binary “on/off” logic. One conclusion from the detailed and complex results of the anatomical studies is that the retina is the first point of “transformation” by summing, and so forth, of the image. (Perhaps this move is way of doing away with the problematic “image” as soon as possible?).

Does this approach to perception persist in later work on embodied cognition (e.g., Maturana and Varela, 1980, 1988; Varela et al., 1993)? Maturana and Varela (1980, 1988) analyze living systems, as opposed to organisms, let alone animate organisms that perceive and act. Living systems are defined as units of interactions that exist in an ambience. Living systems cannot be understood independently from that part of the ambience with which they interact (the niche) nor can that part of the ambience be understood independently of the living system that defines it. The living system is seen as hierarchical, that is, the first order system is made up of cells, the second order of organisms, and the third order of organizations of organisms. “Reproduction and evolution are not essential for the living organization” (1988, p. 11). Cognition is defined as the acting or behaving in the domain of interactions in which a system can act to maintain itself. Living is a process of cognition, whether the system includes a nervous system or not. Living systems have internal states that can be changed relative to the maintenance of the system, that is, to maintenance of its identity. Sensors of an animal are modified by physical events, but a nervous system allows the internal states to be modified by “pure relations” viz.,

“The nervous system expands the cognitive domain of the living system by making possible interactions with ‘pure relations’; it does not create cognition.” (Maturana and Varela, 1988, p. 13).

On this account perception is defined as based on physical changes in sensors (the subpersonal) that then are somehow acted upon as internal states. In more general, i.e., less technical terms, living beings are continually self-producing and cell metabolism is the clearest example of this phenomenon (Maturana and Varela, 1988). Consequently, perception is defined as sensation-based, for example, in the case of a frog seeing and targeting a fly as prey. On this view there is an internal correlation between “the place where the retina receives a given perturbation and the muscular contractions that move the tongue, the mouth, the neck, and, in fact, the frog’s entire body.” (p. 126). This “correlation” is termed “sensorimotor coordination.” As applied to single-celled organisms, e.g., amoebae, this idea leads to descriptions of the formation of a pseudopod and the consequent movement of the cell toward a protozoan in terms of chemical changes at the surface of the membrane of the cell and the maintenance of an “*internal correlation* between the degree of change of its membrane and those protoplasmic changes we see as pseudopods.” (italics in the original) (p. 147). On this view, the amoeba when engulfing and digesting a protozoan is an example of what Varela (1997) described as the simplest living system (see above). It is safe to say that this early sensation-based approach by Maturana persists in later works.

A next step, chronologically, was to take the phenomenological definition of perception as *reflection upon experience*, and to follow Merleau-Ponty in taking this reflection to *create* the relation between self and world (Varela et al., 1993). Thus, experience of one's own body in the world becomes the basis of "embodied action." For enactivists, sensory and motor processes are equated with and taken as defining perception and action. And it is claimed that perception consists in perceptually guided action and that cognitive structures emerge from the recurrent sensorimotor patterns that allow perception to guide action (Varela et al., 1993, p. 173) (cf. frog vision and prey capture). Therefore, "the reference point for understanding perception is no longer a pregiven, perceiver independent world but rather the sensorimotor structure of the perceiver (the way in which the nervous system links sensory and motor surfaces)" (Varela et al., 1993, p. 173).

We are using these quotations in order to be able to point out the contrasts—and later also possible connections—with the ecological approach to perception. Next, however, we focus on the ecological critique of sensation-based functioning—a cardinal point for James Gibson and subsequent researchers.

The Ecological Critique of Any Sensation Based Approach to Perception

Does sensorimotor coordination equal perceptually-guided action? The answer from Ecological Psychology is "no." In both the 1966 book on *The Senses Considered as Perceptual Systems* and the 1979 book on *The Ecological Approach to Visual Perception*, Gibson endeavored to lay out the differences between the senses as physiological processes and perception as the active resonance to an actual surround. We will use his critique of the retinal image theory of vision as a example of the contrast between functioning of the senses and what he called direct perception. First we examine retinal image theories briefly.

Classic Retinal Image Theories and Gibson's Rejection

The retinal image theory is a specific case of a general set of assumptions about the perception of the world that limit perception to operations on the "products" of the senses, and therefore, assume that only sensations (with cognitive transformations) are perceived. We briefly refer to George Berkeley and Ernst Mach as classic formulators of the retinal image theory of vision. In the retinal image tradition Berkeley (1709) assumes that objects in the environment are taken by perceivers to be of determinate size and place, even though the "visual appearance" continually changes, here the visual appearance means a visual image that is assumed to be cast on the retina (cf. Maturana, see above). Mach, in the *Analysis of Sensations* (1897), stated:

"Colors, sounds, temperatures, pressures, spaces, times, and so forth, are connected with one another in manifold ways; and with them are associated dispositions of mind, feelings, and volitions. Out of this fabric, that which is relatively more fixed and permanent stands prominently forth, engraves itself on the

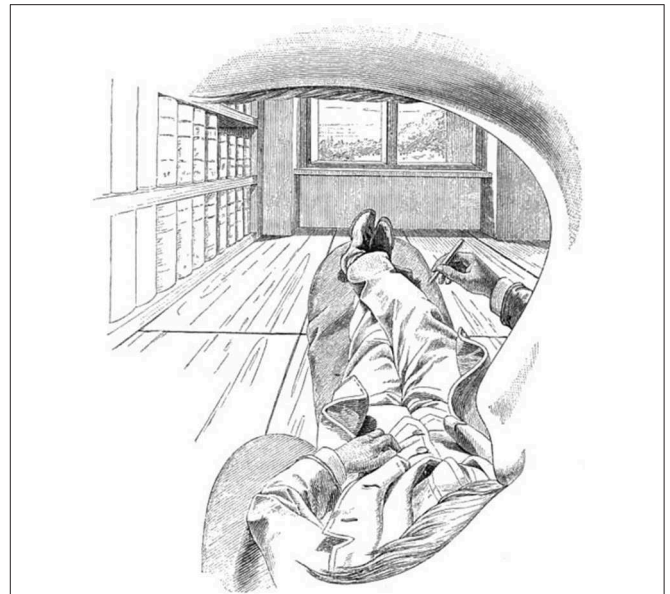


FIGURE 1 | Ernst Mach Self Portrait (public domain). The assertion then is correct that the world consists only of our sensations (Gibson, 1979, p. 10).

memory, and expresses itself in language." (Mach, 1897, p. 1) See **Figure 1** above.

Modern assumptions about vision, in both biology and psychology, are captured in **Figure 2** below. The basic account is that there is a causal line from light rays and lenses to points on a tissue of retinal cells, to firing patterns in nerve and brain, to experience. Enactivist approaches critique the idea of a linear causal chain, and instead use the idea of embedded levels of circular self-sustaining activity. Although that move does away with mental processing as a step somehow separate from brain activity and before perceiving, it accepts, however, the basic assumptions of retinal image theories, as we have seen above. Therefore, we are justified in laying out the deeper critique of retinal images that J.J. Gibson presented.

Gibson claims that the puzzle of rearranging, or correcting, or interpreting the messages of the retinal points is insoluble⁵. He offered ecological optics to provide a new starting point for a theory of perception based not on form-sensations (or perceptions) from the retina, but on information pickup from the ambient light (Gibson, 1968 see footnote 5). The use of the idea of "information" brings certain problems⁶, but at this point we are

⁵"In the modern use of the retinal image theory the connections of the neurological image, or the responses made to the units firing, determine the conscious perception, not the image itself." (Gibson, 1968, *The Puzzle of the Retinal Image*, available at www.trincoll.edu/depts/ecopsyc/perils). See also, Gibson (1972).

⁶The term "information" introduces a complex conceptual tangle that we prefer to avoid. Gibson used the term in a distinct way, which was so different from other uses that it invites confusion. If perception is ongoing over time, and consists of resonance to invariants in structured arrays, then it cannot be based on either bits of code that reduce uncertainty (Shannon), or messages from the stimulus that are somehow processed and decoded to reveal the world (information processing cognition). Information in the direct perception sense also cannot be "sensorimotor" activation, as argued herein. Resonance is an active process, a single dynamic process of seeking invariants and performing goals (cf. Kadar and Effken,

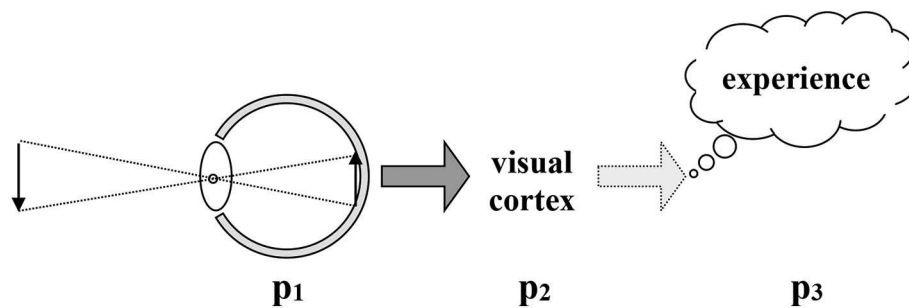


FIGURE 2 | Traditional causal chain in vision Drawn by Robert Shaw, used with permission.

tracking the ecological critique of the idea of a retinal image as it was presented at various times in work by J.J. and E. J. Gibson.

The ecological approach to perception assumes that the inputs of sensory nerves are incidental to perception because perceiving takes place by the action of perceptual systems that function as the whole organism acts in its surround (Gibson and Gibson, 1972). By 1979 Gibson had articulated the fallacy of the image in the eye:

“Ever since someone peeled off the back of the excised eye of a slaughtered ox and, holding it up in front of a scene, observed a tiny, colored, inverted image of the scene on the transparent retina, we have been tempted to draw a false conclusion. We think of the image as something to be seen, a picture on a screen. You can see it if you take out the ox’s eye, so why shouldn’t the ox see it? The fallacy ought to be evident... The question of how we can see the world as upright when the retinal image is inverted arises because of this false conclusion. All the experiments on this famous question have come to nothing. The retinal image is not anything that can be seen. The famous experiment of Stratton (1897) on reinverting the retinal image gave unintelligible results because it was misconceived” (Gibson, 1979, p. 62).

The idea that the retinal image is the basis of vision is only a hypothesis. There are not just logical problems with the idea, but empirical ones. Organisms without chambered eyes nevertheless do see (e.g., insects). We would add that the idea of a retinal image is only possible given the Cartesian/Newtonian accounts of light and optics.

In contrast, Ecological optics focuses on the level of the whole organism living and acting in its natural surround, and the structured arrays (in light, sound, pressure) that are consequences of the structure of the surround. These arrays are what perceptual systems are sensitive too, which allow the organism to detect, coordinate with, and change its surround as the organism goes through its life over time. Gibson, in the case of vision, describes light-filled spaces, that is, ambient arrays, structured by the surfaces, layouts, objects, and events in the

organism’s surround, including other organisms. The ambient structured stimulation available in the sea of energy around us is quite different from signs or signals. “The arrays to which perceptual systems resonate is not transmitted, does not consist of signals, and does not entail a sender and a receiver. The environment does not communicate with the observers who inhabit it. The world is specified in the structure of the light that reaches us, but it is entirely up to us to perceive it (Gibson, 1979, p. 63).

An example of the ecological account of perceiving over time and the structure of arrays is given below in a sequence of drawings (from Gibson, 1979) evoking the perceptual experience of seeing a room as one turns one’s head (see **Figure 3** below, first, second, and third panels), which is an example of visual kinesthesia. The nose is always in view, and the field of view is a “sliding sample” of the ambient array with texture accreted and deleted at the leading edges. The contrast with the stationary views presented above, and especially with the inferences drawn by Mach, is clear⁷.

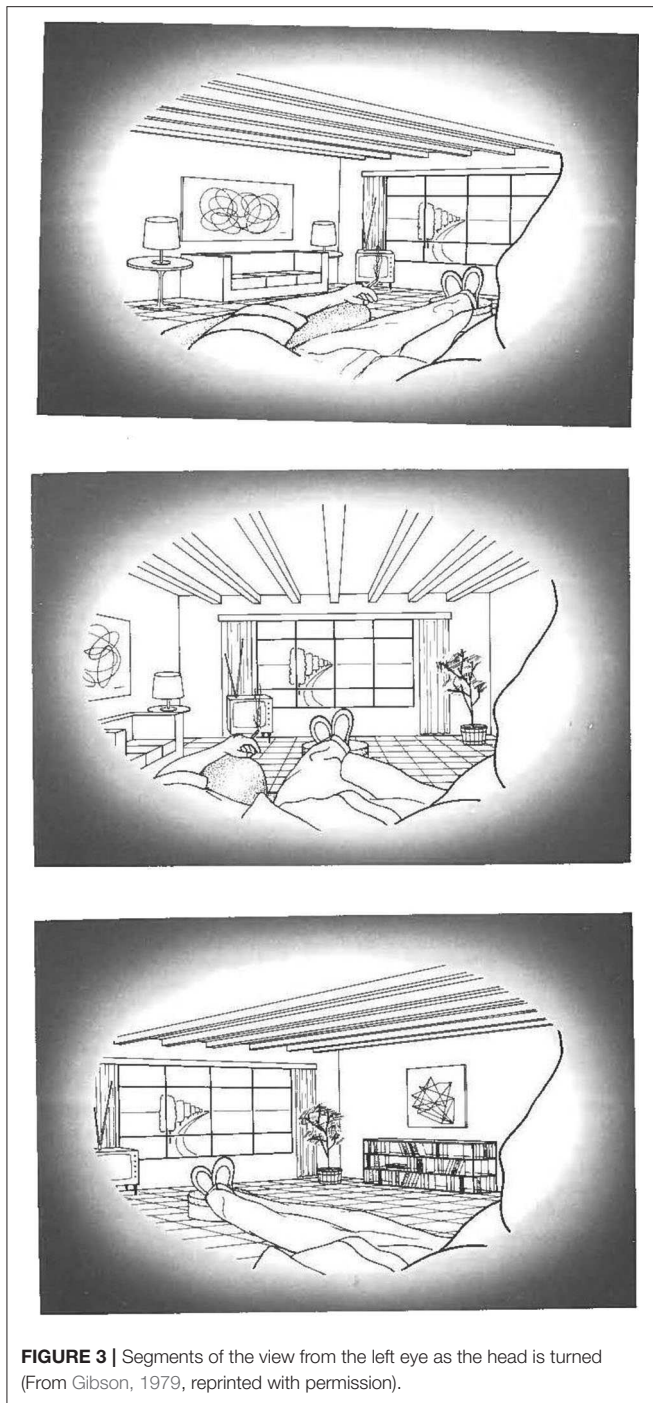
Ecological optics has offered a relational approach to the foundational conditions of understanding vision. This work was essential in rejecting representationism and dualism (cf. Shaw, 2001). Ulric Neisser concluded that Gibson’s ecological optics was “a revolutionary step that rendered geometric optics obsolete. The idea that sensations are the building blocks from which a meaningful world is constructed is replaced by the notion that visual proprioception, or ego motion, and invariants in the optical array are central.” (Neisser, 1977 p. 253). In current day contexts, we add that ecological optics replaces the idea that sensation and motor activity are somehow linked and then form the basis of the organism’s interaction with the world.

Perception in Single-Celled Organisms: Applying the Ecological Framework

The details of perceptual systems that resonate to structured arrays has been elaborated in work that followed on Gibson’s ecological theory. Analogies were made to instruments that respond to higher order variables without calculation of lower

2006, p. 357). Note that Oyama (2012) sees “information” in biology as a metaphor for whatever “controls” or guides the development of form in living organisms (cf. Baggs and Chemero, 2018). Withagen and van der Kamp (2010) use her work to expound the idea that “perceptual information” is not a patterned ambient array separated from a perceiving organism. Also note that the idea of an array “from a point of observation” (Gibson, 1979) is a mutualist idea (see section on mutualism herein).

⁷Note also that Gibson’s illustration is more accurate than Mach’s, that is, is truer to observation—the edge of the view fades gradually, it is not a sharp line. This edge is the orbit of the eye occluding the layout. Gibson’s illustration would be more accurate if the edge of the nose were also gradual, and not a sharp line.



order variables, for example, the polar planimeter that measures area directly, i.e., without calculating length and width (Runeson, 1977). But an example from a living organism will be described here, as it contrasts directly to enactivist accounts given above, specifically on perception in single-celled organisms.

Bacterial behavior in relation to the chemical environment is an example of perceiving, and mechanisms or processes in this single-cell case may help to elucidate general principles of perception that pertain to all perceiving organisms (Pittenger

and Dent, 1988). The basic ecological idea is that organisms attune to arrays structured by the environment in order to keep contact with the layout of the environment and to act adaptively in and on the layout of the surround. Action, in turn, provides stimulation that furthers the organism's contact with the environment. Free-living *e. coli* bacteria have basically one possible way to adapt to changes in the chemical environment in which they exist, and that is movement. Movement takes place by rotation of flagella distributed around the cell and the flagella alternate between coordinated rotation which leads to the formation of a bundle and movement in a straight line, and uncoordinated rotation which leads to the cell tumbling randomly. When these two types of movement alternate the cell moves in a zig zag fashion, but without control of the direction of any particular line segment. Decreases in the probability of a tumble increase movement in one direction, that is, toward a favorable chemical gradient; increases in the probability of a tumble decrease movement in any particular direction and, therefore, away from repellant gradients. The only way the organism can optimize its position in the environment is by relating to a *gradient* of concentration, not a local concentration, and a gradient exists over time, that is, consists of change over time in relation to the single cell. This is because the cell is so small that differences in gradient over the length of the cell, that is, a spatial gradient, are negligible. One model of the control of flagellar rotation (Koshland, 1977) posits a regulator substance within the cell that is continuously forming and decomposing, but at slightly different rates. The change in these rates results in increase or decrease in tumbling, which results in the cell probabilistically moving up or down a temporal gradient of concentration of a particular chemical in the surround.

There exist several parallels to perception in more complex organisms that make the bacterial case important in theorizing about mechanisms or processes for the direct perception of change over time as an organism coordinates with its (changing) environment. Stimulation from certain aspects of the environment is available only when the organism is moving, in vertebrates examples include accretion and deletion of texture in vision, head movement in auditory localization, and active touching in haptic exploration.

These parallels aptly illustrate the general important point that perception is of change, *per se*, and requires action and active exploration on the part of the organism. Finally, even in bacteria experience affects perception and action, i.e., certain receptors are universal, but others only develop on the cell when certain compounds are in the surround (Koshland, 1979). A direct theory of perception would describe these examples as representing the process of "resonance" to relations in the environment, as opposed to enactivist theories that describe the chemical processes that "create" the distinct unit of the cell.

Interim Conclusions

How does the example of chemotaxis in bacteria as the direct perception of change relate to the enactivist description of bacteria as a living system? Both emphasize biological functioning as active and ongoing, as adaptive to the surround, and as unmediated, that is, as functioning without hypothetical

mediational processes such as copying, storing and comparing. But the two approaches diverge in that the living systems approach does not distinguish *levels* of life inasmuch as the processes described apply at all levels from cellular to societal.

There are, however, those who differentiate the level of the organism from other levels (e.g., Denton et al., 2013), and further, those who differentiate perceiving/acting organisms from other living organisms (e.g., Gibson, 1966, 1979). The genetics and cell biology of cells within organisms has been a major focus of research, but we still know little of the ways that the activities of individual cells are orchestrated and coordinated in order to lead to not only large-scale patterns, but to actual morphology of organisms (cf. Levin, 2012a). In other words, organisms do not reduce to the functioning of individual cells that make up the organism. One consequence of this idea is that it is organisms, not their constitutive cells, that perceive and act, even if the organism consists of only a single cell, and even if it is a prokaryotic cell (e.g., *E. coli*).

If perception is defined as a sensorimotor process, then it is carried out by *cells*, at least at some level (i.e., the retinal cells). But if perception is defined as direct resonance to relational stimulation structured by the surround of the organism, then it is carried out by the *organism* with the appropriate perceptual systems, where perceptual systems include sensitive tissues and whole bodies. These two approaches to perception have very distinct consequences for theorizing about what abilities an organism might possess that “build on” perception.

On the Varela living systems approach, living is cognizing and action is cognizing, and the “sensori” is always directly connected to the “motor” as a basis for any action. On the direct perception ecological approach perceiving is always occurring, always open and developing/differentiating/integrating, and always a direct “knowing” of the surround through acting in/on it. Direct perception leaves open the relation of perceiving and other types of knowing, and these topics are active areas of research in current ecological psychology research (e.g., McCabe et al., 1986; Dent-Read, 1997; Rader and Vaughn, 2000; Szokolszky, 2006, 2019; Araujo and Davids, 2009; Rader and Zukow-Goldring, 2012, 2015; Read and Szokolszky, 2016; Szokolszky et al., 2019). The living systems approach, in contrast, begins by defining cognition, and the definition of perception follows from that initial definition/assumption. In this case, perception is entailed, whereas on the ecological approach it is primary. Because of this difference, the ecological and enactivist approaches arrive at very different definitions of cognition (see below in Conclusions).

SECOND MAIN POINT: THE ECOLOGICAL CONCEPT OF THE MUTUALITY OF ORGANISM AND ENVIRONMENT IS DIFFERENT FROM SENSORIMOTOR COUPLING

So far we have covered the ecological critique of and alternative to sensation-based theories of knowing/acting. In this section, we turn to how ecological and enactivist approaches understand organism-environment co-dependency. Ecological psychologists

embrace “organism–environment mutuality” and enactivists refer to “structural coupling.” Although both terms imply organism–environment co-dependency, they do so, however, with very different emphases and underlying assumptions.

For ecological psychologists mutuality of organism and environment is the key to explain perception, action and cognition without recourse to representations. Mutuality ensures a deep ontological and epistemological compatibility between the organism and the environment which makes meaning inherent in the dynamic process unfolding in this relationship. Mutuality works at the level of the organism, therefore, this level is of distinct importance in the ecological explanation. Ecological Psychology has developed elaborate mutualist concepts. Gibson was at pains to show that perceiving/acting organisms and their surround are not separate, and, therefore, do not have to be “coupled” or “conjoined,” especially not by some kind of code or mental representation. “... the terms “affordance” and “ambient optic array” bridge the gap between animal and environment, because they point both ways” (Gibson, 1982, p. 234). Gibson essentially says there is no *relation* of organism and environment; he has defined it out of existence. To support this idea we reintroduce Dewey’s phrase “unity of function” (see Costall, 2004, p. 191). Dewey states: “... it is quite necessary to start from the unity of function and see that the distinction of organism and environment arises because of adaptation in that process, not vice versa” (Dewey, 1976, p. 275, quoted in Costall, 2004). In life, organism and environment are not in relation; in analyzing the whole, we *form* the two parts out of our observations.

Ecological psychologists worry that enactivists do not appreciate the depth of the ecological mutuality principle and, therefore, they introduce concepts like “sense making” that might take us back to the dualism of subjective vs. objective. Fultot et al. (2016) point out that enactivism offers in fact a “physicochemical” level of description (at the level of sensations and brain activity, the subpersonal level) and a subjective level of description which implies internalism. On the other hand, the enactivists are looking for “something more than what can be provided by an ecological psychology framework on its own” (Stapleton, 2016, par.5). They question whether instead of “naturalizing subjectivity” Ecological Psychology rejects it all together, along with such organismic functions as autonomy and active contribution on the part of the organism. Ecological Psychology uses the verb “to act” while Enactivism uses “to *enact*” to characterize meaningful action. “To act” in the ecological sense implies activity of the organism. The use of “enact” is intended to imply that the act brings forth (generates, produces) meaning. Given their priority of enactment and sense making, enactivists’ main critique is that the ecological concept of mutuality does not accommodate this important aspect. They also think that Enactivism provides a deeper explanation not just because of its richer sense of agency, but also because Enactivism addresses sensorimotor coupling at a variety of levels, including cellular–microenvironment, organism–environment and organism–organism levels (Stapleton, 2016).

We propose that regarding the above questions there are true differences between Ecological Psychology and Enactivism, there

are apparent differences, and there are issues in both frameworks that need to be answered and elaborated. Next we lay out these aspects, elaborating the ecological concept of mutualism and also addressing the questions cited above.

The Ecological Concept of Mutualism: The Primacy of the Animate Organism

In this section, we discuss the ecological concept of mutualism in direct contrast to the enactivist idea that to perceive is to be “in interactive relationship with the world” (Roberts, 2018). In other words, mutualism is not interaction (cf. Still and Good, 1998). What is mutualism in the Ecological sense? The term “ecological” refers to the distinct level of the animate organism as an organized whole and the axiom of mutualism: that the organism and its evolutionary and developmental environment mutually define each other. The organism (animal or human) and its environment are codefining and inherently interrelated with each other; environments are animal referential, and organisms are environment referential. Mutuality is defined at the ontological level as codependence, coregulation, codetermination, and coevolution of the organism–environment system. Mutualism in ontology entails mutuality in epistemology. The organism–environment relationship necessarily is based on reciprocity, agency, and functional significance (see, e.g., Alley, 1985; Heft, 2013; Read and Szokolszky, 2018; Szokolszky and Read, 2018).

Gibson worked out his ecological approach to perception based on the idea that the environment to be perceived should be analyzed at the level of the (animal or human) organism (e.g., 1966, 1979). On this view perceiving is an ongoing process of resonating to energy that is directly structured by the layout and surfaces of the environment (which includes other acting organisms), and, therefore, directly perceivable as the organism goes about its activities, some of which change the surround. Perceiving and acting are continually mutual.

The organismic level of analysis in biology was common before the 1950's when concepts and metaphors from engineering, specifically communication theory, began to affect biology and psychology (cf. Kay, 2000; Reisch, 2005; Keller, 2010). A few influential biologists have kept arguing, however, for the importance of the organism as a whole (e.g., Waddington, 1942, 1957; Goodwin, 1982; Webster and Goodwin, 1996; Lewontin, 2002). Ecological Psychology complements these biological theories because it studies not just animate organisms and their mutual surround, but the unity of the organism and the environment, i.e., direct perception⁸. Direct perception is possible and necessary because no animal could exist without an environment surrounding it, and, equally, an environment implies an organism (Gibson, 1979; Costall, 2004, 2011). Psychology pertains to animate organisms, so in our field, an environment implies an animate, perceiving/acting organism.

Perceiving is “adaptive” in two senses: (1) through perceiving the organism adapts to the layout of surfaces and to events by resonating to structure in the ambient energy as it moves and

acts and reacts, and (2) because perception is direct, it allows the organism to live its life—to stay alive, to develop, and to provide the functions it does for its ecological niche/community⁹.

The adaptivity of the organism is by no means passive adaptation to existing circumstances. Gibson's idea of affordances and the perceiving of affordances is a mutualist account of the organism in its conditions of life. The animate organism “is a perceiver of the environment and a behavior in the environment. But this is not to say that it perceives the world of physics and behaves in the space and time of physics.” (Gibson, 1979, p. 4). Through Gibson's work, the “conditions of life” can be specified and elaborated with reference to the organism's perceptually guided action and action-supported perception.

Direct perception, by way of affordances, has begun to influence biological thinking as well, especially in relation to evolution (e.g., Walsh, 2015). Walsh (2015) characterizes proper organismic development as depending upon “the capacity of organisms to assimilate, integrate, and orchestrate the causal contributions from genes, epigenetic structures, tissues, organs, behavior, and the physical, ecological and cultural setting” (p. 157). At least at the level of behavior (action) and its ecological and cultural settings, direct perception is critical to this process. Consistent with this view, brain, mind, and consciousness are different aspects of an emergent evolutionary production, a form of life (Pickering, 2016). Adopting a niche construction perspective, Withagen and van Wermeskerken (2010) also reexamined the role of affordances in the evolutionary process. They argue that affordances and their utilization, destruction, and creation are central elements in evolutionary dynamics. These views are consistent with the idea that mutualism is a perspective on meaning that encompasses formal cause, evolutionary emergence, and ecological realism. Here Ecological Psychology aligns with the biology of Goethe and D'Arcy Thompson, both of whom studied dynamic formative processes, and are represented in modern biology by such researchers as Goodwin (1982), Levin (2012b), and Tung and Levin (2020).

Grappling With Mutualism

Mutualism is not an easy concept to grasp. Researchers who work within Ecological Psychology, and some in related disciplines such as certain approaches to developmental/evolutionary psychology have wrestled with ideas about organisms and their surrounds (e.g., Järvillehto, 2009; Oyama, 2009; Turvey, 2009). And it is important to delineate distinctions among these

⁸But note that these biologists assume indirect perception and that sensation equals perception. Their theories would be more coherent and complete if they, instead, made use of the theory of direct perception. See also (Greene, 1995).

⁹Gibson's work on perception relates to the more ecological side of Darwin's work, in which the “conditions of life” are of primary importance (Greene, 1995, p. 141). “...two great classes of facts make me think that all variability is due to changes in the conditions of life. (1) That there is more variability and more monstrosities (and these graduate into each other) under unnatural domestic conditions, than under nature. And secondly that changed conditions affect in an especial manner the reproductive organs, those organs which are to produce a new being” (Darwin, 1836–1844, quoted in Winther, 2000 p. 425).

Another key idea from Darwin is that of adaptation, that is, the possibility of the members of a species to adjust to and benefit from aspects of their environment. Costall (2001) points out that his idea undermined the dualism of subject and object that is the starting point of Cartesian mechanistic science (p. 475) and he terms Darwin's studies of earth worms an early mutualist example of “ecological” psychology (p. 478).

approaches. Although the term “mutualism” is not always used the idea of the organism-environment system, a related concept, is central to some epigenetic, development, and ecological research. For example, Järvillehto (2009) states that:

“The environment is not just a passive scene in the background of the acting organism but an active part of the system making specific results of behavior possible. Subject and object are inseparable and represent only distinctive points of view in the organization of the system. Subject is the system in action, object is what emerges as the result of this action” (Järvillehto, 2009, p. 116).

In an independent area of research, Developmental Systems Theory (e.g., Oyama, 2009, 2012), the organism and its environment form a system with an inside and an outside which define and specify each other and codetermine outcomes. This in contrast to autopoietic systems (Maturana and Varela, 1988) which distinguish between the internal specifying power and the external triggering power of different aspects of the system. In Developmental Systems Theory there is no causally sufficient self-making but, instead, mutually constructed relations of developing organisms and their environments. We note here, that the system is taken as primary, not the organism.

Developmental Ecological Psychology shares with any developmental approach the emphasis on change over time, but it does *not* make all levels of functioning equivalent (e.g., the cell and the whole organism), and it does *not* assume sensation as the primary contact with the surround (e.g., Read and Szokolszky, 2018). Developmental work from within Ecological Psychology endeavors to place the mutuality of organism and environment into various time scales.

Mutualist concepts are themselves flexible and evolving, as the above variations attest (Still and Good, 1992, 1998; Dent-Read and Zukow-Goldring, 1997; Fultot et al., 2016; Pickering, 2016). Some points of uncertainty are important: even the idea of interrelations or interaction may require admitting the existence of two separate kinds of entities (i.e., organism and environment as entities). That is, if one *begins* with parts already analyzed, then the parts have to be related to make a system or a whole. Even Gibson (1979) used terms such as “complementary” and “reciprocal” interchangeably, but that should be clarified. “Reciprocal” indicates a relation in which one act is given in return for another; and a “complement” is something that completes, so the environment completes the organism (cf. Dent-Read, 1997).

Complementary mutualism in Ecological Psychology demands a consistent and ongoing interdependence of entities. The idea of the organism and environment as *complementary* implies a unity of function that existed before the analysis into parts. Whereas, Dewey linked the “sensory” and the “motor” aspects of organisms in continuous arcs, Gibson describes perceptual systems of the organism that exist within the organism-environment mutuality as a whole, in which the organism and environment mutually constitute each other. Still and Good (1998) list three requirements for a mutualist theory and the language used to describe it. (1) The concepts and descriptions are not primarily about either the organism or the environment, rather they relate to activities that

necessarily involve both, therefore, terms are interdependent; (2) Units retain properties of the whole and (3) explanations are diachronic rather than synchronic. These aspects can serve as a basis for comparing approaches outside of Ecological Psychology, in this case, of Enactivism.

Gibson's Phenomenological Method and the Concept of Mutualism

Gibson used phenomenological methods to investigate the perceived surround, for example, the view from one eye (see the revision of Mach's figure, **Figure 3** above) to show that we always perceive our noses in any act of (unrestrained, natural) visual perception. Therefore, even when one is holding still (which is an act), and nothing else of one's body is in view, part of one's own body is always in view. If we include two eyes, we have two opposite views of the nose and, in a way, a midline is formed, even in a static view of a static scene. Even this reduced case is an example of *visual kinesthesia*¹⁰. Gibson went on to describe what there is to be perceived by describing the layout of the environment in organism-relevant, that is, ecological terms such as texture gradients, flow from the still point of future contact, accretion and deletion of texture at an edge, and, specifically, what was variant and invariant in these perceived structures. Optical structure “guides locomotion by specifying both the invariant surrounding surfaces and the movement of the organism within them.” (Gibson, 1966, p.163). Still and Good point out that “Visual kinesthesia retains the flow of activity; it links organism and environment dialectically, ...; it applies directly to the whole organism; and, by being a part of activity necessarily extended over time it is a foundation for diachronic rather than synchronic explanation.” (Still and Good, 1992 p. 114). Along the same lines, the principle of mutualism has been described as a relational thinking encompassing non-disjunctive distinctions, for example, organism and environment (Costall, 2001). Without this type of thinking, dualisms persist, of subject and object, of agent and world and of the intentional and the material (Costall, 2001, p. 481).

The mutualism of organism and environment was the basis of Gibson's (1966) development of the idea of affordances for *animate* organisms. “Some sources (in the surround) are beneficial some noxious. If the specification is real and if the information is detected and discriminated the individual will be able to detect the values of things at a distance and move toward or away from them in accordance to what they afford.” (p. 73).

Gibson (1979) developed the concept of affordance—what the environment affords the organism in support of action, nutrition, social action, and so forth, and proposed that affordances are specified in the energy arrays that an animal's or human's perceptual systems resonate to as they move through and adapt to and change their surround. This idea clearly meets the three criteria of relational concepts, units with properties of the whole,

¹⁰Gibson was trained in graduate school at Princeton University by Herbert Langfeld who had been a student of Carl Stumpf's in Berlin. Stumpf originated an experimental psychology of tone and musical awareness and termed it “phenomenology.” Gibson, therefore, had training in becoming aware of one's own actions/consciousness in relation to perceiving the world.

and diachronic explanation. The term affordance “points both ways” i.e., to the environment and to the specific organism and so is interdependent; it retains properties of the whole organism-environment system inasmuch as the whole organism in its surround is involved with any particular affordance; and affordances exist over time, that is, are not snapshots and are, therefore, diachronic. The relation between invariants in the energy array over time and the affordances available to perception is a complex theoretical and empirical problem. As of now, there is no agreed upon theoretical specification of affordances that all ecological psychologists or philosophers subscribe to. Work on this problem is ongoing (e.g., Dotov et al., 2012), and, clearly, researchers endeavor to maintain mutualist thinking (with various degrees of success and consistency).

The idea of affordances has been taken in several different directions since Gibson’s initial descriptions, and a review of this important topic is beyond the scope of the present paper. But we do here give brief indications of some of the diversity of approaches. The environment scaled to the organism has been investigated as an example of the range of affordances for action (e.g., Warren, 1984), the distinction between dispositional and occurrent properties of objects (Turvey, 1992) has been argued, and the question of the existence of affordances independent of any particular organism (Noble, 1981) has been raised. Later topics include the role of the organism’s intentions in specifying affordances, especially social affordances (Heft, 1989), “in the course of the individual’s on-going activity, particular affordances will be experienced (i.e., actualized) in conjunction with particular intentional actions; these affordances both complement and constrain these intentional processes” (p. 25). A recent enactivist paper relates affordances back to some basic Gestalt ideas (Kiverstein et al., 2019; See also, Rietveld et al., 2018) and distinguishes between the geographical environment and the behavioral environment, in other words, the environment as perceived by an individual and the shared publically available environment. The authors argue that the two environments are reciprocal and dependent. The challenge for this approach is to avoid the problems inherent in placing the geographical environment within the (human) self-consciousness, and, therefore, removing the inviting affordances from the environment (cf. Webster, 2020) and negating Gibson’s initial insight. Finally, any research on affordances must avoid the fallacy of taking an outcome of a process as the pre-existing source of the process. That is, if organisms engage their surrounds in stable and predictable ways, then it is easy to assume that the qualities of the environment involved in this process are stable and have an existence previous to the engagement (van Dijk, 2019) (cf. Heider’s influence on Gibson’s idea of affordances, de Jong, 1995). One way to avoid this fallacy is to take seriously the idea that perceiving takes place over time, and that events occur at different time scales. A human life is the longest time scale for an individual, and everything they experience takes place on that scale. In that sense there is no “here and now” as opposed to “there and then” on which to base particular vs. general affordances (cf. Shaw et al., 2019). There is only perceiving of persistence over time, by either any individual organism, or by a trained psychologist in their scientific work.

Ecological Psychology has been critiqued for tendencies to overemphasize the environment, and even to think of the environment as preceding the organism (cf. Costall, 2004). There is, however, nothing in the Ecological approach to perception that requires this view of the environment, in fact, such a view is counter to the theory. Ecological Psychology benefits from efforts to counter the idea that the environment exists before the organism, and the organism is the one that “adapts” to a pre-existing environment. As Dewey (1898, p. 283–284, cited in Costall, 2004) points out, the environment of an organism is a product of the process of development, it has developed *along with* the organism. *Mutuality is not interactionism*, that is, the interrelating of two separate entities. Organisms inherit environments as much as they do genes, and environments exist because of organisms. The organism is different from the environment, from its surround, but this distinction “presupposes their relation, just as riverbeds and rivers, and beaten-paths and walkers imply one another’s existence” (Costall, 2004, p. 191).

Gibson’s Idea of Visual Kinesthesia vs. Merleau-Ponty’s Ideas of the Lived Body

In this section, we elaborate the concept of visual kinesthesia as a good case with which to illustrate mutuality in concrete terms. This concept also offers the opportunity to compare Gibson’s ideas to those of Merleau-Ponty on the lived body, as the latter is often taken as foundational in Enactivism. Visual kinesthesia is perceiving the effects on what one is seeing due to one’s own movement. It concerns our “awareness of being in the world” (Gibson, 1979, p. 239). For example, there are the experiences of optic flow, awareness of movement or stasis, and the visible horizon that corresponds to eye level. The visible horizon is neither objective nor subjective; it is a correspondence of distant surround and perceiver.

Still and Good (1998) discuss the ontology of mutualism by linking direct perception to Merleau-Ponty’s idea of “objective co-variation” (p. 53). Merleau-Ponty describes his experience as his right hand touches his left: When my right hand touches my left, I am aware of it as a “physical thing.” But at the same moment, if I wish, an extraordinary event takes place: here is my left hand as well starting to perceive my right, ... The physical thing becomes animate” (Merleau-Ponty, 1942, p. 166).

Compare this description to Gibson’s characterization of visual kinesthesia: “In visual kinesthesia... the nose and the body are visible. There is information for coperceiving the self as well as for perceiving the layout” (1979, p. 84). Independent of the fact that Merleau-Ponty in this example focuses on touch (although we assume he is looking at his hands as they move and reconfigure) and Gibson is focused on vision, Merleau-Ponty takes a “first person” stance and describes his own experience, whereas Gibson takes a “third person” stance and describes vision and movement in general. Nonetheless, Gibson’s description strives to be a mutualist description, by simultaneously taking into account the animate, moving organism and the layout through which it moves and which supports and, in some ways, forms its movement.

Is Merleau-Ponty's description mutualist? Taken in the context of another of his statements, viz., "I am the absolute source, my existence does not stem from my antecedents, from my physical and social environment; instead it moves out toward them and sustains them..." (Merleau-Ponty, 1945, p. ix, quoted in Still and Good, 1998, p. 54) one could argue that Merleau-Ponty is not describing a mutual relation of his self with his surround, but only his self, or at least, only his own awareness/consciousness. If Merleau-Ponty's goal in *Phenomenology of Perception* is to define and elaborate the lived body of pre-predicative experience and to distinguish it from the objective body of science (Still and Good, 1998, p. 54), then his goals and methods are completely distinct from Gibson's, which were to study how we perceive/act in the course of daily life, or in controlled conditions¹¹. Based on Merleau-Ponty's early writings on *The Structure of Behavior* and *The Phenomenology of Perception* Bullington (2013) describes phenomenology as the "systematic study of the realm of subjectivity. Phenomenology does not study the objective world as such, but rather the subjective foundations for being able to experience the world as objective and independent of our acts of attending and understanding" (p. 20). This approach seems to presuppose a separation between perceiver and world, objective and subjective world, and to concentrate only on the *experience* that what is perceived is the objective world—the experience of the appearances of the world.

In the American pragmatist tradition to which Gibson was heir activity takes precedence over ideas and the goal is to develop an ontology based on activity rather than on subjective ideas and sensations. If we return to the example of the hands and touching, the ecological approach would say: when I move my right hand to touch my left, seeing my body and surround as I do this, my right hand touches actively and my left hand receives touch passively. In both cases visual kinesthesia and tactile kinesthesia are ongoing, but one acts and the other rests. The hands, eyes, head, limbs, body, and so forth are all part of the visual and tactile perceptual systems that coordinate with the layout of the surround, including one's own body in the ongoing process of direct perceiving/acting. The ambient energy arrays directly structured by the environment and one's own body are available to the animal or human perceptual systems that can attune to the arrays. Invariants specify the layout, that is, the objects, surfaces, and events in the surround and the layout consists of affordances that are enacted or not as an animal or person goes through their lives using, changing, and contributing to their surround, including other organisms.

The third-person stance of traditional science and of experimental psychology is not necessarily mutualist, but it can be mutualist when the self and the world are observed simultaneously. This is precisely the method used by Gibson

in which the self-in-the-world is experienced, described, and studied through experiments. For example, in his descriptions of "size" and "distance" perception as the detection of "equal amounts of texture for equal amounts of terrain suggests that both size and distance are perceived directly" (1979, p. 162), that is, in relation to the observer. Second-person approaches, in which anything other than self is "you," by definition, sees agency in everything in the world, living or not, animate or not, unless the work is specifically limited to human social interaction. But the living animate organism is the starting point of Ecological Psychology as an approach to perception, and so within Ecological Psychology only the mutualist "person" is fruitful. And the mutualist person can be first person, "I see," second person, "you see," or third person "seeing is taking place." We should point out in summary at this point, that Gibson used the general "I see" as a method for theory development, but the third person stance in his research. The first and second person stances have yet to be further developed in Ecological Psychology, although there is an extensive literature on the second person aspects of human social interactions (Marsh et al., 2009a; Schilbach et al., 2013; Schilbach, 2015).

THIRD MAIN POINT: ECOLOGICAL PSYCHOLOGY AND VARIETIES OF ENACTIVISM ARE LAYING DOWN DIFFERENT PATHS TO PURSUE RELATED GOALS

So far we have uncovered some crucial points on which Ecological explanations differ from the Enactivist explanations. Next we consider sensori-motor enaction directly, and examine its compatibility with Ecological Psychology. We go back to Varela et al. (1993, p. 202–204) criticism of Gibson because it illustrates points of divergence between ecological theory and enactivist, not in what is said there directly, but in the differences between how ecological theory is described there and in how it is described by Gibson.

First, Varela et al. (1993) refer to the sensorimotor capacities of the animal, whereas Gibson as of the 1966 book (*The Senses Considered as Perceptual Systems*) was clear that the senses and perception were two different levels of phenomena. Further, Varela et al. state that affordances, which they define as interaction possibilities of the world, are distinctly ecological features of the world. However, Gibson is clear that affordances are (at least) action possibilities for animals and humans, and are always taken with respect to the animate organism, that is, always "point both ways," i.e., to the animal and the world (Gibson, 1979, p. 129), whether or not they are acted upon.

The core question is: what the two different views mean by "perceptually-guided action." Varela et al. take perceptually-guided action as defined by Gibson as the picking up or attending to invariances in the ambient light that specify their environmental source. However, Gibson specifically refers to invariances that exist because of the animal's locomotion, grasping, looking, tool use, and so forth; and these types of activity are what is meant by "perceptually-guided action" (not

¹¹ Another analysis of the "lived body" of Merleau-Ponty in relation to the idea of affordance from Gibson as two complementary sides of one process is presented in Glotzbach and Heft (1982). The body is experienced in relation to its situation and the world is perceived in relation to one's body. Our analysis highlights differences and possible contradictions between "pre-predicative experience of the body" and direct perception of one's own surround. A full characterization of the relation between Merleau-Ponty's and Gibson's work on perception is for the future.

the picking up of invariants) (cf. Szokolszky et al., 2019). Of course, invariants of motion in the surround also exist (see material on events above). Adaptive, purposive action can be perceptually guided because organisms have the perceptual systems to perceive their surround by means of structured energy arrays specific to the surround. In contrast, Varela et al. go on to clarify what they mean by “perceptually-guided action”—the environment is enacted and perception is sensorimotor enactment (p. 204). They endeavor to specify the sensorimotor patterns “that enable action to be perceptually guided, and so we build up the theory of perception from the structural coupling of the animal” (p. 204).

It is apparent from these contrasts that the ecological and the enactive definitions of perceiving/perception have very little overlap. Both approaches take action as central, but their definitions of what action is and how it takes place differ radically. Enactivism concentrates on “embodiment,” whereas embodiment is implied/inherent in Ecological Psychology, but there the resemblance ends. More recent literature from the enactivist point of view retains the sensorimotor basis of perception and the definition of perceptually-guided action essentially unchanged from that given by Varela et al. (e.g., Barandiaran, 2017; Degenaar and O'Regan, 2017).

A very different definition of enaction and perception is taken by other authors who use the term “enaction” to refer to a set of theories that take action and perception to be interdependent (e.g., Gangopadhyay and Kiverstein, 2009). In this approach two different points are stressed: (1) perception and action are interdependent processes, and (2) the vehicles of perception are distributed across brain, body and world (p. 64). On this view, Gibson is seen not as an opposite to enaction, but as a forerunner. Enactive theories endeavor to understand experience as it unfolds in an embodied subject situated in an environment. In the course of that effort, some theories make a distinction between the subpersonal and the personal, or between the causal neural mechanisms of perception and the contents of experience (see above). The ecological approach to perception emphasizes perception as an exploratory and purposeful activity, and, therefore, pertains to the personal level. Enactive theories also develop accounts of the personal level, but also of the physiology and, therefore, of the subpersonal level. Herein lies the rub: on the Ecological Psychology account physiology does not constitute perception, it supports it (cf. Shaw and Mace, 2005; Read and Szokolszky, 2018). To reiterate, sensation does not equal perception.

Debates on Ecological and Enactivist theory are ongoing. Fultot et al. (2016) make clear some of the distinctions between the approaches and the attempts that are being made to align them. Fultot et al. present a certain approach to Ecological Psychology which we will call the physical systems approach. They describe direct perception as Gibson originated it, but they extend it in particular way by ignoring the organismic level and instead describing “perceiving-acting systems” instead of organism-environment systems. They claim that it is in the tradition of Gibson to “seek a characterization of perceiving-acting systems that is generic for any end-directed physical system, living or non-living” (p. 1). This step puts them

in line with the Varela et al. approach to autopoietic systems, which are living or not.

The systems ecological work coincides, therefore, with some of the main goals of Enactivism, at least of the Varela variety, in using physics as the basis of biology and psychology. Systems ecological psychologists still differ from Enactivists on the possibility of direct perception, that is, direct and adaptive contact with the surround. However, perception becomes the activity of systems rather than of animate organisms in both cases. Enactivism differs even from the systems approach to ecological work, though, in emphasizing “first person” experience and in differentiating the “subpersonal” from the “personal” (with many variations on the use of these ideas, cf. Gangopadhyay and Kiverstein, 2009). Heras-Escribano (2016) attempts to show that Ecological Psychology and Enactivism are complementary because Ecological Psychology accepts the Enactivist ideas on the relation between life and cognition. This even though Fultot et al. had specifically stated they were accounting for “perception-action systems” both living and non-living.

Animate Organism vs. Cognitive Systems

Of course, Gibson's theory and research was aimed not at all of the living, but specifically at the animate living, that is, animals and humans. Systems ecological psychologists and enactivists have extended the idea of perceptually-guided action to plants (e.g., Garzon and Keijzer, 2011; Carello et al., 2012), which are obviously living, but which are not animate (growth, even adaptive growth is not the same as action; it is tropism, cf. Read and Szokolszky, 2018). This research with plants is taken as supporting enactivist ideas of the “subpersonal.” Heras-Escribano (2016) concludes that the best interaction of Ecological Psychology and Enactivism would give the explanation of the agentive or personal level of perception to Ecological Psychology with its elaboration of direct perception, and assign the explanation of the “subpersonal,” that is, processes that shape agency through neurodynamics (for those organisms that have nervous systems) to Enactivism.

The distinction between the “subpersonal” and the “personal” seems to devolve into the distinction between physiology and experience, which might lead to the distinction between body and mind. Direct perception as developed by Gibson, that is, at the level of the animal living in its surround over time, is “between” physiology and experience. Direct perception arises out of the organism and its surround; it is a direct resonance. It is the core process that makes the organism and its surround a system at the level of the living-acting organism. Perception is not “of” anything except the changes in layout as events happen or the organism moves and acts; and the surround changes directly with the organism's activity. What is happening in the organism's physiology as it is living supports perception, but does not constitute perception. In this sense, physiology cannot “shape agency” and the agent/organism cannot emerge from the physiology. Many species must move in relation to solid objects in their surround, but they accomplish this general perceiving/acting in very different ways at the level of physiology (Johnston, 2003). For example, a human child reaching for a ball and a flying bat catching an insect are perceiving the relation of

their body to an object and coordinating with the object, but the underlying physiology is entirely different in these cases. The organism's action, its "ecologically effective solution" is independent of physiology. The animal-environment system is the level appropriate for the investigation of adaptive action.

Toward Ecological Neuroscience

If the nervous system does not cause perception, then what is its role? Ecological Psychology approaches to neuroscience are in their nascency. One approach aims to explain the perception of affordances by conceptualizing neural regions in the brain as "dispositional parts of perception and action systems that temporarily assemble" to allow animals and humans to perceive, and possibly use, affordances in the environment (Schilbach et al., 2013; de Wit et al., 2017). The problem of the relation of physiology to perception is a thorny one. From early on in his work, Gibson distinguished sensation from perception, that is, perceiving is not the having of sensations, it is the detection of the surround in the course of ongoing action by means of structured ambient energy arrays. It is unfortunate that he often called these energy arrays "information" (e.g., 1967, 1979) because that concept imports ideas about signs and communication that are anathema to direct perception theory (We will not lay out this argument in detail here, but we will also not use the word "information" in relation to direct perception. See footnote 5.) Incorporating the idea of dispositions into a theory of how neurophysiology enables of perception is one possible direction in relating neural functioning to perceiving, but dispositions belong either to the surround (as in one definition of affordances, e.g., Turvey, 1992) or, as in this case, to the perceiving organism (specifically to its brain and nervous system). In other words, dispositions entail "readiness to be" of some aspect of either the organism or the environment, but not of the resonance between them, which resonance is the defining quality of direct perception (cf. Walsh, 2015). Further, if the physiology of senses and brain "allow" perception, how is this different from defining perception as constituted of sensations? The main point here is that "allowing" perception is more than "supporting" perception. Physiology is necessary, but not sufficient, for perceiving/acting, but not any *more* necessary than any environmental aspect. Level ground, for example, allows walking, but one would not claim that it allows perception. It is the occasion for perceiving the affordance of locomotion for some animals and humans (and Daleks, who could take over the universe if everything were a flat surface).

Approaches to neuroscience from within Ecological Psychology vary considerably (see de Wit and Withagen, 2019), but there are some main themes that differentiate Ecological work based on direct perception from other approaches that take psychological phenomena to reduce to the physiological (even if the reduction is based on "emergence" out of cyclic processes). van Dijk and Myin (2019) point out that one cannot logically use the pre-existence of affordances to explain the process of perceiving affordances. If action "brings about" an affordance, the existence of the affordance cannot explain the action. Likewise, we cannot logically reify an organism's act of resonating as a nervous system resonating to ambient structure. That is, the

organism's resonating does not reduce to the nervous system resonating; but it does *allow*, in the case of humans who have special skills, reflection on and understanding of the nervous system. Van Dijk and Myin use the example of evoked potentials studied during color naming in two language groups (Van Dijk and Myin, p. 262) which showed a difference in potentials depending on whether the speakers had terms that distinguished light and dark blues. First, the scientific methods used here are a refinement of resonance (attunement and anticipation), and depend on direct perception. Second, the brain is not causal in the use of color names, but coordinates with such use.

A study of infants responding to a simulated looming object (van der Weel et al., 2019) that measured visual evoked potentials and the orientation of electrical source flow showed connectivity patterns emerging and changing directions between trials. The same variable that can be used to describe the flow pattern of a looming object (τ , the ratio between image size and its rate of change, Lee, 1976) can be used to measure the rate of electrical brain activity. The authors found the two τ variables to be linearly correlated and coupled with a constant. When the infant perceives looming the information does not travel "inwards," but, instead the infant's nervous system is getting ready to provide the possibility of resonance. Evaluating the nervous system in thermodynamic terms leads to describing it in terms of "latent states of readiness for action" (Fultot et al., 2016) which corresponds to the "open-ended fractal richness of the affordance landscape in which organisms are immersed" (p. 228). These efforts to characterize resonance are important, and to the extent that they go beyond "coupling," they offer an alternative to "sensorimotor coupling" or "sensorimotor agency" in accounting for perception/action as it is carried out by organisms who can move, but who are embodied in such highly variable ways.

History and Experience

Enactivists emphasize that an agent always has a history; any "sensorimotor coordination" has a history. History implies both continuity and change, and, of course, processes of change over time. Such processes of change deserve close attention (cf. Raeff, 2011; Read and Szokolszky, 2018). There are levels of time to consider—the evolution of species takes place at a different time scale than the ontogeny of individuals. Perceiving, and learning by perceiving take place at a shorter time scale than ontogeny. The idea of "history" is too broad to allow for these distinctions of time scale. And processes of change can exist at any scale; processes such as differentiation, integration, metamorphosis, morphogenesis, and so forth. Which of these is meant by history? If engineers designing a machine and then modifying it after discussion is a case of "evolution" (de Pinedo, 2016) and non-living systems can perceive/act (e.g., Fultot et al., 2016), what is the place of the perceiving animal in its (self-modified) surround? What is the place of an organism perceiving over time, even over the time scale of its whole life? These core concepts of Ecological Psychology may overlap with Enactivist ideas of "history," but basic questions remain of what or who perceives.

Enactivism has taken experience and agency as starting points, whereas Ecological Psychology has taken adaptive perceiving/acting as its starting point. On the Enactive view the

embodied cognizer is an autonomous individuality based on its material ongoing self-constitution. The idea of the embodied cognizer grounds concepts of interiority and agency. Enactivism asks: what makes cognitive systems individual subjects with their own experience and perspective? (Di Paolo and De Jaegher, 2017).

The idea of a cognitive system as an individual contrasts with the original emphasis in Ecological Psychology on the ways animate organisms perceive and act in/on their surround in the process of living. Cognitive systems are a different kind of thing than an animate organism. Organisms have boundaries, and animate organisms move on their own. Plants as organisms grow and reproduce, but growth, even though it is adaptive, is not an act. Animate organisms initiate actions, even though the actions are always in a context of other organisms, other animate organisms, and the physical world in which they live and are embedded. Animate organisms are “centers of perceptions, drives, and actions” (Greene, 1974, p. 270). Stimulus-response theory, of which sensorimotor theories are a descendant, cannot explain our experience of animals as “living centers.” Referring to Adolf Portmann’s descriptions of gorillas in a zoo, Greene states: “Whatever our theories of animal behavior or animal evolution, we must acknowledge quite simply and factually the presence here of a center in which the living being’s dealings with its environment are drawn together and from which they radiate” (Greene, 1974, p. 271). On this view, plants are organized centers of growth and form, but not of perception and action¹².

Systems are comprised of interconnected elements, but they are not necessarily living. The mathematical idea of dynamic systems (e.g., Abraham and Shaw, 1989, 1990; Abraham et al., 1992) can be applied broadly, that is, to the living and the non-living. This has the advantage of potentially providing a very general account, but the disadvantage of blurring the distinction between the living and the non-living.

As an example of the contrast between enactivist experience and ecological perception we take the case of bodily memory (e.g., Fuchs, 2017) and compare it to the idea of direct perception of persistence over time (Gibson, 1979; Warren and Shaw, 1985). On the Enactivist view, if “memory” means “the capacity of a living being to actualize its dispositions acquired in earlier learning processes” (Fuchs, 2017, p. 337), then this capacity is due to an ongoing “dynamic coupling between body and environment.” Here memory is not based on mental representation, but on lived bodily actions that are culturally formed, learned, and carried out “without thinking.” Clearly, on this definition, body memory is dynamic both in its

formation through “the body’s interaction with the environment” and its flexible reactualization in later situations. Here the emphasis is on acquired skills and habits with both objects (learning to type or play a musical instrument) and other people (turn taking, conversation, ritual). On this account, personal experience is a “feeling of sameness” and a capacity to perform over time.

Acting and Enacting

How do these two accounts, the Ecological and the Enactivist, compare? The Ecological concentrates on a perceiver/actor and the Enactivist on a body that enacts. How does action compare to enaction? In Enactivism to ACT means to put something into practice. To ACT is to do something, move, behave, function, conduct oneself. Enaction requires that something, e.g., a statement, exists before it can be put into practice, e.g., made into a law. Action requires an entity that can move, behave, adapt. Enactivists posit an auto-poietic system that functions by enacting its history, its body memory, its consciousness. Ecological Psychology, instead of looking to the perceiver to construct a meaningful world, seeks to uncover rich, lawfully structured arrays that specify the surround to an active organism.

“The world of physical reality does not consist of meaningful things. The world of ecological reality, as I have been trying to describe it, does. If what we perceived were the entities of physics and mathematics, meanings would have to be imposed on them. But if what we perceive are the entities of environmental science, their meanings can be discovered” (Gibson, 1979, p. 33).

The richness of information (i.e., the structured ambient array) is not to be found in animal-neutral physical and mathematical variables, but in variables that concern how an animal makes its way in the world, animal-referential variables, the variables of ecological realism that are perceived not constructed. Therefore, these action-referential variables are no less objective than the physical variables based on the standard physics of mechanics or dynamics with their mathematical measurement and formalism (Gibson, 1979; Michaels and Carello, 1981) (To date the variables often used in Ecological research are described using animal-neutral mathematics based on mechanics or dynamics in physics. Animal-referential variables have received less attention. Note that time-to-contact as measured by ratios of texture accretion and deletion is, as a measure, animal-neutral. Animate organisms do not perceive physical time; they perceive the flow of events).

On the Ecological account, there is no prior something that has to be enacted, instead, there is ongoing unity of functioning of the organism-environment. On the Enactivist account the self-creating system is constantly active and creative of its form of life, its way of being in the world, its knowing. These two approaches have some similarities in their goals. For example, Enactivist approaches endorse the idea that activity is central to motivating, constraining, and characterizing perception. This has been a core theme of James Gibson’s ecological approach since at least the 1950s. However, these two approaches actually “run parallel” to each other because they start from mutually exclusive assumptions, definitions, and theories.

¹²“First, Portmann is by no means alleging that “consciousness” or “mind” is to predicated of all animals, let alone plants as well. Consciousness as we experience it is one expression, one style, of centricity. Even in the human individual it forms in fact only a narrow band in the wider spectrum of mental life. And so, since even our own awareness is by no means wholly focal, we need no great imaginative effort to extend a generalized concept of sentience of some sort at least to other animals. Second, consciousness in us, or sentience in a broader sense in animals generally, is again but the inner expression of centricity as such: of the fact that organisms are centers of metabolism and development, of ordered reaching out toward an environment and taking in from it, of birth and death. It is this centered dynamic, dependent as it is on the existence of *individuals*, that is characteristic of all life and is not characteristic of inorganic phenomena” (Greene, 1974, p.274).

CONCLUSIONS AND FUTURE DIRECTIONS

Do Ecological Psychology and Enactivism converge on the idea of cognition without representation? At first sight: Yes. However, given that the two begin from contradictory assumptions, and proceed in different ways and directions, our answer to this question is: No. The appearance of convergence stems from the word “cognition,” but the two approaches arrive at completely different definitions of the term. In Ecological Psychology direct perception and action is the basic way of knowing, and all other ways originate there. In Enactivism cognition is emergent out of sensorimotor coupling.

We noted that both approaches propose that adaptive behavior emerges from dynamic interactions. However, whereas Ecological Psychology has emphasized “generic agency” and lawful constraints in co-dependence, enactivists have emphasized individual contribution to meaning that is “brought forth” (enacted) by active agency, in lived experience. Ecological psychologists share with enactivists the focus on organismic activity itself as the overarching purpose of cognition, and it is, therefore, the central material of experimentation. But they do not make the extra claim that activity is the reason that organisms have to construct meanings.

The central insight of the enactivist approach is that mind is a living process (Thompson, 2007). That is, mental activity is self-producing, in the sense that the organism produces and maintains a boundary between itself and the world; it is asymmetrical in the sense that the organism does something to its surroundings across the boundary that it has itself established; and it is normative in the sense that the animal acts in accordance with norms that are established, for example, by the biological need to act in an adaptive manner (Di Paolo et al., 2017). Related is the idea that living systems construct themselves by generating the very boundary conditions that are necessary for the maintenance of their self-organization (Witherington, 2011).

Ecological and Enactivist thinkers diverge primarily with respect to the emphasis placed on the contributions of the organism to perception-action. Enactivists claim that a fundamental asymmetry in the organism-environment relationship should be credited for the existence of meaning in the world. Ecological Psychologists counter that theory must take into account both the asymmetry and symmetry of organism and environment, as well as with the role of specificational arrays that allow their unity of functioning.

With regard to an ecological approach to knowing we refer back to Gibson (1979). The theory of direct perception

clear that perceptual seeing is an awareness of persisting structure” (Gibson, 1979, p. 258).

The Ecological knower is an adaptive actor and explorer in the course of its life. For Gibson, perception is not a process of passive reception of information that is built up into a representation of a meaningful environment, but direct sensitivity—often made possible by exploratory activity—to an environment that is action-relevant. In brief, there are no intermediaries between the knower and the known, and what is known is at the ecological scale of the behaving organism. Specifically, ecological psychology has also taken on the problem of memory, in contrast to a cognitivism that posited mental representation (Gibson, 1979; Wilcox and Katz, 1981b) and, most importantly, the idea of perceiving over time (Warren and Shaw, 1985; McCabe et al., 1986; Read and Szokolszky, 2018). If perceiving takes place over time, then it is events that are perceived and participated in by perceivers, and events take place over very different time scales (cf. Warren and Shaw, 1985). Therefore, direct perceiving/acting takes place over very different time scales (cf. Wilcox and Katz, 1981a,b; Read and Szokolszky, 2018). Examples of perceptible events comprise motion events, such as kicking in water, and structural events, such as the development of the organism (see McCabe, 1986a,b). Clearly events such as kicking and those of development exist over different scales of time, but both are perceptible (see Gibson, 1997; Gibson and Pick, 2000). These ideas have yet to be truly mined within Ecological Psychology. Efforts to understand coordination between a person’s action and various descriptions of variables in perceptual arrays have proceeded apace and coordination between perceivers has also received a fair amount of research attention (e.g., Turvey, 1990; Richardson et al., 2008; Marsh et al., 2009b; Schmidt et al., 2011). But research on how perceiving is related to knowing in a broader sense, and to visualizing, remembering, and talking or conversing is still in its infancy (e.g., Dent, 1990; Dent-Read, 1997; Szokolszky, 2006, 2019; Costall, 2010; Rader and Zukow-Goldring, 2012, 2015; Read and Szokolszky, 2016).

Although this Ecological work makes assumptions about what organisms experience, it does not explicitly bring the dimension of first person experience into its theory. Organisms act as if their experience were *x*, and so the act is what is important to the scientist observer.

Enactivist accounts of cognition draw on the idea that a human being or animal has to make sense of its environment. To “make sense” is to relate, to complete, to coordinate one thing with another so that “sense” or understanding arises. The enactive knower is active in making sense of its environment as it creates its life.

Understanding the distinctions between Ecological Psychology and Enactivism has the potential to clarify and, therefore, strengthen each approach in its own work. Ecological Psychology are not foes but rather, friends with distinct background and ideas, who take an interest in each other (cf. Zahidi and van Eemeren, 2016). In this sense the question of possible coordination and convergences is an important one. Our answer after pursuing the question is that convergence is not possible, but mutual clarification is a worthwhile endeavor.

“...closes the gap between perception and knowledge. The extracting and abstracting of invariants are what happens in both perceiving and knowing. To perceive the environment and to conceive it are different in degree but not in kind. One is continuous with the other. Our reasons for supposing that seeing something is quite unlike knowing something come from the old doctrine that seeing is having temporary sensations one after another at the passing moment of present time, whereas knowing is having permanent concepts stored in memory. It should now be

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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Mind After Uexküll: A Foray Into the Worlds of Ecological Psychologists and Enactivists

Tim Elmo Feiten*

Department of Philosophy, University of Cincinnati, Cincinnati, OH, United States

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*Correspondence:

Tim Elmo Feiten
feiten@ucmail.edu;
tim.elmo.feiten@gmail.com

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For several decades, a diverse set of approaches to embedded, embodied, extended, enactive and affective cognition has been challenging the cognitivist orthodoxy. Recently, the prospect of a combination of ecological psychology and enactivism has emerged as a promising candidate for a single unified framework that could rival the established cognitivist paradigm as “a working metatheory for the study of minds” (Baggs and Chemero, 2018, p. 11). One obstacle to such an ecological-enactive approach is the conceptual tension between the firm commitment to realism of those following James Gibson’s ecological approach and the central tenet of enactivism that each living organism enacts its own world, interpreted as a constructivist or subjectivist position. Baggs and Chemero (2018) forward the concept of *Umwelt*, coined by the biologist Jakob von Uexküll, as a conceptual bridge between the two approaches. Inspired by Kant, Uexküll’s *Umwelt* describes how the physiology of an organism’s sensory apparatus shapes its active experience of the environment. Baggs and Chemero use this link between the subject and its objective surroundings to argue for a strong compatibility between ecological psychology and enactivism. Fultot and Turvey on the other hand view *Umwelt* as steeped in representationalism, the rejection of which is a fundamental commitment of radical embodied cognition (Fultot and Turvey, 2019). Instead, they advance Uexküll’s “compositional theory of nature” as a conceptual supplement for Gibson’s ecological approach (von Uexküll, 2010, p. 171; Fultot and Turvey, 2019). In this paper, I provide a brief overview of Uexküll’s thought and distinguish a crucial difference between two ways of using his term *Umwelt*. I argue that only one of these ways, the one which emphasizes the role of subjective experience, is adequate to Uexküll’s philosophical project. I demonstrate how the two ways of using *Umwelt* are employed in the philosophy of cognitive science, show how this distinction matters to recent debates about an ecological-enactive approach, and provide some critical background to Uexküll’s compositional theory of meaning.

Keywords: enactivism, ecological psychology, *Umwelt*, Jakob von Uexküll, embodied cognition, philosophy of nature

INTRODUCTION

For several decades, a set of diverse but related approaches has been challenging the cognitivist orthodoxy. By recognizing the mind as embedded, embodied, extended, enactive, and affective (4EA), they have invigorated debates in the philosophy of cognitive science on a wide number of topics. Their diversity of methods and concerns is both a strength and a weakness: many of the different tendencies within 4EA cognition draw on disparate conceptual sources and so far, the various perspectives have not coalesced into a single unified framework that could rival the established cognitivist paradigm as “a working metatheory for the study of minds” (Baggs and Chemero, 2018, p. 11). Recently, attempts have gained traction to create such a common framework through a combination of ecological psychology and enactivism. For such an ecological-enactive approach to emerge, the conceptual foundations of its two components have to be in harmony with each other.

One of the main sources of tension between ecological psychology and enactivism is the contrast between the firm commitment to realism of those following James Gibson’s ecological approach and the central tenet of enactivism that each living organism enacts its own world, interpreted as a constructivist or subjectivist position. Baggs and Chemero forward the concept of *Umwelt*, coined by the biologist Jakob von Uexküll, as a conceptual bridge between the two approaches (Baggs and Chemero, 2018). Inspired by Kant, Uexküll’s *Umwelt* describes how the physiology of an organism’s sensory apparatus shapes its active experience of the environment. Baggs and Chemero use this link between the subject and its objective surroundings to argue for a strong compatibility between ecological psychology and enactivism. Fultot and Turvey on the other hand view *Umwelt* as steeped in representationalism, the rejection of which is a fundamental commitment of radical embodied cognition (Fultot and Turvey, 2019). Instead, they advance Uexküll’s “compositional theory of nature” as an account of how meaning takes place in the interactions between biological entities that meshes better with Gibson’s ecological approach (von Uexküll, 2010, p. 171; Fultot and Turvey, 2019). However, the roots of Uexküll’s musical theory of meaning in neovitalism and romantic holism have to be considered carefully before we can evaluate the costs and benefits of potentially importing it into the philosophy of embodied cognition.

There is still a lot of work to be done in piecing the parts together for a united ecological-enactive paradigm for cognitive science. If Uexküll’s thought is to provide one or more pieces of this puzzle, the necessary first step is to give a clear picture of what those pieces are, how they might connect to the philosophy of embodied cognition, and what philosophical commitments come with each of them. To this end, I provide a brief overview of Uexküll’s thought and distinguish a crucial difference between two ways of using his term *Umwelt*. I argue that only one of these ways, the one which emphasizes the role of subjective experience, captures Uexküll’s philosophical impetus. Simultaneously, it is only this second interpretation of *Umwelt* that really connects to the source of the tension between ecological psychology and

enactivism. I will then use some examples from the literature to demonstrate how the two ways of using *Umwelt* are employed in the philosophy of cognitive science, show how this distinction plays out in recent debates, and provide some critical background to Uexküll’s compositional theory of meaning¹.

THE MANY WORLDS OF JAKOB VON UEXKÜLL

Jakob von Uexküll was an Estonian-born biologist who is considered a predecessor of cybernetics, a pioneer of ethology and even as the “founder of two separate disciplines, ecology and semiotics” (Amrine, 2015, p. 47). Born in 1864, he published his most influential works between 1909 (*Umwelt und Innenwelt der Tiere*) and 1940 (*Bedeutungslehre*, translated as *A Theory of Meaning*). A physiologist by trade, Uexküll conducted extensive experimental studies prior to his career as a writer. Beginning in 1891 with experiments on the nervous systems of frogs conducted in Heidelberg, Uexküll soon moved on to the sea creatures that would become his specialty, studying first squid in Naples and later sea urchins on the coast of the Indian Ocean at Daressalam until 1900 (Mildenberger and Herrmann, 2014b, pp. 274–279). At the beginning of this decade of empirical work, Uexküll was still convinced that biological phenomena could be explained by mechanistic principles.

Throughout his research, he encountered increasing difficulties to account for the phenomena he observed by purely mechanistic means and came to endorse a philosophy of nature influenced by neovitalism and romanticist holism. These developments culminated in his view that the “machine theory of living beings” is fundamentally flawed (von Uexküll, 2010, p. 41). The “machine theorists” hold that “all living things are only machines” and treat them as “pure objects” (von Uexküll, 2010, pp. 41, 42). Instead, biology can only understand the nature of organisms by treating them as subjects experiencing and inhabiting their own worlds (von Uexküll, 2010, p. 41). Uexküll advanced a model of how perception and action link the organism’s nervous system with its environment in a *functional cycle*: “everything a subject perceives belongs to its perception world [*Merkwelt*], and everything it produces, to its effect world [*Wirkwelt*]. These two worlds, of perception and production of effects, form one closed unit, the *environment* [*Umwelt*]” (von Uexküll, 2010, p. 42).

In its full sense, the *Umwelt* refers to the phenomenal world which an individual organism constructs for itself by turning physical stimuli into patterns of neuronal excitation which constitute signs. The *Umwelt* constitutes the sum total of the subject’s experience, but the process in which the organism constructs its own *Umwelt* is not conscious and not accessible to the subject in its experience. Instead, the meaningful objects and the space in which we encounter them appear to us as objective reality. This reading captures Uexküll’s central

¹My gratitude belongs to the two reviewers who have provided numerous helpful and critical suggestions to all parts of this analysis. My forays into the reception of Uexküll’s thought have benefitted greatly from the works of Carlo Brentari and Frederick Amrine, to whom I am likewise grateful.

concern for the animal as subject, in an explicitly Kantian² sense:

“The task of biology consists in expanding in two directions the results of Kant’s investigations:—(1) by considering the part played by our body, and especially by our sense-organs and central nervous system, and (2) by studying the relations of other subjects (animals) to objects” (von Uexküll, 1926, p. 15).

I will refer to this full sense of *Umwelt* as the world of subjective experience constructed by the organism itself as type 2 *Umwelt*.

In a deflated reading, *Umwelt* is often understood merely as that subset of physical properties which are accessible to the perception and action of an organism based on its physiology. The entire aspect of subjective experience is lost here, and the specific physiological makeup of a single organism is still fully within the scope of a purely external, quantitative description. This sense of *Umwelt* I call type 1 *Umwelt*. Uexküll himself sometimes uses type 1 *Umwelt* and speaks about *Umwelt* as if it resulted from a mere selection, as a “tiny excerpt,” “small section,” or “only a piece cut out of its surroundings” (von Uexküll, 2010, pp. 53, 133). Most of the time he uses type 2 *Umwelt*, which lies at the heart of his entire intellectual project. Unfortunately, the majority of uses of the term *Umwelt* in the literature since Uexküll use type 1 *Umwelt* (Mildenberger and Herrmann, 2014b, pp. 264, 265).

The reasons for adopting type 1 *Umwelt* rather than type 2 can be traced to two main differences in interpretation: First, *Umwelt* is sometimes described as the result of a mere selection, rather than the more intricate process of construction. But the material world as described by physicists contains no experience, and in order to get from physical perturbations to experience, the subject has to construct the *Umwelt*. Experience is not just a set of carefully selected physical perturbations. Second, the specific structure of an *Umwelt* is sometimes described at the level of a species, rather than an individual organism. This makes sense insofar as all bees have very similar sensory organs, and the structure of their experience is likely to be very similar, while being very different from the structure of human experience. However, a species does not, as far as we know, have experience—individual organisms do. If *Umwelt* is the world as experienced by an organism, this is not an abstract model organism standing in for a whole species, but a concrete individual living being. While there are many situations in which it makes sense to talk about the kind of environment described by type 1 *Umwelt*, it excludes the majority of philosophical points

that are central to Uexküll’s thought. Some examples will help illustrate this point.

Mildenberger and Herrmann (2014a, p. 10) consider Uexküll to be a predecessor of the concept of niche construction, which they regard as a “more poignant version of the *Umwelt* concept.”. The link is plausible. Uexküll’s description of *Echinocardium caudatum* burrowing into the sand through the wavelike motion of countless tiny bristles with spoon-shaped, widened points is a particularly apt illustration of niche construction. However, the notion of construction that is central to Uexküll’s philosophy, and that will be used in this paper, refers only indirectly to the shaping of the physical environment by the organism. The construction of the *Umwelt* is the generation by the organism of the world it experiences³. Uexküll explicitly models this process on Kant’s account⁴ of how the transcendental subjectivity provides the necessary structure that makes our experience possible: “with Kant, we make the constructive activity of the subject the very center of our consideration” and understand “space as the means whereby we construct external experience” (von Uexküll, 1926, p. 19). Brentari (2013, p. 17) summarizes the “transcendental construction of the *Umwelt*”: “the stimuli coming from the outside reality are translated into signs by the nervous system, then the physiologically produced signs are transposed outwards and, finally, they are experienced as objective qualities of the world.” Only by locating all the signs it has constructed outside of itself does the subject span open the spatial dimensions of its own experiential world, somewhat like opening an umbrella. This world that is experienced by the organism which has constructed it is at the heart of Uexküll’s thought. I will refer to it as type 2 *Umwelt* in contrast to the deflationary usage of type 1 *Umwelt*.

Many of the examples that Uexküll uses reappear throughout his works, but their presentation is often subtly different from text to text. The case of the semicircular canals helps illustrate how Uexküll expresses the same idea in different ways that emphasize either type 1 or type 2 *Umwelt*. In *Forays*, Uexküll describes the effect space of humans and relates its three-dimensional structure to the semi-circular canals in the inner ear (von Uexküll, 2010, pp. 54–56). We can understand the relationship between effect space and the physiology of the inner ear purely in terms of type 1 *Umwelt*: The observable behavior of the experimental subject and their verbal reports allow us to investigate the space that structures their behavior, while the physiology of the semi-circular canals provides a potential mechanism in the organism that can ground the capabilities of the subject to interact with their environment in a way that is spatially structured. The entire connection between spatial behavior and the inner ear can be explained without any special reference to the subjective experience of the organism.

²Uexküll’s appeals to Kant concern almost exclusively the role that the structure of the subject plays in enabling its own experience of time and space. Interestingly, Uexküll makes no mention of the *Critique of Judgment* and Kant’s notion of organisms as autonomous *Naturzwecke* (natural purposes), even though this aspect of Kant’s thought has been argued to play a crucial role in the work of early biologists like Karl von Baer, whom Uexküll cites favorably and who was “one of the principal architects of the teleo-mechanist research program” according to Timothy Lenoir’s account of the influence of Kant on early 19th century German biology (Lenoir, 1982, p. 16). While some teleo-mechanists treated organismic teleology more as a methodological commitment, Uexküll’s use of romanticism instead of Kant’s *Critique of Judgment* leads him to treat it as a fully real part of nature.

³For a discussion of this distinction in enactivism and ecological psychology, see Fultot et al. (2016).

⁴The references to Kant’s *Critique of Pure Reason* in this paper reflect the level of Uexküll’s reception thereof, rather than the intricacies of Kant’s actual philosophical system. A careful comparison between the two would be worthwhile, but constitutes a separate research project. Langthaler (1992) provides some short but useful remarks on the matter.

The same connection is described in *Bausteine zu einer biologischen Weltanschauung* (1913) with much the same content but very different implications. As in *Forays*, Uexküll compares the semi-circular canals to a coordinate system with three dimensions that allows us to experience objects as located in space. In this early text, however, the role of the semi-circular canals is explicitly introduced as an update to the Kantian account of the three spatial dimensions. In Uexküll's account, Kant declared space to be a "structural element of our soul" which exists before any external impressions take place and which allows them to be synthesized into unities (von Uexküll, 1913, pp. 284–286). Uexküll considers Kant's claim that the three dimensions of space exist preformed in our "soul" without the need for any external cause to be outdated: the discovery of the role played by the semi-circular canals has provided us with a physiological substitute for Kant's idealist subjectivity (von Uexküll, 1913, pp. 286, 287). This is a rare critical note, as Uexküll presents his thought as a more harmonious continuation of Kant's enterprise in his later texts (von Uexküll, 1926, p. 15). It is worth pointing out this earlier stance as a counterweight to the view of Uexküll as naively overestimating his proximity to Kant (Langthaler, 1992, pp. 232–234; Winthrop-Young, 2010, pp. 230, 231). Even though Uexküll's reading of Kant may be unsophisticated and philosophically crude, he was aware of the crucial difference between Kant's teachings and his own empirically informed account of the constructive process that gives rise to *Umwelt*.

Part of the difficulty with Uexküll's concept of *Umwelt* arises because at different times he writes about the environments of animals as a scientist or as a philosopher of nature, and sometimes as both. When Uexküll invites us to "make a bubble around each of the animals living in the meadow" and imagine these bubbles as their *Umwelten*, he invents for us an exercise of the philosophical imagination (von Uexküll, 2010, p. 43). The poetic tone of the *Forays* is not due to an arbitrary stylistic preference. Uexküll studied Kant together with the poet Rainer Maria Rilke, and his respect for nature was a deeply personal attitude (Winthrop-Young, 2010, pp. 230, 231). But the reason for this change in style is more systematic: When the description moves from functional cycles to bubbles, Uexküll the scientist has passed the baton to Uexküll the philosopher of nature. There are two very different intellectual activities involved here: a scientific research program into the behavior of animals and a philosophy of nature that considers each organism as a subject experiencing its own world (Godfrey-Smith, 2001). While the two are deeply connected, there are also clear differences in their methods and limits, and depending on the task at hand, Uexküll moves freely between the two perspectives. These shifts are not made explicit, which makes them hard to track. The transition from type 1 to type 2 *Umwelt* is the move from a scientific research project to a philosophy of nature. It is clear that in the case of the bubbles we are dealing with experience: in imagining ourselves entering the bubble and seeing the world transformed, we are imagining the experience of the animal.

The role of experience is absolutely crucial for the concept of *Umwelt*, which is why any account of it that omits type 2 *Umwelt* is problematic. *Umwelt* as the world experienced by a living subject is at the heart of Uexküll's project. It grounds his most important points, from his insistence that every organism is a living subject and not just a machine all the way to his claim that the limitations posed to the knowledge of any subject by its *Umwelt* apply also to human scientists, which concludes both *Foray* and *A Theory of Meaning*:

"We can certainly get closer to all things through the use of increasingly precise apparatuses, but we do not gain any more sensory organs thereby, and all the properties of things, even when we analyze them down to the smallest details—atoms and electrons—will always remain only perception marks of our senses and ideas" (von Uexküll, 2010, p. 207).

The situation that Uexküll describes is the same one that Varela, Thompson, and Rosch diagnose at the start of *The Embodied Mind*: "we are in a world that seems to be there before reflection begins, but that world is not separate from us" (Varela et al., 1991, p. 3). Uexküll shares with enactivism the awareness that philosophers and scientists investigating minds should never lose sight of their own minds as the context in which these investigations take place. Similarly, they both start from the conviction that mind cannot be explained while ignoring experience. This is why any productive reception of Uexküll's thought in the philosophy of cognitive science will have to grapple with type 2 *Umwelt*, and it is also why doing so might be relevant for the task of furthering rapport between ecological psychology and enactivism.

UMWELT IN THE PHILOSOPHY OF COGNITIVE SCIENCE

Discussions of Uexküll in the philosophy of cognitive science have become more detailed recently, especially in debates about embodied cognition. Yet a deeper sensibility for his thought has only just begun to spread, and several decades of Uexküll's presence in the literature as a mere foot- or sidenote have shaped the vague and sometimes distorted image of his thought that is now still prevalent. It is worth briefly illustrating the range of these different interpretations or misreadings of Uexküll's thought. Members of the general philosophical audience interested in the study of cognition might well encounter Uexküll for the first time in the works of Daniel Dennett. In his 2015 he writes:

"Every organism, whether a bacterium or a member of *Homo sapiens*, has a set of things in the world that matter to it and which it (therefore) needs to discriminate and anticipate as best it can. Call this the ontology of the organism, or the organism's 'Umwelt' (von Uexküll, 1957). This does not yet have anything to do with consciousness but is rather an 'engineering' concept, like the ontology of a bank of elevators in a skyscraper: all the kinds of things and situations the elevators need to distinguish and deal with. An animal's 'Umwelt' consists in the first place of affordances (Gibson, 1979), things to eat or mate with, openings to walk through or look out of, holes to hide in, things to stand

on, and so forth. We may suppose that the ‘Umwelt’ of a starfish or worm or daisy is more like the ontology of the elevator than like our manifest image. What’s the difference?” (Dennett, 2015, pp. 11, 12).

The difference is that organisms are living subjects and machines are not. It is immediately clear that Dennett’s use of the term *Umwelt* is diametrically opposed to Uexküll’s in a crucial dimension: For Dennett, there is absolutely no difference between living organisms and machines, while for Uexküll this difference is of primary importance, and the whole project of developing a philosophically grounded concept of *Umwelt* is launched as a direct attack on the “machine theory of living beings” (von Uexküll, 2010, p. 41). What exactly *Umwelt* has to do with consciousness depends on the precise definition in play, but *Umwelt* is directly related to subjective experience. In the same text, Dennett rehearses his position that there is no “no double transduction in the brain” that would transduce the neuronal spike trains into “qualia, conceived of as states of” “the medium of consciousness” (Dennett, 2015, p. 11). It is precisely this position which Dennett rejects that meshes rather well with Uexküll’s account of *Umwelt*. The process whereby “the stimuli coming from the outside reality are translated into signs by the nervous system” which “are transposed outwards and [...] experienced as objective qualities of the world” can be understood as the construction of just this medium of consciousness that Dennett denies (Brentari, 2013, p. 17). Dennett’s account of *Umwelt* is opposed to Uexküll’s in at least two respects: the relationship between experience and the brain, and the relationship between animals and machines. It is of course perfectly legitimate for Dennett to disagree with Uexküll, but giving the appearance of agreement where none exists is bound to mislead. Since his most recent book *From Bacteria to Bach and Back* (2017) contains the same account of *Umwelt* as the passage cited above, it is possible that many members of Dennett’s (2017) large audience will be first introduced to a distorted version of Uexküll’s thought.

Within the field of embodied cognition, one of the most widely read texts in which readers may encounter a brief description of Uexküll’s *Umwelt* is Andy Clark’s *Being There: Putting Brain, Body, and World Together Again* (1997). Clark introduces *Umwelt* as a conceptual precursor to “niche-dependent sensing” in robotics and defines it as “the set of environmental features to which a given type of animal is sensitized” (Clark, 1997, p. 24). His explanation of the concept is short and centers on a citation of Uexküll’s popular passage on the tick. From Clark’s description, it is not clear whether an *Umwelt* involves experience or not, but he embeds it in a larger account of a robot called Herbert and concludes that the “similarity between the operational worlds of Herbert and the tick is striking” (25). This makes it at least possible to understand *Umwelt* as unconcerned with experience from Clark’s account, but whether other authors who suggest that robots have *Umwelten* were directly influenced by Clark or not cannot be established. Clark himself, at least, clearly believes that *Umwelt* without experience is possible, more than two decades after *Being There*: “A simple robot could [...]

properly be assigned an *Umwelt*. But the simple affordance-sensitive robot need not thereby experience any world at all” (Clark, 2019, p. 284). This is in contrast to Uexküll, for whom having an *Umwelt* is the same as experiencing it.

UMWELT AS A BRIDGE BETWEEN ECOLOGICAL PSYCHOLOGY AND ENACTIVISM

Baggs and Chemero (2018, p. 5) argue that *Umwelt* allows ecological psychology to better account for the specific way in which each animal perceives its environment, bringing it closer to enactivism. In keeping with central tenets of the ecological approach, they argue that “the environment is not a separate mental realm,” but rather a mere “subset of the physical world, considered from the vantage point of an animal.” Their goal is then to show how *Umwelt* can be derived from an account of the physical world. They advance two complementary arguments. The first focuses on the environment and describes a single world which is continuous across the different scales of physical universe, species habitat, and individual *Umwelt*. The second focuses on the individual organism and explains how different physiological abilities as well as learned skills and acquired knowledge determine which affordances present in a given habitat become part of an individual’s *Umwelt*. I will focus here on the first argument and argue that it does not adequately account for experience because it treats the creation of *Umwelt* as selection, rather than construction, and thus does not address type 2 *Umwelt*. This latter sense of *Umwelt*, however, is what Baggs and Chemero need to get at if they want Uexküll’s thought to provide ecological psychology with an account of experience that is closer to the enactivist perspective.

The “key to Gibson’s theory of affordances” is his distinction between physical space and the environment of animals (Baggs and Chemero, 2018, p. 4). A central part of this concerns scale: the “physical world exists at all spatial and temporal scales, from nanoseconds and nanometers to millennia and galaxies” (Baggs and Chemero, 2018, p. 4). In contrast, the environment of animals occupies the “middle scale,” and for humans the “spatial scale of the environment is from millimeters to kilometers; the temporal scale is from hundreds of milliseconds to decades” (Baggs and Chemero, 2018, p. 4). This distinction gives us the impression of zooming in on the *Umwelt*, from the complete picture of the universe to just the tiny section of it that is relevant for a species, and even further to just the *Umwelt* of a given individual organism. This visualization is in concord with the attempt to describe one single continuous world, and matches the description of *Umwelt* as a “subset of the physical world” (Baggs and Chemero, 2018, p. 5). There is, however, one problem: “Most crucially, the physical world is inherently meaningless, but the environment is not; the environment contains affordances” (Baggs and Chemero, 2018, p. 5). If the physical world is a set which contains no meaning, no subset of it can contain any meaning either, by virtue of how sets and subsets are defined. Similarly, optical magnification can only enhance features which

are already present in a visual phenomenon; we cannot zoom in on something that is not already there to begin with.

The central difficulty is that ecological psychology holds that there is just one world, one physical space, while Uexküll believes that “[s]pace as we think of it is the space with which the physicist deals, while intuited space as we look at it is the space of the biologist. The two are fundamentally different from one another” (von Uexküll, 1926, p. 42). Already committed to a single world, Baggs and Chemero can only select different parts of it and thus cannot move from type 1 *Umwelt* to type 2, i.e., they cannot account for the subjective experience of the organism. This is because the fundamental perspective of looking at the organism from the outside never changes, it merely zooms in on a subset of the environment in which this organism lives and on that subset of all affordances potentially available to the species which this specific individual can actually perceive and act upon, based on its history and physiology. In order to account for subjective experience, we have to consider both the scientific perspective on an organism from the outside and its own experience from the inside. Even in this account of an ecological psychology which deals with individual organisms and their type 1 *Umwelt*, this perspective from the inside, type 2 *Umwelt*, is left out.

UMWELT IN ENACTIVISM

It may be that enactivism is better poised to grapple with *Umwelt* type 2 because it has had a strong focus on the experience of cognizing subjects from the very outset. Since *The Embodied Mind* (1991), a central influence on enactivism has been the structured exploration of one’s own consciousness, drawn predominantly from Eastern traditions and from the phenomenology of Edmund Husserl and Maurice Merleau-Ponty (Varela et al., 1991). In Thompson’s (2007) *Mind in Life* (2007), *Umwelt* appears at crucial points:

“This idea of a sensorimotor world—a body-oriented world of perception and action—is none other than von Uexküll’s original notion of an *Umwelt*. An *Umwelt* is an animal’s environment in the sense of its lived, phenomenal world, the world as it presents itself to that animal thanks to its sensorimotor repertoire” (Thompson, 2007, p. 59).

Thompson emphasizes the experiential character of *Umwelt*, which makes sense given that this reference to Uexküll follows a discussion of Maurice Merleau-Ponty and Kurt Goldstein, both of whom developed critical readings of Uexküll that grappled with the central role of experience (Merleau-Ponty, 1968, 1988; Goldstein, 1995). The process of constructing an *Umwelt* is explained as sense-making, an activity that each organism has to engage in constantly to maintain itself within the delicate bounds of its “needful freedom” (Jonas, 2001, p. 80; Thompson, 2007, pp. 146, 147). The needful freedom of the organism is what gives valence to the “[p]hysical and chemical phenomena” in the environment of the organism which, “in and of themselves, have no particular significance or meaning” (Thompson, 2007, pp. 153, 154). “Sense-making changes the physicochemical world into an environment of significance and valence, creating an *Umwelt*

for the system” (Thompson, 2007, p. 147). In his exposition of Varela’s claim that “living is sense-making,” Thompson posits seven points, among them that “[e]mergence of a self entails emergence of a world. The emergence of a self is also by necessity the co-emergence of a domain of interactions proper to that self, an environment or *Umwelt*” (Thompson, 2007, p. 158).

Thompson’s account emphasizes central aspects of type 2 *Umwelt*, its experiential character, its emergence from the activity of every living organism, and the one-to-one mapping of subjects—or selves—to *Umwelten*. However, large parts of Uexküll’s thought have not been taken over into Thompson’s enactivist account: the entire semiotic vocabulary is left out. Where Uexküll uses signs to describe relationships of meaning, Thompson instead employs a notion of information that is derived in part from the work of Scott Kelso:

“What could be more meaningful to an organism than information that specifies the coordinative relations among its parts or between itself and the environment? This view turns the mind-matter, information-dynamics interaction on its head. Instead of treating dynamics as ordinary physics and information as a symbolic code acting in the way that a program relates to a computer, dynamics is cast in terms that are semantically meaningful” (Kelso, 1995, p. 145, quoted in Thompson, 2007, p. 58).

Thompson’s combination of type 2 *Umwelt* with Kelso’s notion of information is ingenious and important for two reasons: First, it shows that the essential insight of type 2 *Umwelt* can be retained while discarding much of Uexküll’s often cumbersome and idiosyncratic terminology. Second, Kelso’s work on dynamics and the notion of information that is part of it lie at the heart of 21st century ecological psychology. Its central role in both schools suggests that Kelso’s notion of information might be one good place from which to work toward a unified ecological-enactive approach as “a working metatheory for the study of minds” (Chemero, 2009; Baggs and Chemero, 2018).

FROM CONSTRUCTIVISM TO HOLISM: UEXKÜLL’S MUSICAL THEORY OF MEANING

Fultot and Turvey (2019) reject Uexküll’s claim that each organism constructs its own world as representationalist. They highlight how the construction of *Umwelt* as modeled—in an idiosyncratic way—on Kantian epistemology parallels key aspects of cognitivism that ecological psychology rejects. Their rejection of *Umwelt* thus follows from their full appreciation of type 2 *Umwelt* and the process of its construction. Instead of the concept of *Umwelt* which entails that there are “as many worlds as there are subjects,” Fultot and Turvey develop an understanding of nature as a unified world in which all elements are harmoniously interconnected by melodies, harmonies, and counterpoints of meaning from a reading of Uexküll’s *A Theory of Meaning* (von Uexküll, 1926, p. 70, 2010).

To argue against Uexküll’s doctrine of many worlds, Fultot and Turvey recapitulate Gibson’s rejection of the Gestalt theorists’

subjectivist conception of “[A]ufforderungscharakter”, which Gibson translated as “affordance” (Fultot and Turvey, 2019, p. 14). They note the links between Gestalt theory, Gibson and Uexküll, but also emphasize the conceptual tensions between them. In his development of affordances as “organism-relative without being organism-dependent,” they take Gibson to be implicitly “targeting von Uexküll’s theory and theories like it” (15). The argument hinges on the question of whether there is “a unique, private access of each individual organism to its surroundings,” which Uexküll endorsed and Gibson rejected (15). Fultot and Turvey follow Gibson in tracing this view back to the fact that “no two individuals can occupy the same geographical point at the same time” (15). According to Gibson, the primary reason to think that each living organism lives in its own subjective world is based in “a narrow conception of optics and a mistaken theory of visual perception” (Gibson, 1979, p. 38, quoted in Fultot and Turvey, 2019, p. 15).

Read as a criticism of Uexküll, this appears to miss the mark. The problem that Uexküll’s constructivist account of *Umwelt* seeks to solve is posed in terms opposed to those of Gibson’s ecological approach. Where Gibson considered a single environment containing meaningful affordances and which “all inhabitants have an equal opportunity to explore,” for Uexküll the main explanatory work has to start earlier (Gibson, 1979, p. 38, quoted in Fultot and Turvey, 2019, p. 15). The problem is not that different organisms cannot occupy the same point in an environment at once, it is that they each have to construct their environments from scratch. Once an organism perceives meaningful affordances, indeed as soon as it experiences any environment at all, we are already *in medias res*, and much of what Uexküll describes has to have taken place already as the condition of the possibility of this experience. The *Umwelt* of an animal has to be accounted for because the colors that a bee sees are neither part of the objective material world described by the physicists, for whom there are “only waves, after all, and nothing more,” nor do they coincide with the colors that humans see von Uexküll (2010, p. 134). More than that, each bee has to generate their own experience as an organismic activity in contact with its physical surroundings. The dynamical relationship of the organism to its physical surroundings gives rise to its subjective experience of its *Umwelt*.

Fultot and Turvey point out the sharp contrast between Uexküll’s Kantian constructivism and the conceptual underpinnings of Gibson’s direct realism. As an alternative to the notion of *Umwelt*, they introduce a second theory of meaning in nature found in Uexküll’s *Bedeutungslehre* (first published in 1940). This later text, which was published in English translation as *A Theory of Meaning* together with the slightly earlier *Foray*, develops an account of why the structures of living organisms fit so perfectly into their environment of other organisms and the inorganic world. As a staunch critic of Darwinism, Uexküll sees the harmonious composition of the natural world as evidence of a greater plan that orders the realm of the living into one overarching symphony of meaning, composed of countless melodies, harmonies, and counterpoints.

Fultot and Turvey highlight a series of parallels between Uexküll’s musical theory of meaning and Gibson’s emphasis on

a “complementarity between organism and environment” that enables the former to directly pick up on affordances specified by information available in the latter (18). They outline two ways of conceiving the organism/environment relationship, as the familiar representationalist dualism that is to be rejected, or as a *duality*, which involves a different kind of symmetry between organism and environment. Where a representational symmetry involves “the preservation of all the relations and their order,” duality preserves “the number of relations but can transform their quality and revert their order” (19). Representation entails the creation of duplicates or copies, while duality works on the basis of correspondences, such as the peg of a cogwheel fitting into the socket of another.

Two problems with this evaluation of Uexküll’s musical theory of meaning arise: First, the account of meaning in nature as one great holistic symphony does not replace the constructivism of *Umwelt*, it complements it. Second, the arguments that Uexküll provides in support of this musical theory of meaning are quite different from the Kantian constructivism of *Umwelt*, but they are not free from conceptual baggage. On the contrary, they are drawn in part from Hans Driesch’s neovitalism and Goethe’s romantic holism. These views depart so radically from generally accepted philosophical assumptions in contemporary philosophy of the natural sciences that they require substantial amounts of conceptual work before they can be integrated into existing accounts of embodied cognition.

In their careful reading of *A Theory of Meaning*, Fultot and Turvey identify an “implied realism about the properties of the environment” (20). They cite Uexküll’s description of an octopus, where he states that the “incompressibility of the water is the precondition for the construction of a muscular swimming sac” (von Uexküll, 2010, p. 173). The incompressibility of the water does depend on the existence of the octopus as subject, illustrating the point that the role played by seawater in the meaningful activity of swimming is “organism-independent yet organism-relative” (Fultot and Turvey: 20). “Meaning is *already there*, so to speak” (Fultot and Turvey: 20). Two points relativize this realism. Even though we are taking an external perspective on the octopus that allows us to understand its place in a system of meaning by reference to a larger harmonious whole rather than purely as constructed by the octopus itself, *A Theory of Meaning* does not constitute a departure from Uexküll’s *Umwelt* theory. Besides the musical theory of meaning, the text still contains the same constructivist view of how a subject creates its *Umwelt*: “The sun is a light in the sky. The sky is, however, a product of the eye, which construct here its farthest plane, which includes all of environmental space” (von Uexküll, 2010, p. 190). According to Uexküll, this principle of how a subject constructs its phenomenal *Umwelt* is valid for octopi just as it holds for humans, and scientists too can only ever investigate their own *Umwelten* (von Uexküll, 2010, p. 207). The incompressibility of the water has octopus-independent reality, but always within the *Umwelt* of a subject. In this case, the subject is a musical ecologist analyzing “the octopus as subject in relation to the seawater as carrier of meaning” (von Uexküll, 2010, p. 173). Uexküll ends both *A Theory of Meaning* and the *Foray* with the reminder that the limitations of *Umwelt* also apply to our scientific endeavors.

Fultot and Turvey are clearly exaggerating when they consider “his Kantian views having been abandoned” (24).

As *Umwelt* grows out of Uexküll’s reading of Kant, so his musical theory of meaning grows out of romanticist holism and the neovitalism of Hans Driesch. Uexküll and Driesch had met in Naples in the 1890s, where Uexküll was researching the physiology of *Eledone moschata* while Driesch studied the development of sea urchins (Mildenberger and Herrmann, 2014a, p. 5, 2014b, pp. 274–276). Driesch demonstrated that “a sea urchin germ cell cut in half became not two half, but two whole sea urchins of half the size,” which to Uexküll demonstrated that nature is not exhausted by mechanical explanation and warranted far-reaching conclusions: “Everything physical can be cut with a knife—but not a melody” (von Uexküll, 2010, p. 194). Uexküll agrees with Karl von Baer that there is a “goal-pursuing quality in the emergence of living beings” and identifies musical harmony as the driving force of this teleological embryogenesis:

“planned embryonic development [...] beings with the three beats of a simple melody: morula, blastula, and gastrula. Then, as we know, the development of the buds of the organs begins, which is fixed in advance for every animal species. This proves to us that the sequence of formal development has a musical score which, if not sensorily recognizable, still determines the world of the senses. This score also controls the spatial and temporal extension of its cell material, just as it controls its properties” (von Uexküll, 2010, pp. 159, 160).

To today’s reader, the role of the melody in this account of embryogenesis is at best a poetic placeholder that has to be replaced by scientific explanations and at worst a kind of vital life force. The latter option is unfortunately very plausible, as Driesch was a leading proponent of neovitalism (Mildenberger and Herrmann, 2014a, pp. 5, 6). While Fultot and Turvey choose to ignore Uexküll’s appeals to an overarching plan in nature as “creationist-sounding,” it seems that his vitalistic tendencies are tightly linked to the musical account of biological form and cannot so easily be separated from it (Fultot and Turvey, 2019, p. 18).

The second philosophical source from which Uexküll’s musical theory of meaning draws its strength is a romanticist holism. The melodies, harmonies, and counterpoints are an *explanation* rather than a *description* of the organization of the biological realm only if we accept a holistic worldview in which wholes determine their parts in accordance to an overarching and preexisting schema, rule, or “*primal image [Urbild]*” (von Uexküll, 2010, p. 159). This principle, which we saw in action in the embryogenic formation of a sea urchin in accordance to its “primal score,” goes back to Goethe’s famous *Urpflanze* (160). Frederick Amrine has outlined Uexküll’s deep debt to Goethe, with whom he sides against Newton in the question of color perception (Amrine, 2015, p. 50). Amrine explains Uexküll’s musical theory of meaning as an instance of Goethean ecology, and his arguments are convincing: A central refrain in *A Theory of Meaning* is developed from Goethe:

“If the flower were not bee-like,
If the bee were not flower-like,

The harmony would never succeed.” (von Uexküll, 2010, p. 198)

This is based in Goethe’s claim that:

“Were the eye not sunlike
It could never gaze upon the sun” (von Uexküll, 2010, p. 190).

The vision of nature that Uexküll expresses in musical terms is deeply grounded in romanticist holism, and the “meaning plan” which guarantees that its parts, developing in accordance to their “primal images” and “primal melodies,” fit into the overarching harmony is guaranteed by Goethe’s spinozist “God-Nature” (von Uexküll, 2010, p. 192). The problem for us today is that Uexküll is tapping into an entirely different conception of science than the one that has dominated the last centuries and that is accepted today. For Uexküll, “[m]eaning is the pole star by which biology must orient itself, not the impoverished rules of causality” (von Uexküll, 2010, p. 160). Besides its roots in romanticism, Di Paolo provides another good reason for caution about holistic harmony:

“while we must avoid the flattening out of the biological and psychological worlds into a series of mechanisms, we must also be cautious with the theme of the harmony of the world [...] if we understand harmony as a primordial state of mutually counterpunctual relations of meaning (“the spider is fly-like”). Here, what is excluded, to repeat, are the precarious conditions and the ongoing, effortful processes by which meaning is achieved whatever the timescale, whether evolutionary, developmental, or behavioral” (Di Paolo, 2019, p. 254).

In the context of Uexküll’s holism, it is worth mentioning that his belief in a great whole that unifies individual organisms under one rule of meaning found a deeply disturbing expression in his *Staatsbiologie*. In 1920, Uexküll first published this interpretation of the state as a biological organism. After Germany’s defeat in the First World War, Uexküll had become increasingly antisemitic and began channeling this conviction in his academic writing (Mildenberger and Herrmann, 2014b, pp. 294, 295). A second edition of the book published in 1933 included a partially rewritten section on “the diseases of the state [Die Krankheiten des Staates],” which identifies members of foreign races who are detrimental to the state as “parasites” (von Uexküll, 1933, pp. 59, 72). Uexküll concludes the book by praising the “ingenious doctor” into whose care Germany has delivered itself as a “deeply sick patient”—a reference to Adolf Hitler (von Uexküll, 1933, p. 79; Winthrop-Young, 2010, pp. 226, 227). These connections between romanticist holism and fascism in Uexküll’s work are deeply disconcerting (cf. Harrington, 1996). To be clear, the musical holism of *A Theory of Meaning* itself contains none of these vile totalitarian biologisms, and using its concepts in ecological psychology would not thereby import anything objectionable. However, it still seems important to mention this aspect of Uexküll’s work in any discussion of his holism.

One problem with using *A Theory of Meaning* to bolster an account of the organism/environment relation in embodied cognition is that its main function in Uexküll’s work is to provide an account of the appearance of design in nature. This was a desideratum for Uexküll because he firmly rejected

the Darwinian account. That is not a pressing question for us today. Few people doubt that our best explanation for why the spider spins a web that corresponds so well to the structure of the fly will invoke Darwinian evolution. The potentially useful part of *A Theory of Meaning* is its account of meaning understood through the musical concepts of harmony, melody, counterpoint, and so on. However, most of the arguments given in support of this musical account derive from neovitalism and Goethean ecology. Were we to remove all elements that are not immediately compatible with our contemporary understanding of natural science, *A Theory of Meaning* does not seem to offer much argumentative support for an account of how organisms are attuned to their environments. There are interesting parallels to Gibson's ecological approach, and some of Uexküll's descriptions provide vivid illustrations to the principles of ecological psychology, but it is unclear what is added to its explanatory power or conceptual clarity by bringing in Uexküll's musical idiom.

Even if we accept Uexküll's musical theory of meaning and the overarching harmony guaranteed by its elusive plan, this only accounts for the appearance of design in nature, not for the experience of living subjects. What the musical holism explains is why the different organisms observed in nature appear to fit each other and their environments so perfectly. This explains why the *Merkwelt* and *Wirkwelt* of type 1 *Umwelt* fit together in functional cycles. It does not contain an account of why the execution of functional cycles involves subjective experience. Uexküll's musical holism does not appear to offer any help in grappling with the problem of accounting for subjective experience in a scientifically grounded account of mind—the “explanatory gap between consciousness and nature” (Thompson, 2007, p. 10).

CONCLUSION

We have seen that Uexküll's concept of *Umwelt* is fundamentally concerned with subjective experience. A deflated account of *Umwelt* as a mere ‘engineering concept’ is still widespread in the philosophy of cognitive science, but it does not help address the problem of subjective experience and is only tangentially related to Uexküll's philosophical project. Since the point of contention between the ecological and enactive approaches is the status of subjective experience, only the full sense of *Umwelt* as the unique subjective phenomenal world of each organism is relevant for this debate. However, this sense of *Umwelt* is not immediately compatible with deeply held commitments of

ecological psychology, as Fultot and Turvey point out. If some specifics of Uexküll's Kantian constructivism are omitted, *Umwelt* seems compatible with enactivism, but this compatibility depends on the degree to which enactivism is understood as constructivist.

Uexküll's compositional theory of meaning, which Fultot and Turvey propose to adopt instead of *Umwelt*, poses some difficulties that have been pointed out above. It does not do the same job as *Umwelt*, since it does not account for subjective experience as such but only for the observable complementarity between the different parts of nature. Its original purpose, to provide an alternative explanation for the appearance of design in nature for those who reject Darwinism, does not seem useful to us today. Importantly, the compositional theory of meaning is based entirely in Uexküll's adoption of Goethe's romanticist philosophy of nature and Hans Driesch's neovitalism. This means that it does not come with less metaphysical baggage than *Umwelt*, just with a different kind. If ecological psychology were to adopt the compositional theory of meaning, it would have to deal explicitly with this philosophy of nature that appears to be quite far removed from the philosophical foundations of the ecological approach.

To establish a common philosophical foundation for a joint ecological-enactive approach to the study of cognition, more work seems necessary than importing new concepts from Uexküll, or from some other thinker. The main benefit of *Umwelt* for this particular debate may be that it provides a structured and principled account of how subjective experience constitutes the worlds we perceive and act in which allows ecological psychologists and enactivists to systematically assess their points of agreement and rejection. By itself, this will not unite the two approaches. But may well give us a clearer picture of the specific structure of their disagreements and the underlying philosophical commitments that cause them. The difficulty of accounting for subjective experience in any theory of mind suggests that a true unification of the two approaches may only be possible if both sides are at least in principle willing to question some of their most longstanding beliefs. If the central philosophical intuition of *Umwelt* is taken to be correct, mind after Uexküll can only be understood in light of the foundational character of subjective experience.

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The author confirms being the sole contributor of this work and has approved it for publication.

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Zoom Out Camera! The Reflexive Character of an Enactive Account

Fred Cummins*

UCD School of Computer Science, University College Dublin, Dublin, Ireland

The reflexive character of enactive theory is spelled out, in an effort to make explicit that which is usually implicit in debate: that we are responsible for the distinctions we draw, and that ultimately, the world that we collectively characterize is a joint production. Enaction, as treated here, is not a positivist scientific field, but an epistemologically self-conscious way to ground our understanding of the value-saturated lives of embodied beings. This stance is seen as entirely congruent with the scientific field of ecological psychology, which is itself then cast as a specific example of the kind of science that can be done in an enactive mode.

Keywords: enaction, laws of form, ecological psychology, reflexivity, adaptivity

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Mario Villalobos,
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Dave Ward,
University of Edinburgh,
United Kingdom

***Correspondence:**

Fred Cummins
fred.cummins@ucd.ie

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1. INTRODUCTION

At the end of Alejandro Jodorowsky's cult film *The Holy Mountain*, the pilgrims have shed themselves of their worldly attachments, have ascended the mountain, and there is every expectation that enlightenment, or some form of spiritual elevation will be found at the summit. Instead, one of the figures at the table on top of the mountain turns out to be the director, and he turns to face the camera. "Zoom out camera!" he instructs unambiguously, and as the camera pulls back, we reinterpret the whole situation as a group of actors on a set. We see the boom microphones, the props and the make-up assistants, all the trappings of the making of a film. Conventions are made to be broken, and the provocation or perturbation that happens to the audience when the fourth wall is broken like this has been played with since the Proscenium Arch was first erected.

One effect that can arise is that the viewer is solicited to enter more fully into the fictional world, as when the player of a video game is encouraged by an on-screen character to have the player's avatar engage in the action. Far from placing the player outside of the fiction, this serves instead to enlarge the magic circle, so that the player is now, to some extent, in the world of the fictional beings (Conway, 2010). When Kevin Spacey winks at the camera in *House of Cards*, it is likewise to include the viewer as a co-conspirator, not to negate the drama.

Another effect that might happen is disenchantment or alienation. When the audience is directly addressed, the fiction is unmasked as nothing more than fiction. They must abandon the pleasant conceit and face a stark reality. This kind of cold shower for the imagination was used by Bertolt Brecht as a way of directly infusing urgent political content into the distraction of the theatrical play. After disenchantment, there is no pretending any more. This is what Jodorowsky does too, though for rather different purposes. "What?" he seems to say. "You expected enlightenment from a film? Pick up your own damn cross and carry it!"

Jodorowsky's challenge to the viewer resembles the challenge that an enactive account presents to those who engage with it. The injunction this time might better read "You expected an account of reality from a model or a story? Own your own distinctions!" Let's explore some of those distinctions.

2. TWO ACCOUNTS OF THE ENACTIVE CELL

The most frequently presented exemplary embodiment of the central concerns of the enactive literature is the wistful picture of a lone cell in a petri dish, equipped with a single glucose sensor hooked up to its means of propulsion, and mechanically locomoting toward a distant nutrient source (Cummins and De Jesus, 2016). In picking out one direction rather than another, the cell is drawing a distinction. We need to develop an awareness of the difference between the distinction the cell is drawing (self/non-self) and the distinctions we draw (picking out a cell, a source, a medium, etc.). The cell knows nothing of chemistry or geography, but is, as far as we can tell, pursuing the project of its own continued existence. To us, the cell appears to be acting in its own interests by swimming toward a nutrient. In the example, glucose is taken to play a role in the metabolic economy of the cell, and the business of detecting the ambient glucose gradient, and hence navigating toward the source, pretty much exhausts the sense-making activity of the cell. Sense-making, here, is the regulated exchange with the surrounding petri dish that the cell conducts in order to persevere as a distinguishable unity, as, indeed, a cell.

Why is this picture redrawn, again and again? In Cummins and De Jesus (2016) we explored this central narrative myth in detail. We listed Maturana and Varela (1987, p. 148/149), Thompson (2007, p. 74), Barandiaran et al. (2009), Froese and Di Paolo (2011), and Egbert et al. (2010). Many more examples could have been adduced, and the chemotactically swimming cell continues to thrive in the literature, if not in the petri dish. Formally, the model cell, as we describe it, illustrates no more and no less than a first order cybernetic system, not terribly different from a thermostat or a heat-seeking missile. Such a system can be understood as a concrete embodiment of an abstract notion of control, provided by the set point to which the system converges through negative feedback with its environment: for the thermostat, that is a temperature that lies within specific bounds which are determined by the user; for the missile, it is a trajectory that converges on a pre-specified target selected by the programmer. What is the equivalent of the temperature or the target for the cell? If we are to accept the claims of the enactive literature it is the cell's own persistence as a dynamically individuated entity that we are observing. Unlike the thermostat or the missile, this purposiveness is understood by us to originate with the cell itself, to be emergent, expressing the perplexing "natural purposes" of the living organism (Weber and Varela, 2002). Here, we should feel the 4th wall straining, as we become aware that our own recognition of the cell as a dynamically individuated entity cannot be separated from any account of the cell as a unity. Our attention is captured by the cell as a minimal form of life, persisting in the only way it can, asserting itself in its sense-making. By contrast, in the domain of observation that we bring forth, the cell is a mechanism that swims toward the glucose source, with apparent purpose. This is a disenchanting account, of the kind science likes to construct, but it is not a simply objective account. It is teleonomic in

form¹, in that it attributes an "as-if" purposiveness to the cell, allowing the cybernetic characterization. It is an account that we have framed by drawing specific distinctions. It is objective, but an objectivity in parentheses, as Humberto Maturana frequently puts it (Maturana and Poerksen, 2004). We can see our own role in bringing forth the domain of observation by pulling back to become aware of the ground from which we draw distinctions.

One obvious reason for the centrality of the account of the lone cell is that contemporary enactive theory draws inspiration from the theory of autopoiesis associated primarily with Maturana and Francisco Varela (1980). Autopoiesis was, and is, a hugely influential account of what it means to be a living being, and it was articulated in the chemical domain of the cell, with due regard for the complexities of biochemistry. Although some have tried to retrospectively identify an "autopoietic" school of enactive thinking (Hutto and Myin, 2013), the term "autopoiesis" did not appear in the volume "The Embodied Mind" (Varela et al., 1991), usually understood to be an original source text from which enactive theory draws, and autopoiesis is and remains a theory of philosophical biology, not a general theory of enaction. This distinction has often been blurred, to the point of eradication, as theoreticians concerned with the characterization of autonomy in terms of operational closure have chosen to describe many kinds of biological and social systems as autopoietic (Luhmann, 1995; Hutto and Myin, 2013). This genie can probably not be put back into the bottle, and we will have to contend with the confusion of autopoiesis and autonomy in the future. But there are some very important characteristics of the account of the cell, developed in autopoietic theory, that go on to inform and shape all enactive theory. I will draw some of them out as best I can, seeking to situate the concerns of enactive theory in a broader landscape of motivated theorizing. The reader is warned that the niceties of distinction drawn here are not always presented in the same way or with an identical concern in the enactive literature.

2.1. The Domain of Operation

The cell exhibits *operational closure*. This means that we understand the cell to consist of a set of circularly linked processes of production, which we might caricature as A producing B producing C ...producing A². The processes produce something, of course, and what they produce are the components required to keep the processes of production going, and of course the boundary that contains all those processes. This is the recursive character of the self-producing processes within the domain of operation of the cell: they produce themselves, and in so doing, the unity perseveres from one moment to the next. These processes are not a perpetual motion machine, of course, and so some form of energy supply is needed to keep the whole affair ticking over, along with some means of getting rid of waste. The cell thus engages in regulated exchange with its surround, through careful upkeep of a border, the membrane, across which

¹The distinction between teleonomy and teleology is crucial here. Teleology is concerned with purposes that exist. Teleonomy is concerned with accounts that refer to purposes, in the understanding that such purposes do not really exist, but could be replaced, in principle if not in practice, by a more expansive account.

²More fulsome descriptions are available, e.g., in Di Paolo (2019, p. 5).

substances may be taken in or released. However, in the domain of operation of the cell, there is no representation of an exterior, and there is no appeal to purpose, goal, or function, even in the teleonomic sense. The register within which the processes are described is deanimated, free of any tinge of agency. There is simply the ceaseless churn of self-production, and when it stops, so too does the cell as a living entity. In this way, Maturana and Varela describe the autopoietic unity as a “machine.”

2.2. The Domain of Observation

We now need to pull back and consider the cell in its immediate physical and chemical context. Having recognized the cell as a bounded self-producing unity, we can now distinguish it from other elements that we see around it. We, as observers, can see the mindless churn of the cell as achieving self-production and self-distinction simultaneously (Di Paolo et al., 2018). In the case of the cell, the membrane itself makes clear (to us) the separation between cell and non-cell. The cell/non-cell distinction is spatial, bounded, and easy to point out. If we move on to consider other autonomous unities, this is work that would need revisiting. As we consider the cell in its environment, we will need the teleonomic frame we met above to characterize the cell as a cybernetic system. This is because the activity of the cell becomes more intelligible to us, as observers for whom it is a distinguished self-producing unity, if we speak of the “function” of glucose in its metabolic economy, or the “function” of its movement as being the acquisition of nutrients. Function reflects purpose. Functional ascription is thus available to us in the domain of observation, but not in the domain of operation. Did we just open a chink to unbounded teleological explanation of the kind associated with Aristotle, and shunned by latter-day science? No, but the charge has to be taken seriously.

I will here simply adopt the position of Varela (1979, p. 73) who points out that the two forms of explanation, operational and observational, are both to be understood relative to the perspective of some observer(s)³. Our hypothetical observers might hope to exhaustively characterize the steps within the domain of operation, itemizing reactants, catalysts, and products, measuring reaction rates and quantifying ingredients and products at each step in the circular chain of production, and thus arrive at a naturalized, causal, account of goings on. This seems to be a reasonably finite task (cell biologists may demur, but we are concerned here with matters of principle alone). In contrast, understanding the causal chain that gave rise to this particular form of organized matter, and its structural coupling to its surround, seems to be an impossible task, even in principle. The ascription of function or purpose then is to be understood as a form of shorthand, “conceptually abbreviating the intermediate steps of a chain of causal events, and concentrating on those patterns that are particularly interesting to the inquiring community” (Varela, 1979, p. 73). Teleonomy is not teleology,

and the appeal to function serves to make things intelligible to the observers, who have chosen to make specific distinctions.

In laying out things in this way, Varela has introduced a crucial semiotic distinction between the domains of causal and of symbolic explanation, motivated by the explanatory requirements of a specific observer, or, more importantly, a community of observers—for explanation is a public act. A fully causal, or nomic, account of the cell would require the inclusion of an uncountable number of variables, interacting over millennia, nay billions, of years, and would thus not satisfy the demand for explanation of any community. But not everything in that history is relevant to the community’s intentions in regarding the cell as indicated by them, and those aspects of the cell that are of interest are well-accounted for by ignoring the causal chain and describing the resulting relationships with recourse to teleonomic terms.

Varela expands on this thus:

The possibility of choosing to ignore intervening nomic links is at the base of all *symbolic* descriptions. What is characteristic of a symbol is that there is a distance, a somewhat arbitrary relationship, between signifier and signified. This is, of course, very immediate in human discourse: Words and their contextual meanings have such a remote and involved historical and structural mode of coupling that any effort to follow such nomic connection is hopeless (Varela, 1979, p. 73).

3. OF INDICES, ICONS, AND SYMBOLS

The introduction of the notion of distinct causal and symbolic forms of explanation opens the door immediately to semiotic issues, and we might feel it necessary to ask about the processes of elision, compression, selection, and exclusion that are assumed to underlie the teleonomic, or symbolic, account we provide in the domain of observation. The confident assertion that we might arrive at an acceptable explanation (for a specific community) with free use of teleonomy, without thereby introducing the bugaboo of teleology, requires some careful consideration. It is virtually axiomatic in the hard sciences (physics, inorganic chemistry) that an undisciplined appeal to function or purpose turns any account into mere wishful thinking, while functional ascription is riotous and exuberant in the psychological and social sciences. Ecological and biological fields have their own specific reliance upon certain kinds of functional description. A biology of the organism is unthinkable without appeal to function, but an ecological picture becomes more complex as the environment turns out to be constituted by and constructed by other living agents. Neo-Darwinian accounts of evolution typically eschew any appeal to function. Care is needed here, and the territorial issues that arise run deep. In particular, it would behoove us to be as aware as we can be of the frame of any specific discussion, with its attendant unwritten commitments, and its selective delineation of entities and processes, which, in being discriminated, thereby bring a discursive landscape into being within which some things can be expressed, and others not.

A possible starting point to ground such discussion lies in the twilight domain of human somatic physiology, with one foot

³The manner in which this distinction between the observational and operational domains is treated in the broad context of enaction is not always well-aligned with the similar distinctions drawn in the more specific context of autopoietic theory, and the reader is warned that my elaboration here straddles the two fields somewhat uneasily. Thank you to one of the reviewers for drawing my attention to this potential confusion.

securely in biology and the other steeped in human values and normativity. Here we might hope to refine our use of terms, and to prepare the ground for subsequent discussion in more contentious domains. We can take as our anchor, as the hinge on which everything turns, our shared understanding we (as a collection of observers, including you, the reader) have for the importance of the integrity of the individual human body. It requires little debate to agree that we need stories in which the continued persistence of the human living body features as a central element. Such accounts may, perhaps, be teleonomic, but they are no less secure for all that, precisely because we share this common ground, this unstated and inalienable interest in the integrity of the human body. We usually do not have to argue this, or better, if we adopt a stance toward the body that does not presuppose this singular value, we will immediately alienate other people with whom we jointly observe, describe, and discuss things (different conversations may develop from different starting points, with different framing considerations, and different attachments to obligatory value commitments).

Given this common ground, it is now unproblematic to provide two distinct, but non-contradictory, accounts of what the heart is doing. In the domain of operation, we will observe a complex unity composed of several cell types that displays gross collective movement organized as a regular pulsation by means of an appropriate distribution of nerve cells. In this operational description, there is no place for any appeal to function. We ask what are the parts of the heart, and how do they interoperate. The heart, in this account, is a machine.

When we pull back and view the heart in its larger context, we are drawn inexorably to consider its position as one organ in a larger composite whole, the human body, in which we have a concerned interest. Note that we could have chosen other frames of reference, other contexts, within which the pulsation of the heart would be a contingent detail, playing no organizational role. However, in adopting the frame of physiological integrity, we now see the heart as a pump. Its role in this context is to pump blood, and the circulation of blood is an integral part of the sense-making activity of the body considered as a whole as it perseveres from one moment to the next.

The importance of these framing considerations that allow us both a mechanical and a teleonomic account of the heart is made clear by Stafford Beer in his preface to Maturana and Varela (1980): “Note that Aristotle thought that the brain was a ‘human radiator,’ namely an apparatus for cooling the blood. Note also that he was right” (Maturana and Varela, 1980, p. 68). Framing is, in a sense, everything.

Varela describes the teleonomic account as “symbolic” because the continuous causal chain of a fully nomic account has, of necessity, been interrupted in order to discuss the unity as it appears to our curious gaze. This introduces a possible challenge to any scientific account that leans on such a description, should the abbreviations and simplifications that lie between the teleonomic account and a strictly causal account be refused by the collection of observers. This tension is an old one, long predating the theoretical biology of autopoietic or enactive theories. To examine this a little further, I will make use of the tri-partite distinction between index, icon and symbol most commonly

associated with Charles Pierce, though my interpretation of these three key terms will be my own. All three terms speak of an intentional relation between a sign of some sort, and the grounded incarnate reality of which the sign speaks. The sign of which we here speak is an element within the domain of description, whether it be operational or observational, for all descriptions must employ words, symbols and the like. We might take the situated collective discourse as an interpretant.

An *index* arises when there is a causal link that we can follow exhaustively⁴. This is typically conceived of as a single step in mediation. The body contracts a disease, and spots appear on the skin. The spots stand in a causal relation to the pathology and allow confident inference about the underlying condition. The spots are an index. A polaroid photograph of a scene might likewise be considered an index, as we can follow all causal steps from the photo in our hands back to the distribution of light in the original scene (more elaborate forms of photography complicate things precisely because of representational hiatuses that are introduced and the complex embedding of the original registration in distributed patterns of activity, e.g., digital storage on computers).

A *symbol* stands in a purely conventional relation to the world. Causal links are not traceable in any complete sense. A symbol might be replaced by another and, if the convention be adopted, the symbol-referent relation will be preserved.

Between these two extremes lies the *icon*, and here I depart more radically from Pierce’s account somewhat to adopt a more expansive view of icons as they have featured throughout millennia in religious wars and periods of iconoclasm, in which the topic of heated disagreement (real wars!) lies in the interpretation of the links between the descriptive element or sign (an icon) and its presumed referent. Pierce relies on a notion of “similarity” between icon and its referent, but the notion of similarity turns out to be untrustworthy, as well-argued by Goodman (1976). I will instead ask about the chain we must follow to trace a path from sign to referent.

To a member of one of the Orthodox churches, which place a high value on icons as objects of veneration, an icon is not an arbitrary picture. It arises within a tradition, and the process of icon production carefully guards against free invention and whimsy at every point within that tradition. Innovation does occur, of course, but it is strictly controlled, and acceptable only when introduced by those steeped in the tradition. An icon is typically a copy of another icon, and the lore of the tradition traces specific icons back through a chain of careful copies to some original. Of course the view of what an “original” is must be left to those who lie within the tradition, but in an idealized form (equivalent, perhaps, to the physicist’s spherical cow in a vacuum) we might consider an origin in an *acheiropoieton*, an image not made by human hands, such as the image of Christ’s face imprinted on the towel of Veronica, or the shroud of Turin, which has been claimed to be a direct imprint of Christ’s body

⁴There are accounts of indexicality in which causality here is explicitly ruled out. I mean a one step overt chain of mediation, from pathology to spot, from face to cloth, as causal, mediated through direct contact or continuity, without any representational hiatus, and uncontested within the frame of a specific discourse.

in the tomb. The first image, the acheiropoieton, is index-like, in that it stands in a causal relation to the original. Within the icon tradition, copies made from such an index likewise stand in a chain, and the chain extends all the way to the situated present. Of course this is not a causal chain in the sense implied by a naturalized account, but the chain is not arbitrary either, and the theoretical possibility of tracing the intervening steps is central to the structure of the icon making tradition. This may be a matter of faith, but it is a faith of the kind we ourselves display when we regard the steps of mediation as unproblematic that would serve to bring the operational and observational accounts into alignment.

Iconoclasts object. The reasons for objection are inevitably mired in the political discourse of the day, and the terms of the debate, and its resolution, will differ from one instance to the next. It is not necessary here to tease out fine distinctions between worshipping an image or statue and merely venerating it, though such debates have been important in allowing iconic traditions to persist into modernity. The core of the iconoclasts' objection is, however, very similar to the disenchantment that arises in scientific accounts when we adopt the strongly objectivist stance of the hard sciences and bar any appeal to function. The trust in an unbroken chain, it is asserted, is misplaced. The hiatuses are unbridgeable.

Varela asserted above that any effort to follow the nomic relations that gave rise to a specific embodied organization we observe and describe is hopeless. This is the practical impossibility outlined also in Cummins and De Jesus (2016) who considered the limitations of a first order cybernetic sketch of the enactive cell as so often presented in the literature. The cell appears as an already-formed unity whose originary story is not miraculous, but is also not something we can make perfectly explicit, as doing so would require simultaneous description of the entire history of the organism, and its sociality, that is, its history and the history of everything it had interacted with and everything those things had interacted with, and so on until we are forced to draw the entire history of the cosmos into our account. There is no obvious limit to the degree to which the contingencies of history and prior interaction (and the prior historical trajectories of each of the interactants) are relevant to the present observations. Put baldly: some assumptions are going to be necessary if we are to assert anything at all of substance, or, to paraphrase Richard Feynman: In order to answer any why question, we must be within some frame of reference, in which some things are simply allowed to be.

Varela is asking us, as embodied beings, to join the faithful. The faithful here is merely the set of embodied beings who try to understand their world and its inhabitants, from singular perspectives rooted in the unity of the personal body. The trust that is required is that it might be possible, in principle, to move from the teleonomic observational description to the mechanical operational description, even if such a move is impossible on practical grounds. The reasons we might be willing to join him is the logical coherence of the framing which makes the activity of the living intelligible to us, and the desire to develop accounts in which the singular perspective associated with the individual body is a central anchor. The consensus we arrived at with respect

to the heart provides grounds that we might cautiously grow such accounts to better understand what it is to be an embodied being. No guarantees are provided.

4. THE INNOVATION OF ADAPTIVITY

Adaptivity was introduced in Di Paolo (2005) as an attempt to bridge the link between an operational (mechanistic) account of the cell and an observational account (teleonomic). It was noted that the strict separation of the two accounts left an explanatory gap, as there was no obvious way in which the operational description of a cell could take into account operating conditions in which the continued flourishing of the cell was threatened by external conditions. The proposed additional concept of adaptivity to the vocabulary of enaction sought to allow a view of the cell as *self-regulating* with respect to the boundaries of its own viability. Absent this additional concept, the activity of the cell could not be properly viewed as sense-making.

Di Paolo identifies two separate normative dimensions that call out for recognition in an account of a living unity. The first is the norm exhibited by an autopoietic entity, resulting in the continued process of self-maintenance and self-distinction. The second is the norm of sense-making, which must, it seems, appeal to homeostatic (i.e., cybernetic) concerns and is thus not available in the purely operational terms provided by autopoietic theory. I suspect that Di Paolo is correct in his view that some notion of self-regulation is necessary to understand the living being as a locus of self-concern, and that this does not follow from the strictly causal account provided by the domain of operation.

The norm generated by autopoiesis, which produces and distinguishes the unity simultaneously, allows us to recognize when it has been violated: the cell is dead. As a norm, this must be apportioned to the domain of the observer, for it was we who chose to pick out the cell as a unity. The norm that distinguishes existence from non-existence never played any role in the domain of the operation of the now deceased cell. In this respect, we might also recognize a norm arising from the suite of atmospheric and topographical processes that bring into being a tornado. Here too, if we have chosen to identify a tornado as a dynamically individuated entity, we can distinguish between situations in which it exists, and when it goes away again. There is no suggestion I am aware of that a tornado actively regulates the condition of its own existence, and if one were to characterize any such activity, it might be viewed as likely to succumb, upon further study, to a purely nomic account, devoid of any teleonomic terms. But tornadoes belong in a different conversation. We are here concerned with unity and autonomy as exhibited by the living.

Crucially, there is more than mere existence as a dynamically individuated entity at stake here. With respect to the discursive exemplar of the chemotactically ascending cell, Di Paolo notes "Bacteria will not seek higher concentrations just because they are autopoietic, since improving the conditions of self-production is not part of the definition of autopoiesis" (p. 437). Rather, self-production, in this case, requires that encounters with the world

are “evaluated” by the system in as much as they contribute to the maintenance of autopoiesis. In the absence of such evaluation, it would appear that an autopoietic account might preclude any satisfactory account of stress, illness or fatigue, for the cell is not provided with any means to notice or respond to changes in its environment that do not actually kill it. This is an important lacuna for any biological theory of the organism.

However if we come back to the strictly separated domains of operation and observation, we find that the mechanical characterization of the cell that is repeated again and again provides almost all the required machinery to carry out this “evaluation” in a strictly non-teleological manner, for the cell as described is not just a collection of metabolic processes, but it is conventionally described as having means for registering the ambient glucose concentration over time, and means for allowing that determination to modify the probability of switching from a random to a directed mode of locomotion and back again. This is the first order cybernetic machine we noted above. Augmenting this mechanism with a graded response to ambient glucose concentration provides a similarly mechanical implementation of adaptivity. It is a carefully drawn sketch of what it is to be sensitive to something. As with any such machine, the goals that we recognize are external, as imposed by the designers of the machine, which is us as we make distinctions in the domain of observation.

What seems to be missing here is the assent of the community of observers that the teleonomic description could, in principle if not in practice, be unrolled into a much larger nomic account, without any fanciful inventions. This is the leap required of the observing community by Varela in order to “conceptually abbreviat[e] the intermediate steps of a chain of causal events, and [to] concentrat[e] on those patterns that are particularly interesting to the inquiring community” (Varela, 1979, 92). In Cummins and De Jesus (2016) an argument was made that two essential elements were missing from the portrait of the enactive cell that must be included in any account of any living organism: historicity and sociality. Each of these precludes any exhaustive reckoning for any real case, making the causal chain strictly untraceable, leaving us with the necessity of evaluating, for ourselves, the plausibility of the leaps and bounds required to produce the cell we see. The mechanical elements that do the heavy lifting, steering the cell toward its nutritive source, have been drawn by us, on the shared understanding that the cell is not merely alive, but self-regulating.

Reliance on the untestable assumption that the two domains of observation may be reconciled in principle if not in practice may look worryingly like a leap of faith, rather than a strongly objective scientific programme. I want to suggest that this is not quite accurate, it is not necessarily a problem (though it demands being taken seriously), that it opens the way toward a scientific epistemology grounded in the embodied concerns of the living, and that the need to introduce adaptivity to such an account demarcates an important development in enactive theory that takes it beyond autopoiesis, and has consequences for the further development of such theory.

5. OF THE QUESTION OF NATURALIZATION

I have deliberately employed scandalous terms, such as “faith” and “faithful” as a counterweight to the repeated use of the terms “science” and “nature,” “natural” and “naturalization” as they have been wielded in the enactive literature, taking particular note of their use in motivating the innovation of adaptivity in Di Paolo (2005). I do this to draw out the necessary tension that arises around what might be considered a “naturalistic” account. The term “naturalization” is wielded most often when the concepts in play seem to be of dubious ontological status, relying on assumptions that have been freely invented, rather than painstakingly induced through observation. Thus, for example, Barandiaran (2017) asserts that theories of autonomy provide a “naturalized account of normativity,” Di Paolo, drawing on Jonas, discusses a “naturalization” of teleology, and asserts that the suite of fundamental notions that enactive theory has received from autopoietic theory needs to be augmented with the notion of adaptivity in order to “naturalize sense-making” (Di Paolo, 2005), which in turns leads to considerations of “natural agency.” Weber and Varela (2002) provided a somewhat convoluted argument that sought to “naturalize teleology” without falling into the trap of reductionism. Behind the desire to naturalize our accounts stands the hope that the hiatuses that interrupt the symbolic account can, in principle, be unified with the continuities of a causal account, so that apparent teleology will be shown to be no more than mere teleonomy.

When we maintain care in our distinctions between the operational and observational domains, it is of paramount importance that we examine the extent to which we are relying on appropriate epistemological foundations. The reflexive self-awareness of the observer (community of observers) drawing a distinction is a central part of any enactive account, and this second-order cybernetic injunction precludes any unthoughtful appeal to a simply existing world. Rather, it requires that the distinctions drawn be uncontroversial for the observing community. This rules out unreflective reliance on notions of the physical (pre-existing? products of physical theory? or merely uncontroversial?), the objective, or even the natural. We can illustrate this by appeal, once more, to how the heart features in an operational and an observational account. It would not be unreasonable to describe William Harvey’s influential account of the circulation of the blood (1628) as a naturalization of the role of the heart in the economy of the body. The account was not immediately accepted, but needed further argumentation and the test of public debate to come to its present role as a generally shared understanding. This consensus was possible as it was effective at making intelligible to a broad community how the heart *functions* given the framing context of the body’s physiological organization. The 2-fold view of the heart is, I hope, not perceived to be at variance with the tenor of scientific accounts.

We might be reminded at this juncture of the traditional contrast between emic and etic accounts of the form of structured human behavior. This distinction was introduced by Ken Pike

(1967) to bring coherence to our descriptions of many domains of human activity. The origin of the contrast lies in the relation of phonetics (etic) to phonology (emic). Phonetics deals with uncontroversial observables: muscles, spit, waveforms of vibrating air, ear morphology, and so on. Phonology is an abstract structural domain of discrete elements (phonemes) which, it is asserted by linguists of a certain stripe, constitute basic element of a language. One might adopt an iconoclastic position with respect to the abstract domain of phonology (Port and Leary, 2005), and yet merrily work alongside a phonetician, whose observations are grounded, at least potentially, in the secure space of physical (here, meaning only uncontroversial) measurement. Emic accounts require us to agree on the structure of a domain in terms agreed by specialist practitioners. Such an account is an insider account, drawn in terms meaningful to those who subscribe to the discursive frame. It co-exists with etic accounts which might be understood as those made by outsiders, or that are couched in terms accepted and presumed by all discussants, without prior commitments to the dimensions and distinctions of the emic story.

The emic/etic distinction has traveled far afield. The need to accommodate insider and outsider views of cultural forms of organization arises, for example in cultural anthropology (Harris, 1976), cross-cultural psychiatry (Marano, 1982), comparative legal studies (Morris et al., 1999), ethnomusicology (Alvarez-Pereyre and Arom, 1993), cross-cultural psychology (Triandis et al., 1993), and many other fields of comparative social science. This allows parallel descriptions of one and the same event to be couched, one drawing on distinctions accepted and required by insiders, and another that requires no such commitment. So, for example, an etic account of the Roman Catholic sacrament of the eucharist would document liturgical form, event sequences, historical development, aesthetic qualities, etc., while an emic account would note that the event of transubstantiation takes place at a particular moment in the ritual, after which the host is changed in substance. Emic and etic accounts can exist in felicitous parallel as long as such borders are clear, as Pike's own use of a church service and a football match remind us.

To many, autopoiesis seemed to open the way to finally arriving at scientific, objective, accounts of what it is to be a living being. Enactive theory has grown beyond the autopoietic characterization of the single cell, and has set its targets on multi-cellular entities, and their social and ecological domains. At stake here is the foundation of scientific epistemology for science as conducted by embodied beings in the domain of the living. The rush to subsume enactive accounts under a science that has itself not yet developed such an epistemological foundation seems to this author to run counter to the promise that enaction holds out. The cautious distinctions between causal and symbolic accounts, together with the insistence that the community of observers bear responsibility for the distinctions they draw, suggests that the sciences of the living might be better understood as rooted in the kind of reflexive care that enaction has to offer, rather than viewing enaction as a specialization within scientific discourse. For it is in the care of drawing distinctions that are adequate to the task of explanation to a specific community that enaction can provide a foundation for epistemology in which the tools,

methods, and insights of science can flourish. This is a bold claim, but one that might merit consideration as we take stock of what role scientific argumentation will play in a future in which our own position within the biosphere is threatened, and an urgent need arises to reconsider what a truly ecological science, capable of understanding the interdependencies of the living, might look like.

In a recent volume, Latour (2017) lays out a cogent argument that the concept of "nature" has become an impediment to our understanding of ourselves, our world, and our practices. "Nature" has played several different and incompatible roles in all such accounts. On the one hand, it has been thought of in operational terms (to adopt our present conceptual vocabulary). It is the non-negotiable domain whose characterization must be free of normative claims, for this is simply how things are. On the other hand, nature has been conceptualized as pointing the way toward felicitous being in the world, set apart from artifice, corruption, pollution, human hubris, as we speak of the nature of a species, of human nature, or of 100% natural yoghurt. Nature, here is strongly normative. When prescription (normativity) and description (operational accounts) become confused and inseparably entangled, there is no way in which our common articulation of a shared understanding can be rendered apolitical. Embodied beings are beings with specific vested interests. A science done by and for embodied beings is never free from the negotiation of the collective whose joint observations, and consensual distinctions, provide its raw material.

Latour does not offer a simple substitute. By leaning on the provocative figure of Gaia (Latour, 2017), he introduces a view of the territory we live on as multiple, contested, and saturated with agencies we are only beginning to recognize, but with which we have to contend. Gaia is a muddle and a mess, not a unified causal domain, and the frequent misunderstanding of Gaia as some kind of self-regulating super-organism is absolutely not what is being proposed. There is no helmsman in charge of the whole. The shift that is required is from a thoroughly disenchanting deanimated world driven by inexorable Laws of Nature to recognizing that the biosphere is animated through and through, with different kinds of organizational unities interacting, each affecting and being affected by others, each constituting part of the environment for the other, so that the notion of "an environment" goes away entirely, consigned to the same scrapheap of legacy concepts, such as Nature, or even Human.

The familiar distinction of humankind separate from the natural world is as incoherent, in his view, as the idea that we can cleanly separate the cultural, symbolic domain from the deterministic and causal. Once more we are faced with the task of reconciling symbolic and causal accounts, but, under the new climatic regime, or as he puts it, after the ecological mutation, our task is not merely clarification and the sharpening of the distinctions we draw. Rather, it is a diplomatic task in which we construct our best objective accounts using the tools and methods of science, to learn how to co-exist with others on the only territory that is available to us. An objective account, in this framework, is not the pristine transparent representation of an immutable truth, but an account that can withstand objections. This was the lesson William Harvey had to learn too.

Ecology clearly is not the irruption of nature into the public space but the end of “nature” as a concept that would allow us to sum up our relations to the world and pacify them (Latour, 2017, p. 36).

The emic/etic distinction is importantly different from a contrast between causal and symbolic accounts. Emic accounts make sense to insiders, whether they be phonologists, economists, or shaman. Etic accounts make use of uncontroversial observables (for a specific community), but they are necessarily prior to the commitment to any specific emic interpretation. Yet in considering our position among the living, we are all, to some extent, insiders. There is no outside vantage point we can adopt from which to illuminate an external reality. There is no outside. We are here. The process of pulling back, enlarging the frame to include our own commitment to distinctions that make our observations intelligible, goes on indefinitely (Nagel, 1986). Autopoiesis kicks things off, by providing a specific account of what the unity is that we see as a cell. Enactive theory goes further, not by changing its origins, but by drawing further distinctions as different kinds of unity are considered. As the questions change, so the set of concepts that we rely on, that we are happy to consider etc., will change.

Adaptivity seems to provide one such extension, and to point the way to which the general enactive framing will make possible specific kinds of scientific accounts within specific domains. The innovation of adaptivity is to regard one link in the chain of mediation as closed, by taking particular cybernetic norms as given, and in need of no further justification to a specific community of observers. In consideration of the metabolic sense-making activity of a lone cell, it is by no means difficult to assent to this, no more difficult, in fact, than to accept the role of the heart as a pump. But it is useful to recognize what we have done when we provide such assent. Joint recognition of the autopoietic nature of the cell was possible because we recognized it as a self-producing unity. Joint assent to the innovation of adaptivity is a further step, one that embeds all subsequent accounts that build on it within the frame of sense-making by the unity observed.

6. ON LEVELS AND DISTINCTIONS

Varela (1979) produced a formidable formalization of the enactive agenda in his *Principles of Biological Autonomy*. In that, he extended the foundational work of Spencer-Brown (1969) as laid out in his enigmatic and profound *Laws of Form*. Spencer-Brown tries to find a starting point for formal description that is prior to both mathematics and logic, and he does so by taking as given the idea of *distinction* and the idea of *indication*. A distinction, we might observe in the present context, is drawn by a community of observers when they pick out, by indication, something to characterize. The unity that is at the origin of the autopoietic account is distinguished by being so picked out. At the outset, Spencer-Brown says “There can be no distinction without motive, and there can be no motive unless the contents are seen to differ in value” (p. 1).

To embodied beings, the motive is clear. We recognize the cell as a minimal form of life, and we understand its sense-making as an activity that continuously produces the distinction between

self and non-self. We value the living over the inert. This is the starting point for the enactive programme. It is not the starting point for all formal or informal discussion, but it is a principled starting point when we wish to progress to a scientific account that can be relevant to the lives of individual embodied beings.

Louis Kauffman describes the intertwining of the observer and the observed thus (Kauffman, 2017, p. 11):

An organism is seen, by an observer, to make a distinction. By starting with a distinction we understand how (for an observer) the organism exhibits structural stability and autonomy, and becomes an exemplar of the living. This notion of distinction is crucial to our understanding of the nature of an organism and the nature of life itself. The distinction is a joint creation of the organism in its environment and the observer. Together they give life to the organism. The distinction does not appear without the observer, and the distinction that is the organism does not appear without the actions of the organism, producing itself from itself through components taken from and given back to the environment.

The introduction of adaptivity in order to license the cybernetic machinery of the lonesome cell draws a further distinction. This too is motivated, but the motive is a step further than the indication of a distinguished dynamically persisting unity. One could draw further distinctions, for many reasons. It is a long way from the cell to any account of a multi-cellular body, and along the way, our accounts will involve the drawing of distinctions that might be contested. Distinctions drawn within one domain of discourse may be pursued and refined, while they may be never drawn in a separate discourse.

Within the calculus of indications developed by Spencer-Brown and used by Varela, we can draw further distinctions predicated upon any starting distinction, traveling down into a world of detail and structure. We can also undo distinctions, popping back up to higher levels, and allowing different subsequent courses of discrimination, with different commitments. This calculus formalizes the operations which are both kataphatic (drawing distinctions) and apophatic (undoing distinctions). If kataphasis produces positivist assertions, apophasis tentatively undoes prior distinctions, allowing us to regard the effect of such distinctions, and the landscape that opens up if we had chosen other distinctions and pursued other debates⁵. We can get a sense of how this applies to the discussion of the cell by contrasting the operational and observational levels of description.

At the operational level, the cell recursively produces itself. It does so with no reference to any environment. Environmental influences are seen as external perturbations, uninterpretable, though exerting influence on the processes of production. The components of the cell are taken as given and we pay attention to their mutual relations.

When we pull back and consider the cell in its environment, the cell, which was characterized as a suite of processes, is now cast in a different role, as a distinguished *thing* that

⁵Iconoclasm seeks to disenchant by denying specific attributions; Apophasis is a rhetorical move, allowing consideration of alternative framings and starting points.

exhibits a *behavior*, predicated upon inputs (glucose readings) and outputs (locomotory activity). Calling something a *behavior* is a cybernetic, purposive, characterization. It comes at the cost of simplifying the account of the cell, removing reference to recursive self production, and the important simplification that the outputs of the cell are assumed to simply land in the environment, without consequence for its characterization.

We can continue to pull back. To quote Varela once more:

The cell biologist emphasizes the cell's autonomy, and views the organism of which it is part as little more than a source of perturbations for which the cell compensates. But the physiologist views the cell as an element in a network of interdependences constituting the individual organism: This corresponds to a wider view of environment, namely the ecology in which the individual participates. A population biologist makes his distinctions at a still higher level, and largely ignores the cell. A similar hierarchy of levels can be found in the social sciences. It seems to be a general reflection of the richness of natural systems that indication can be iterated to produce a hierarchy of levels (Varela, 1979, p. 85/86).

Varela here might be misunderstood, and the misunderstanding can best be seen by returning to our opening theme of breaking the fourth wall, which can have two contrasting effects: widening the magic circle, or extinguishing the drama.

Widening the circle is analogous to the approach taken by Nagel to "objectivity":

To acquire a more objective understanding of some aspect of life or the world, we step back from our initial view of it and form a new conception which has that view and its relation to the world as its object. In other words, we place ourselves in the world that is to be understood. The old view then comes to be regarded as an appearance, more subjective than the new view, and correctable or confirmable by reference to it. The process can be repeated, yielding a still more objective conception (Nagel, 1986, p. 4).

For Nagel, this process never stops. There is no view from nowhere that cannot be improved by pulling back, and forming a larger, more encompassing view that takes our position as observers into some account. The magic circle continues to expand, but the drama never stops either. It just gets bigger, as if all descriptive accounts could be accommodated within a single regime of truthful correspondence. The nature of the account at one level is also not fundamentally altered as we move up and down the levels. Introducing the hermeneutic reference to our own role as observers does not change the characterization of anything that went before. It may serve to relativize our previous account, but it does not fundamentally change it. To the extent that it admits of continued enlargement, this approach to scientific description is universalizing in its character, and in the asymptotic limit it would reach a picture of "nature" where all truths are written.

Latour, to whom this universalizing approach to nature is anathema, lampoons the idea of a universal regime of truth. In his 2013 Gifford Lectures on Natural Theology, he takes David Hume as his foil, and says:

For him, it seems, there is just one regime of truth that he may use exactly in the same fashion to ask his butler if he should carry an umbrella to visit his friend, Adam Smith, if his mistress loves him for good, if Cromwell was born on the 25th of April, 1599, or if God is a spider, an architect, or a giant vegetable (Latour, 2013).

Latour is, of course, more sensitive than most to the muddles that arise when we pretend that objective descriptive accounts can be cleanly separated from those that lean on function, purpose, or behavior. The sensitivity to the responsibility of the community who draw distinctions makes all such scientific work inherently political, and the reliance on indubitable commitments of a community of observers makes religious considerations a necessary part of ecological discussion too.

Varela is not relying on this kind of universalizing approach to "nature." Here, we might return to the deflationary effect produced when breaking the fourth wall, as Brecht and Jodorowsky employ it. When we draw our attention to the role of the observers in drawing distinctions, we do not simply add the observer as another represented element within a somewhat enlarged discursive domain. Rather, it becomes clear that the observer community is always a participant in founding the epistemology. A participatory epistemology is revealed in which describer and described are interlocked. In Spencer-Brownian terms, we say that the distinction is reentered in the space of the observer, making those drawing the distinction responsible for the distinctions they draw. "Own your own distinctions!" is the injunction.

7. ECOLOGICAL PSYCHOLOGY AND ITS RELATION TO ENACTION

The field of ecological psychology seems to be poorly named. It is not concerned with most of the broad concerns that motivated the foundation of scientific psychology, often enumerated as experience and behavior. On the experience side of the account, it has nothing to say about phenomenology, experience, emotions, or feelings⁶. Two of the three central pillars that have enabled the construction of the psychological subject, perception, attention, and memory, are omitted altogether, while the third, perception, is redefined in relational terms, thereby radically transforming the notion of perception to something quite alien to all internalist theories. It typically addresses the control of behavior with minimal reliance on an executive controller. The term "ecological" is also unfortunate. It fails to take any engagement with ecology seriously as it inevitably assumes a physical environment as a given, and it ignores the interdependencies of multiple life forms. Perhaps a rebranding is in order?

Yet it has provided some of the most assured, insightful and powerful accounts within the domain of perceptually guided action. The old injunction to ask what the head is inside of,

⁶My ecological colleagues will rightly disagree, as a great deal of recent work, e.g., by Rietveld, Chemero, and others, significantly expands the scope of ecological accounts. Here, I draw this picture in broad and crude strokes, leaning on early canonical work that has come to partially define the field, and in that limited context, I believe, the field is built in terms foreign to most of the field of psychology.

instead of what is inside the head, turns out to set an excellent working agenda, that can be tackled using clearly defined concepts, empirical variables that can be directly measured, and to produce insights about the fit between the capacities of an organism and its immediate physical surround. The technical innovation of the affordance allows such relations to be explored in functional terms, relative to the goal-directed behavior (Chemero, 2003).

To many researchers, most of the present contributors included, there seems to be something quite compatible between the subject-world relation explored reflexively within enaction and the organism-surround relations laid out and quantified within the Gibsonian frame. And yet nothing in the foregoing discussion would be at home in an ecological psychology account. Why?

Let us take, as an illustrative example, the famous account of diving gannets by Lee and Reddish (1981). The work is sufficiently well-known that we can skip almost all of the details, looking only at those aspects that speak to the ongoing discussion. In that work, the expanding pattern that must be present on the retina of a perpendicularly diving bird as it approaches the textured surface of the water was considered, and found to be highly informative. Specifically, the time to contact with the water was directly available in a variable τ , derived from the rate of expansion of inhomogeneous elements in the optical pattern on the retina. Recognizing that this valuable information is just there for the taking greatly transforms our understanding of what the bird is doing, and what part of that might be apportioned to internal mechanisms. Gannets must dive with outstretched wings, but must retract them before entering the water. The presence of information on the surface of the retina about time to contact allows us to vastly reduce the explanatory load on hypothetical internal mechanisms, requiring little more than a thresholding mechanism to trigger wing retraction. Without the insight provided by the relational analysis, one might be fooled into attributing all kinds of complex computations and discriminations to the bird's brain (Van Gelder, 1995). The analysis transforms our view of what is going on completely.

But note the frame that is assumed by this analysis. We have a bird and a physical environment, both of which are taken as given. We have a behavior that is also presumed, with no reference to the observer. Because all organisms must feed, the behavior seems uncontroversial, and in need of mechanical explanation. Indeed, mechanism seems to be the preferred type of explanation in much work within the field (Golonka and Wilson, 2019). To the extent that behavior and environment are characterized to the satisfaction of a community of observers, the Gibsonian analysis appears especially insightful. The relation often described as “perception-action” is given a quantifiable objective (in these particular parentheses) characterization.

But a bird is far more than a mere organism. The enactive use of the term organism is usually grounded in consideration of the minimal form of life, the cell. Calling something an organism leaves much unsaid, but the frame will license discussion of some specific kinds of behaviors common to all organisms: feeding, excreting, locomoting, and perhaps a few more. Where most scientific psychology is still lamentably prone to using normative

and teleological constraints as if Vitruvian Man were the accepted norm for a human, we have no Vitruvian Organism we can rely on. Diving for fish, wing-spreading and retraction are not behaviors that are common to all organisms, but they make sense in the shared discursive frame of the diving gannet viewed by behavioral scientists. Other organisms might leave us less secure in our framing of behavior or environment. Microscopic marine monsters, eyelash mites, corals, these cannot be viewed in the same way as a diving bird or a playing human child.

When ecological psychology employs the term “organism,” I cannot escape the feeling that it is trying to get away from the commitments of most psychological frameworks, and to suggest allegiance to the world of broader biological accounts. This is, of course, entirely in the spirit of the enactive approach, but the pictures so drawn are specific kataphatic⁷ elaborations drawn as required by the consideration of specific behaviors recognized in advance. The ecological analysis starts by singling out a “behavior” to be characterized, by fixing the organism/animal/agent and the environment of relevance, and it builds its account from there. In so doing, it frequently has the result that much of the explanatory load normally consigned to hidden interiorities and brains is reduced, but not removed.

8. ATTRIBUTING MINDS, SOULS, AND MORE

The reflexive characteristic of a discourse within an enactive framework requires that we be explicit in our assumptions, in the distinctions we choose to draw, and their acceptance or contestation by those conducting the discussion. But no discourse can make all distinctions patent. No matter how fundamental the frame we carefully draw, it is always drawn within a larger, unwritten and unspoken frame. In Spencer-Brown's formalism this is referred to as the unwritten cross, assumed to accommodate those distinctions that do not need to be drawn, because they are uncontroversial (Spencer-Brown, 1969, p. 6).

The ecological psychologist typically leaves consideration of agency at the door. The task-centered nature of the description is assumed, as the structure of the task is probed. There is an unspoken presumption, therefore, that whatever else is necessary for more complete, or merely overlapping discourses, will be found elsewhere. In this way, a Gibsonian is not committed to any fixed view of mind, agency, or individual executive control. Different framings of different tasks will leave unaddressed commitments at the door.

In this respect, a Gibsonian account is once more entirely within the spirit of an enactive approach. When we move beyond the bare recognition of autopoietic self-production and self-distinction and consider the cell as a minimal sense-making form, we find we need further distinctions to conduct our account. This is where adaptivity is introduced, because it is needed. It is an add-on though, demanded of the specific example being discussed. This is how an enactive framing grows

⁷That is, built upon specific positive distinctions required to conduct the discourse in a manner intelligible to all discussants.

its distinctions within specific discourses, creating descriptive domains of increasing detail and complexity. Further attributions will be needed as more complex systems are considered. Each add-on might be contested by the observing collective, and the resulting detailed descriptive characterization will depend on the consent of the collective to make sense. Objectivity in parentheses allows us to nest parentheses, but we need to clean up after ourselves, and not assume that distinctions drawn and accepted within one discourse can thereby be wielded without caution more generally.

The elephant in the room I am skirting around is the psychological subject, so central to most narrative accounts of the person. Centuries of debate, and 150 years of constructed methods and experimental vehicles have installed in most of our debates the idea that a person is a subject who perceives a world, allocating attentional resources, with access to a transcendental memory database, and ruled over by an executive controller. This is a being endowed with something called a “mind” and animated by a single spirit. Spelled out in this stark fashion, one might indeed begin to ask whether the distinctions drawn that are necessary to allow this descriptive figure to go unchallenged are either secure or might demand consent. If one addresses any of the central elements in this construction, they are easily seen to be subject to challenge, and they become entirely untrustworthy in any debate not framed by some kind of materialism. The Buddhist roots of much of the enactive approach are destabilizing precisely because they belong within a different metaphysical frame. Increasing awareness of the existence of Buddhist or Advaitic frameworks, in particular, might help to increase awareness that the dualities required to support the psychological subject are local in character, grew within a specific cultural and theological framework, and to encourage us to consider alternatives. There is not room here to pursue this in depth, but the foregoing discussion allows us to perhaps provide a weak pointer.

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- Enaction does not start with the posit of individual personal minds. This leaves us without many of the familiar constructs we lean on in our everyday discourse. The enactive framework is young, and developing. Cast as mind-in-life, it adopts a maximally consensual starting point, situating us, the discussants and observers, among the living. The leap of faith Varela calls us to is nothing more than the consensual adoption of this common ground. The elaboration of this basic discursive position allows us to construct and create many kinds of descriptive characterizations in a strictly scientific mode. Ecological psychology has provided us with one such example. There will be others, leaning on other frames of distinction. They will satisfy our need for explanation to the extent that the distinctions drawn are consensual, and can survive the objections.
- For at the heart of the enactive move is not an act of description, but an act of recognition. In picking out the cell as a living agent, we recognize our embedding in a world from which we are not distinct. Even in the ecological characterization of the gannets, we find a familiar world of birds and surfaces. We are at home there, too, and we happily conduct our analysis with a background that attributes the required animating spirit to the bird, sufficient to take care of that which we did not get around to considering. The mind constructed by scientific psychology is an elaboration of the notion of the soul as a singular animating force (Reed, 1998), but we are multiply animated. The person is not a fixed entity, nor a mere organism, but a locus of mutual recognition and negotiation.
- Zoom out camera!

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Ecological Psychology and Enactivism: A Normative Way Out From Ontological Dilemmas

Manuel de Pinedo García*

Departamento de Filosofía I, Universidad de Granada, Granada, Spain

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Edited by:

Anthony Chemero,
University of Cincinnati, United States

Reviewed by:

Sarah Robins,
The University of Kansas,
United States
Guido Baggio,
Roma Tre University, Italy

*Correspondence:

Manuel de Pinedo García
pinedo@ugr.es

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Two important issues of recent discussion in the philosophy of biology and of the cognitive sciences have been the ontological status of living, cognitive agents and whether cognition and action have a normative character *per se*. In this paper I will explore the following conditional in relation with both the notion of affordance and the idea of the living as self-creation: if we recognize the need to use normative vocabulary to make sense of life in general, we are better off avoiding taking sides on the ontological discussion between eliminativists, reductionists and emergentists. Looking at life through normative lenses is, at the very least, in tension with any kind of realism that aims at prediction and control. I will argue that this is so for two separate reasons. On the one hand, understanding the realm of biology in purely factualist, realist terms means to dispossess it of its dignity: there is more to life than something that we simply aim to manipulate to our own material convenience. On the other hand, a descriptivist view that is committed to the existence of biological and mental facts that are fully independent of our understanding of nature may be an invitation to make our ethical and normative judgments dependent on the discovery of such alleged facts, something I diagnose as a form of representationalism. This runs counter what I take to be a central democratic ideal: while there are experts whose opinion could be considered the last word on purely factual matters, where value is concerned, there are no technocratic experts above the rest of us. I will rely on the ideas of some central figures of early analytic philosophy that, perhaps due to the reductionistic and eliminativist tendencies of contemporary philosophy of mind, have not been sufficiently discussed within post-cognitivist debates.

Keywords: enactivism, ecological psychology, affordances, normativity, dispositionalism, analytic philosophy, representationalism, agency

INTRODUCTION

I will begin by distinguishing between two forms of antirepresentationalism, one regarding cognition and the other regarding language. I will then claim that, even after having presented a serious challenge and alternatives to the former, there can be a residual form of linguistic representationalism behind the thought that we are in the business of describing facts and referring

to free-standing properties when we speak of affordances or give normative explanations of agency (section “Ontological Approaches to Affordances and Normativity”). In section “Non-descriptivism and Rule-Following” I will review some alternatives to descriptivism that draw from early and recent analytic philosophy: some vocabularies, normative, evaluative, intentional, are fundamental for our understanding of nature but they do not bring commitments to additional entities. I will then explore how these ideas apply to the possibility of non-social normativity (section “Non-social Normativity”) and to the relationship between ontological and normative/ethical perspectives on life, cognition and agency (section “Ontology and Ethics”). My central target is to free up a space after exposing three apparent ontological dilemmas as leading to dead ends: either affordances are intrinsic properties or there is no distinction between describing and evaluating (section “Ontological Approaches to Affordances and Normativity”); either the mind has a causal role in nature or we should abandon our mental vocabulary; and (section “Non-descriptivism and Rule-Following”) either values and norms exist independently of evaluative practices or they are a mere projection from a provisional stance (section “Ontology and Ethics”).

The present special issue deals with the convergence and complementarity between enactivism and ecological psychology. This is a refreshing and much needed alternative to one common approach to the relationship between both research programs, namely trying to highlight the alleged superiority of one over the other regarding, say, learning, the role of the agent, the role of the environment or the possibility of giving explanations that scale up to linguistic or social phenomena (Varela et al., 1991; Flament-Fultot et al., 2016; Di Paolo et al., 2017). The topic can be an invitation for an alternative take on the issue, which I won’t pursue, but I assume that is both feasible and desirable: to embark on an ecumenical collaboration between ecological psychology and enactivism, putting together the strengths of one and the other for the major glory of a positive alternative to representationalism and cognitivism (Heras-Escribano, 2019a). However, I think that there is a less explored perspective regarding the convergence of both traditions, one that precisely aims at deepening the antirepresentationalist character of the new paradigm by warning against a common danger that lies ahead, in slightly different forms, for enactivism and ecological psychology, the danger of conflating normative questions with ontological, descriptive ones.

To do so I’ll draw on a philosophical tradition, analytic philosophy, which is often ignored in the post-cognitivist discussions in favor of phenomenology, perhaps because many of its main representatives in the second half of the last century have embraced physicalist or functionalist agendas in the philosophy of mind. However, I think that such agendas are the result of deliberately misunderstanding or plainly ignoring the ideas of analytic philosophers from the previous generation. In which way can a philosophical tradition centered on conceptual analysis often performed without much attention to empirical issues illuminate debates regarding, as in our case, the relation between ecological and enactive approaches to cognition? I think that, at the very least, some methodological clarity may be obtained

when thinking about some questions that have been a source of perplexity for philosophy through the centuries—in the case at hand, questions such as “what is life” or “what is mind” or “what is agency”—in terms of the kind of thing that do we do when we say that something is alive or minded or an agent. The questions may become more tractable as well as less abstract and more related to practice.

I can be illuminating to call attention to the fact that the two above-mentioned philosophical strands, phenomenology and analytic heterodox, together with pragmatism, constitute the core of Rorty (1979). The reason I believe it is important to briefly go back to Rorty is that his opposition to representationalism has two sides that are not always distinguished, a cognitive/epistemic one and a linguistic one: we can pursue a conception of the mind with no representations mediating between the cognitive agent and the world and still retain the idea that the main function of language is to represent reality, to describe facts, objects and properties. The mirror of nature that Rorty wants to expel from philosophy is both the mind as a mirror and language as a mirror. While a lot of attention has been paid to the problems of representational understandings of the mind within the cognitive sciences, and both ecological psychology and enactivism can be seen as deeply articulated positive non-representational alternatives (both avoiding the idea that cognition is computation over internal or external representations), antirepresentationalist views of language have tended to remain within the confines of traditional, purely conceptual analytic philosophy. Post-cognitivism can benefit from an emphasis on the idea that some, perhaps most, of our linguistic practices don’t aim to describe a reality that is there anyway but to take an evaluative stance. To think of affordances as intrinsic properties of things that exist independently of the agents that could perceive and take advantage of them and to think of normativity as a describable feature of the pair agent/environment may be two sides of the same conceptual pitfall.

ONTOLOGICAL APPROACHES TO AFFORDANCES AND NORMATIVITY

As I mentioned above, I am highly optimistic regarding the complementation between ecological psychology and enactivism toward the common project of replacing a representationalist, intellectualist and computationalist conception of life and cognition. I think that there would be a lot to be gained if the different emphases on the meaning-making and evaluative character of cognitive agents, on the one hand, and on the direct perception of information in the environment that is relevant for the agent, on the other, are just that, a difference of emphasis. The plea that I hope to make for keeping ontology and normativity apart is grounded on the rejection of: (1) the realist idea that values—meanings, relevancies, affordances—could be individuated without any reference to practices of evaluation (either those of the agent that finds them of value or our own normative explanations of such interactions) and (2) what we could call a purely projectivist understanding of normativity,

where meanings and values are mere shadows of agents' sense-making processes or, worse, just a convenient way for us to explain their behavior.

I will claim that dispositionalist *factualism* or *realism* regarding affordances (1, above) and non-social *descriptivism* regarding life (2, above) are two instances of the same problematic approach and that we can still understand affordances relationally and dispositionally, and all forms of life in terms of a basic, non-social, sense of normativity after giving up factualism and descriptivism. Factualism and descriptivism are the metaphysical and the conceptual side of the same coin. Following the usage in contemporary expressivism, being descriptivist about an area of discourse (say, discourse about ethics or life or knowledge) is to assume that the main purpose of the discourse is to describe some feature of reality. Descriptivism goes hand in hand with factualism, according to which our normative talk is made true by independent facts and it ultimately refers to entities such as objects, properties or relations that can be scientifically described (Chrisman, 2007; Yalcin, 2011; at some points in the paper I will use "realism" instead of "factualism," for instance when I discuss dispositionalism or moral realism, because the former term is more established in those debates). Descriptivism is closely related to representationalism, although they are not necessarily the same thesis. Antirepresentationalism can be global or local: we can claim that language in general should not be understood as aiming to represent facts or we can reject that the purpose of some specific vocabularies is to refer to entities. Local antirepresentationalism about a vocabulary amounts to antidescriptivism regarding that vocabulary (Brandom, 1994; Price, 2011). Although I sympathize with both ways to oppose representationalism, it is the local, descriptivist variety the one that I will mainly take issue with in the rest of the paper (Heras-Escribano and Pinedo García, 2018).

In order to show the ineliminability of our dispositional and normative vocabularies without acquiring dubious ontological commitments, I need to retract some of my previous statements regarding both the non-normative character of affordances and the inconsistency of having a normative take regarding non-social animals and plants (both made in conjunction with one of the editors of this issue: see Heras-Escribano et al., 2015; Heras-Escribano and Pinedo García, 2016). The strategy is to move away from the idea that we generously grant an evaluative dignity to some living creatures by finding out "facts" about them. Complex, adaptive, evolutionary behavior can only be made sense of in relational, agential and normative terms, not because of the possession of this or that inner structure (as much contemporary representationalism would have it), but because recognizing something as an agent capable of behaving is already acquiring a set of essentially normative commitments regarding what the agent *should* do and what we *should* expect from the agent, as well as what would be *better* or *worse* for the agent to find in its environment.

Assuming that there is a difference between descriptive and normative uses of language, I'd like to explore what I take to be a dilemma for cognitive science and for enactivism. On the one hand, if we apply recent debates in metaphysics to the cognitive

sciences, we can say that some popular ontological approaches to affordances within ecological psychology have embraced forms of dispositional realism or factualism (Turvey, 1992). Realism regarding dispositions and, in particular, regarding affordances, has some unwelcome metaphysical consequences: in order to individuate affordances, we may need to commit to the existence of dubious entities (Tugby, 2013). In a nutshell, the difficulty is this: in order to say that an object possesses a specific affordance we cannot wait for it to manifest, because that would not account for its potential aspect and because there are affordances and dispositions that disappear when they manifest (an acorn is edible for a pig as long as it has not been already eaten, an artifact is explosive until it explodes) (for an exhaustive characterization, see Martin, 2008). What can we appeal to for their individuation? Given that we cannot individuate them in terms of their particular manifestations because, as we have said, many affordances never manifest (are never taken advantage of), we could do so in terms of their prototypical manifestation (being eaten by a pig, exploding). But we would like to say that the acorn is edible or the material is explosive even if none has been eaten or has exploded before, in which case we would need to individuate the property in terms of something which not only is a type, rather than a particular token, but which need not have ever actually manifested. Tugby (2013) defends that the best candidates are Platonic universals, i.e., universals that exist independently of whether they have ever been instantiated or not. This is hard to swallow from a naturalistic point of view [see Heras-Escribano (2017) for an exploration of a Rylean conception of disposition and Heras-Escribano (2019b) for an application to affordances; I will come back to this below].

The most obvious alternative (Chemero, 2009) is to claim that our talk of affordances has an intrinsic normative character. Here, the ecologist would be joining forces with some forms of enactivism that take normative evaluation to be adequate for any living being, whether social or not (Barandiaran et al., 2009). This other horn of the dilemma runs a two-fold risk: on the one hand, it is close to local representationalism (descriptivism) regarding normative language: even our evaluations have as their purpose referring to entities and describing facts about them. On the other, it needs to answer to the accusation of embracing a private model of rule-following (Wittgenstein, 1953; Kripke, 1982; Heras-Escribano et al., 2015; Heras-Escribano and Pinedo García, 2016): for an agent to be normatively assessed it needs to distinguish between what is correct and what it merely seems correct to it and this capacity may only be acquired by means of social sanctions and corrections. To think of affordances as intrinsic properties of things that exist independently of the agents that could perceive and take advantage of them and to think of normativity as a describable feature of the pair agent/environment may both invite the threatening thought that values are determined by independently intelligible facts (e.g., intrinsic properties of things, measurable inner forces of agents).

Of course, we could try to avoid the dilemma by reducing the demands for normative evaluation (Kiverstein and Rietveld, 2018): placing an organism within a normative network would be just a question of saying that some things were better and some worse for it. While this kind of proposal respects the distinction

between describing and evaluating, it seems very hard to see in what sense it allows to distinguish between living and non-living entities. To see something as living, as an agent, as a subject of experience and behavior, is to take an ethical, rather than ontological stance, is to recognize a dignity beyond anything merely factual, as we will see in section 5. Gibsonians and neo-Gibsonians are right to insist that perception and cognition are basically active and relational. Enactivists are right to insist that to understand the living we need evaluative vocabulary. But precisely because of that, I will argue, their project should not be seen as merely discovering facts and describing processes.

NON-DESCRIPTIVISM AND RULE-FOLLOWING

By establishing a contrast between normativity and ontology I mean to highlight what I take to be a false dilemma that has pervaded much of the discussion regarding mind and cognition. The dilemma is this: either the mind has a causal role in nature, explainable in lawful terms, or we must sooner or later eliminate all uses of mental (cognitive, agential, intentional...) vocabulary and replace them by the vocabularies of bona fide natural sciences. If the only alternative to placing the mind causally in the world is to think of it as a mere epiphenomenon, we would seem not to have moved away too far from Descartes' predicament. What makes the dilemma seem inescapable is a Cartesian premise shared by both horns: the only thing that we do when we speak is to refer to things (to substances, to *res*), to describe them in order to predict their behavior and control it.

So what do we mean when we say that we do different things than describing facts when we speak about the world? What else do we do other than placing entities in a nomological, spatiotemporal framework? Here is Sellars speaking about knowledge: "The essential point is that in characterizing an episode or a state as that of *knowing*, we are not giving an empirical description of that episode or state; we are placing it in the logical space of reasons, of justifying and being able to justify what one says" (Sellars, 1956, §36). What Sellars opposes is the idea that the epistemic can be analyzed in terms of non-epistemic facts, whether these facts are public or private, phenomenal or behavioral. Sellars will ultimately opt for an early version of eliminativism: given that normative spheres cannot be reduced to scientific discourse, and given that, according to him, the scientific image and the normative/manifest image compete as complete pictures of the world, we will have to eventually discard the later (Sellars, 1962).

This, however, is not the only lesson that we can take from the irreducibility of our normative vocabulary. We can also accept that we do not display the same attitude regarding the epistemic, the cognitive or even the biological than the one we take toward the merely physical. Think of Moore's open-question argument, which he presents for ethical vocabulary but we could extend to every discourse that recognizes meanings and differential valences: someone may argue that when we say that something is good what we say is that it is pleasurable (or useful or desirable or preferred by the gods or whatever),

but it will always make sense to ask "OK, it is pleasurable, but is it good?" while it makes no sense to ask "OK, it is good, but is it good?". Even if we embraced a fully hedonistic ethics and considered that "good" refers to pleasure, we cannot conclude that both words mean the same (Moore, 1903, §13). But even someone with recalcitrant reductionist intuitions needs to recognize that different things are at issue when we disagree about something being pleasurable and when we disagree about something being good. The second disagreement is intrinsically connected with what to do, with how to live one's life, the first isn't (Gibbard, 2012: 42–46; Moore, 1903, § 11).

So, if we, unlike Moore, refuse to populate the world with non-natural entities such as goodness (i.e., if we insist on having a naturalistic ontology), we can still retain his conceptual non-naturalism: some of our concepts, those with normative force, are not used to refer to properties but to make intelligible the actual and potential actions of the agents that we evaluate by using those concepts (some of the most developed versions of this idea can be found in contemporary semantic expressivism; see Frápolli and Villanueva, 2012; Gibbard, 2012). Again, the idea is not that our explanatory practices themselves are subject to normative assessment, as correct, illuminating, relevant, elegant and so on, but that normativity is constitutive of the very subject matter of our explanations when it comes to agency. The lesson from these arguments is that concepts and properties are not the same: on the one hand, some concepts have a high contextual variation with respect to the properties that fall into their extension (think of "tall" or "flat") and, on the other, there can be several concepts of the same property, some aiming at descriptively situating it within a causal network, some aiming at making salient its value for an agent. Saying that something is a better environment for a frog is different from saying that it contains lots of such and such protein, even if what makes the environment better is precisely the presence of the protein.

Let's come back briefly to the problems of an ontological approach to affordances, one according to which affordances exist over and above the informational flows between agent and environment and the categorical properties of things. Trying to argue that affordances are intrinsic, dispositional properties of things leads to serious metaphysical difficulties, perhaps even to a commitment to Platonic universals. But this does not mean that we should abandon the idea that affordances are dispositions. We could follow Ryle's elucidation of the explanatory power of dispositional vocabulary while, like him, avoiding the temptation of thinking that dispositions are occult forces that cause their manifestations. "There still survives the preposterous assumption that every true or false statement either asserts or denies that a mentioned object or set of objects possesses a specified attribute" (Ryle, 1949: 104; see also Heras-Escribano, 2017). Our dispositional explanations, like explanations that appeal to general laws, can be true or false not because they refer to extra entities (a causal connection, an unobservable tendency), but because they allow us to infer some factual statements from other causal statements (they are what Ryle calls inference tickets). If a thing is explosive it will explode in such and such circumstances. Ryle is particularly interested in applying this way of understanding dispositions to mental states such

as beliefs in order to, among other things, reject Cartesian or representationalist understandings of the mind. My suggestion is that we fit affordances within this framework.

But, is there an evaluative, normative element involved, besides the dispositional one, when we explain behavior in terms of affordances? I think that the best way to tackle this question is in conjunction with the possibility, insisted upon by some forms of enactivism, of thinking of agency in normative terms even in the case of non-social agents. Wittgenstein (1953), §§185–243, considered by some of the most influential contemporary philosophers to be the starting point of recent focus on normativity (Kripke, 1982; McDowell, 1984; Brandom, 1994), is often interpreted as follows. If, in order to judge whether an agent has acted correctly or incorrectly according to a rule, we must interpret the rule so as to ascertain that the action is or is not an instance of what the rule calls for, then there will be no end to the chain of interpretations and reinterpretations of the rule and there will always be interpretations of the rule that take the action to be correct and others that take it to be incorrect. As long as we cannot ground our interpretation on some facts which, themselves, are interpretation-free, there is no final saying regarding rule-following.

One of Wittgenstein's favorite examples is a child learning how to add. After some time going through examples, the teacher asks her "How much is 1000 plus 2." The child answers "1004" and, in response to the teacher's protestations, argues that she has done like before. "Wasn't I supposed to add 2 extra units until 1000, 4 extra units until 10000 and so on?" This could be the beginning of an endless stubborn discussion if the pupil decided to reinterpret each word at her convenience. She may claim to understand "count" such that it works one way until 1000 and a different one after that, for instance. Can we ever stop interpreting? Wittgenstein seems to believe that we can: we can appeal to social practices, to learning, to training, to routines and customs, to being corrected by others with reinforcements and punishments of many sorts. According to the standard way of understanding Wittgenstein's appeal to such social, public phenomena, for something to count as normative it must be placed in the context of the interaction between agents. I act correctly (regarding some norm) if I act as others do. The child in the example is making a mistake, not because she is offering the wrong interpretation of the rule, but because she is not following the socially established mathematical practices. Communities not only train us to behave as others do, but they also provide the necessary gap between it merely seeming to me that I am right and my actually being right.

If this were correct, it would make no sense to evaluate normatively the behavior of non-social agents or even the behavior of social agents when they are isolated from all communities of rule followers. The idea would be that thinking of an agent as devising and following its own rules would immediately lead to the vicious regress of interpretations: anything the agent did could fit its own rule according to some interpretation. To institute a rule and to follow it you need more than one individual ("it takes two to err"). This has been a conclusion that many, including myself, have embraced. However, now I believe this is not the only way to think

of normativity nor the only way to understand Wittgenstein's profound teachings in this sphere. Let me briefly introduce one of the usual suspects in this discussion, Robinson Crusoe. Crusoe once belonged to a (rather strict) community and he probably learned the hard way to distinguish between what merely seemed right to him from what it was considered to be right by the community. But, surely, he could still make plans and take resolutions and organize in many ways his solitary life on the island. There not being anyone around to keep him honest, could we say that he is actually following rules, that his behavior is opened to normative evaluation, his own evaluation, to start with? It seems obvious that the answer should be yes: at the very least, we could say that he has interiorized the possibility of being wrong and that would allow him to self-correct. In fact, you don't need to be Crusoe to make up rules and to follow them. We often make decisions concerning timetables or beer consumption and manage to follow them (or fail to manage, but still realize that we are not following them) without anyone checking on us. Is the role of a community just to introduce us to the possibility of error?

There is a further, potential role the community can play and that may open up the space that we need, not for private rule-following, but for rule-following by non-social agents. The thought would be this: Wittgenstein's target is the idea of a rule that is followed privately, that is, a rule that may only be followed by one agent. But for something to be a rule and for an action to be in accordance with it, it is sufficient that a similarly placed agent may act in a similar way to advance toward its goals. The rejection of, say, the intelligibility of a language that only I could understand (for instance, a language to refer to my sensations or my private memories) does not entail that an agent is incapable of using strategies that are fully original to itself. For this reason, I think that my previous criticism of some enactivists' discussions of normativity with respect to bacteria and other non-social creatures was misplaced (see Heras-Escribano et al., 2015).

NON-SOCIAL NORMATIVITY

Situated, unreflective and primitive or naive normativity are usually characterized in terms of social or communal practices or customs (see, for instance, Dreyfus, 2005; McDowell, 2007; Heras-Escribano, 2019b; Andrews, 2020). Normative considerations, whether explicit or implicit, put forward by Wittgenstein (1953) and Ryle (1949) or authors in the phenomenological tradition are linked to practice, to know-how, to bodily action but almost systematically in relation to institutions, to socially established practices. However, we could also find discussions that insist on the continuity between life and cognition where being a social creature is not a condition of possibility for the legitimate use of normative explanations (for instance, Barandiaran and Egbert, 2013; Di Paolo et al., 2017, 2018)¹. There are two paths to the acceptance of the possibility

¹An obvious exception is radical enactivism, a position that is informed by the early analytic ideas presented in this paper and which mostly avoids approaching agency and cognition from a descriptive and ontological perspective (see Hutto and Myin, 2012).

of attributing normative features to non-social agents. One of them is to commit to the descriptivism or factualism that I am recommending against in this paper. The other is to stress the link between being a normative agent and being recognizable as such. This is the main point of this paper and it is important to explicitly avoid a certain reading of the insistence on the role of attribution, both regarding enactivism's discussions of normativity and with respect to normative and dispositional approaches to affordances, a reading that views normativity as a useful or convenient fiction, the stance or pretense of looking at parts of the world "as if" they could act purposely and to do so better or worse. To be an agent is to evaluate the environment, to recognize opportunities, dangers and resistances, to find sense in the world and to make sense of it. To understand something as an agent is also to evaluate its behavior. But neither in the first case nor in the second the agential and normative elements are a projection from the agent to the world or from the attributor to the agent. And yet, I claim that there is a dependence between meaning and meaning-making practices and also between normativity and attributions of normativity. What kind of dependence?

Let me go back to the idea of a private model of rule-following: the possibility of an isolated agent navigating its own normative field is a powerful idea, but one that needs the background of other potential agents either acting similarly or making normative sense of its behavior. I take this to be the real revolution behind any form of antirepresentationalism, including enactivism and ecological psychology: to show the absurdity of any project that makes it intelligible to offer, from the outside, so to speak, a complete, causal description of a universe with cognition and life in it². The revolution will only be complete when both faces of representationalism are discarded, the idea that our judgments are true or correct only if they correspond to one fact or another, and the idea that wherever there is cognition there must be some kind of cognitive substance or entity or organ waiting to be causally reconciled with the physical world.

The distinction between internal and external norms of evaluation can suggest that we must choose between the idea that our uses of normative vocabulary are referential and descriptive and the thought that when we evaluate behavior we project norms onto an agent which could, in principle, also be made sense of in non-normative terms. The authors of *Sensorimotor Life* make ample use of this distinction:

What is the origin of these norms? If we are not speaking of a self-individuating system, but one defined by convention, the relevant norms are also given externally to the system (...). Such would be the case of a machine designed to perform a particular purpose. What a machine "does" is thus evaluated normatively in accordance with what the designer or the user expects of it. But it is possible also to conceive of a concept of intrinsic norms (...), a concept not tied to the observer's conventions and convenience. Intrinsic normativity cannot be the result of observers making judgments on behalf of the agent (...) (Di Paolo et al., 2017: 121; see also 102–3 and 125)

The contrast is highly intuitive. It can be at most metaphorically illuminating to take a toaster's environment to be meaningful or dangerous for the toaster. It is bad for the toaster to suffer a sudden power surge only in the sense that the owner may have to buy a new one. Similarly, for "the thermostat knows that it is below 21 degrees Celsius" or "the printer refuses to speak to the computer," being knowing and speaking paradigmatic normative activities. There is something unique and fundamental about entities that follow their own norms, entities for whom it matters what they find in their environment, which genuinely care about the opportunities and resistances that the world provides for them and the way they act with respect to them. The frog that fails to catch a single fly in a forest where no one can observe her dies anyway.

In this sense, I cannot but agree with the idea that "intrinsic normativity cannot be the result of observers making judgments." And yet, the idea of intrinsic normativity, as opposed to the external norms imposed by the maker on an artifact, need not be understood in descriptivist, nomological terms. It is because the frog cares about catching flies, for her own good, that we evaluate her action as more or less suited for the task (or the environment as better or worse for her needs and goals) and not the other way around.

But to think that such caring should be explained by appeal to properties and facts about the frog is to remain within a representational view of language and to invite a backlash of reductionism and physicalism. Anyone who finds emergent properties or *possibilia* mysterious and believes that every explanatory enterprise is at bottom ontological would feel forced to pursue conceptual frugality. If all our concepts aim at referring to entities but there are only physical entities, then we will have to eliminate most of our concepts (see Pinedo García, 2016). In contrast, we can accept the existence of a plurality of ineliminable explanatory approaches, some mechanistic, some agential, intentional and normative (see Pinedo García and Noble, 2008).

ONTOLOGY AND ETHICS

The worry I have been trying to express is that a descriptivist, ontological reading of our explanations of agency in terms of affordances and in terms of intrinsic norms may obscure the evaluative dimension of such explanatory practices and, perhaps, invite reductionist and eliminativist agendas that try to do without the idea of a meaningful environment or a normative encounter with it. Part of my concern has to do with what I have called a residual representationalism regarding language. My insistence on the fact that there is some inescapable ethical and normative aspect in our approach to the living is shared by many enactivists and ecological psychologists. For instance, the authors of *Linguistic Bodies* are quite clear about the ethical dimension related to meaning and intentionality, even in their most basic forms:

(...) there is an ethical dimension (...) entailed by our theory (...) [I]f living organisms are autonomous sense-makers that behave in relation to vital norms, this implies that they are

²I'm thankful to Neftalí Villanueva for pressing me on several points, including this one.

recipients of ethical concern. This must be reflected and not occluded by the language we use to talk about them (Di Paolo et al., 2018: 34).

Ethical concern is not something that is added to already constituted linguistic bodies, as sociocultural normativity is supposedly added to a presumed original nature in dualistic thought (Ibid.: 310).

Perhaps an unavoidable, though unfortunate, consequence of the still felt Cartesian influence is a tendency in the philosophy of the cognitive sciences to play the “you are more dualist than I am” game. But it may help to pause and see whether the game is always played with the same rules or whether there is some basic equivocation in the appeal to dualism. Unlike eliminativism, which is better understood as a linguistic than as an ontological thesis, being a dualist involves an ontological commitment with the existence of things of radically different nature, in the extreme case, so different that it is a mystery how they could causally relate to one another. In contrast, to affirm that the language of, say, art criticism or gastronomy cannot be replaced by the language of molecular biology should not be seen as a dualistic statement. So, inasmuch as dualism concerns what there is and not our ways of making sense of it, dualistic thought, at a minimum, involves taking norms, meanings or values to be entities and that’s where the problems start. However, one can accept, wholeheartedly and for normative and ethical reasons, the need to understand living being’s interactions with their environment as meaningful or significant without feeling the urge to populate the world with meanings and values. We would be avoiding dualism at the price of embracing a false dilemma: in one horn we would have values and norms out there, either waiting to be found or merely projected by the living, in the other, they would be just a manner of speaking, a stance we can choose to take toward nature.

Both poles of this dilemma share a problematic premise: the purpose of our explanatory vocabularies is to represent facts, so either there are facts about meaning and value or our normative practices are provisional shortcuts, ready to be discarded as our knowledge develops. But factualism, interpretativism and eliminativism can be all avoided if we recognize that there is a lot more that we do with our words than representing, predicting and controlling nature. This is where the best analytic philosophy of language, from the early days, can still open up a space that contemporary debates often ignore: Moore, Wittgenstein, Ryle or Austin (who coined the expression “descriptive fallacy”, see Austin, 1962/1979) all share this antidescriptivist approach and it is depressing that so much contemporary philosophy of mind seems to stem directly from ways of thinking that were deeply challenged by these philosophers. My main purpose in this paper has been to question that to oppose functionalism in the philosophy of mind and cognitivism in psychology we should share their ontological playfield and quarrel about what there is. Our mundane values or our free-standing dispositional affordances may be preferable to their representations and computations, but we will be turning a debate that should focus on the normative and ethical dignity of the living on a Cartesian debate about measurable substances and attributes.

One of the consequences of this Cartesian heritage is the disproportionate importance that the mind-body problem has had in the philosophy of mind, especially in the analytic tradition, but not exclusively. The mind-body problem is an ontological problem and the different solutions that have been proposed are descriptive: they try to establish what kind of entity a mind is in order to account for its causal interaction with the physical world. But this concentration on the mind-body distinction has tended to hide a more important one, the distinction between an agent and a thing, a distinction which is not so much descriptive or ontological as normative or ethical (see Ramberg, 2000; Rorty, 2000). In his debate with Rorty, aptly situated under the heading “post-ontological philosophy of mind,” Ramberg insists on this point and attributes to Davidson a poignant form of subversiveness against the philosophy of mind mainstream. The same way that I have extended Wittgenstein’s thoughts on normativity beyond language and society, I’d like to apply Ramberg’s point to all forms of agency:

[T]he vocabulary of agency leaves us better off, better in the sense of “politically more free.” I see Davidson as providing a tool, a marginal tool (...) in a struggle against the steady spread of dehumanizing, homogenizing management of human existence that is the real threat of scientism. Scientism is not bad, I am sure Rorty would agree, because it gets the world wrong, or even because it is a rehash of Kantian and Platonic ontology, but because it renders us subject to certain forms of oppression (Ramberg, 2000: 367).

The ethical concern brought about by agency-vocabulary is an obstacle to treating living creatures, and us humans, as ownable and controllable entities. But there is another desideratum, besides avoiding a view of agents as mere things: not making everything into an agent. Although our resistance to accepting a normative treatment of non-social creatures (Heras-Escribano et al., 2015) is now, to my eyes, misplaced (if we think that using normative vocabulary is adopting a perspective that transcends mere description and prediction and, hence, is not in the business of following track to intrinsic properties of agents), it was an overreaction to a genuine worry: the risk that we will end up extending our normative nets to spheres where they are not needed. In the past, we have expressed this worry by pointing out that naturalizing normativity cannot be achieved by normativizing nature on pains of a dangerous form of idealism (Ibid.). To embrace the thought that there are areas beyond human linguistic and institutional practices that should be understood normatively should not make us think that there are no important distinctions to be made, however, fuzzy the borders may be, between prediction and control and understanding and ethical concern. One of the strategies of oppressive power is to present issues of value as factual and factual questions as matters of opinion. The former can be found in the attempt to put in technocratic hands decisions regarding public policies (cf. Samuel Huntington’s advice to the trilateral commission: “to employ the language of expertise more widely as a mechanism to deal with the ‘excesses of democracy,’” Stanley, 2015: 210)³.

³“Al Smith once remarked that “the only cure for the evils of democracy is more democracy.” Our analysis suggests that applying that cure at the present time could

and the latter in the efforts to muddle scientific consensus with allegedly discording voices in cases such as climate change or the connection between tobacco smoking and certain types of cancer. If we suggest that everything is normative, some powerful tools of political resistance may be lost.

I have assumed from the beginning that enactivism, ecological psychology and the non-descriptivist and antirepresentationalist strands of analytic philosophy share a commitment with the need to start with the vocabulary of agency, of meaning and value, if we are to do justice to life and cognition. But I believe that what gives philosophical and ethical edge to this commitment may be lost if we present ourselves as pursuing a project that competes with standard, non-normative forms of approaching nature, as merely offering richer redescrptions of a world that others may try to describe with the vocabulary of the physical sciences. The reduction of living beings to things, of value to price, of the sphere of normative negotiation amongst legitimate options regarding how to live to a technocratic calculus of benefits, are all equally threatening consequences of blurring the distinction between evaluation and description.

THE INESCAPABILITY OF THE NORMATIVE DIMENSION

All attempts at explaining or understanding any kind of phenomena have a normative nature. We can have better and worse explanations, our understanding can be deeper or shallower. Our explanations can be wrong and there is always room for misunderstanding, whether we are dealing with subatomic particles or with cultural practices. This is the simplest argument in favor of the irreducibility and ineliminability of our normative vocabulary: even the most purist reductionist and eliminativist projects need to be evaluated. However, sometimes the very subject matter of our explanations seems to need tackling by using normative vocabulary. Is this just a convenient stance, a provisional perspective that we adopt when we lack the knowledge or the time needed to give a causal explanation, grounded on laws rather than on norms? There are strong reasons to doubt this. One of them is a consequence of the point I have just highlighted regarding *all* of our explanatory practices: at the very least, when we are interested in understanding nature our activities are guided by norms, norms of coherence, of simplicity, of empirical adequacy, of truth... But if some of our behavior necessarily has to be seen as an instance of rules being followed better or worse, correctly or incorrectly, the very idea that normativity is a non-compulsory stance loses its strength and the possibility, dear to some enactivists and ecological psychologists, that acting, perceiving, in sum, being alive, is to be normatively regulated becomes more attractive.

well be adding fuel to the flames. Instead, some of the problems of governance in the United States today stem from an excess of democracy (...). Needed, instead, is a greater degree of moderation in democracy. (...) First, democracy is only one way of constituting authority (...). In many situations the claims of expertise, seniority, experience, and special talents may override the claims of democracy as a way of constituting authority" (Crozier et al., 1975: 113).

Making sense of agency in terms of rules and norms, of evaluations, of relationships of meaning and relevance, of opportunities and dangers being properly or wrongly tackled, cannot be a question of projecting a certain explanatory frame into nature on pain of devoiding agents of their constitutive normativity and reducing them to mere things, objects to be controlled and possessed. But we should also avoid the opposite temptation, the temptation of thinking of an agent as a mechanism whose wheels should find the right preexisting rails, as if sense, meaning and correctness were things that could be understood in descriptive and nomological terms independently of agents' practices of making sense of the world. The danger of putting too much emphasis on ontological matters is to lose sight of what I have placed on the side of the ethical and normative: that the intrinsically ethical dignity linked with being an agent is not something we generously bestow on the living, but it is not something we find in there by merely aiming at predicting nature in order to control it (McDowell, 1984; Ramberg, 2000). The problem that lurks behind the rails metaphor is that, besides the danger of giving pride of place to an understanding of the world, including the biological world, as something to be predicted, controlled and, ultimately, owned by us, there is a different, although related, menace behind the descriptivism I have been warning against: to think that we are in the business of describing normative facts when we approach agency could give us a sense of entitlement to treat agents as mere things if we fail to discover such facts. Hartry Field puts the point forcefully concerning moral realism, but it can be extended to any version of factualism regarding the normative:

Why make our policies conditional on our beliefs about the existence and nature of normative facts? If we morally disapprove of torturing dogs, why rest this disapproval on a pure belief that there is a straightforward normative fact that we oughtn't torture dogs? Indeed, *I'm tempted to say that the moral realist has not only a dubious metaphysics, but also a dubious morality that allows torturing dogs under the condition that there are no straightforward moral facts, or under the condition that those moral facts permit or even require such torture* (Field, 2009: 270, *my italics*).

The temptation which I fear concentration on ontological matters brings is this: to avoid a subjectivist projectionism according to which normativity is just a manner of speaking, we want to say that agents follow their own norms independently of whether we understand their behavior in terms of such norms or not. But this should not lead us to think of criteria of correctness and norms as transcending the contingent activities and practices, either solitary or public, of agents. My insistence on the ethical aspect of our normative vocabularies is a way of highlighting the difference between measuring the radioactive decay of a group of atoms and explaining how plants communicate. We need to engage in meaningful and communicative interactions to understand plant communication, but we don't need to be radioactive to explain the behavior of Uranium-238.

Our distinction between the animate and the inanimate world is, at the end of the day, a distinction between having an internal

perspective and having an external perspective on things (or, rather, between things that demand an internal perspective and things that do not). Even practices that are fully alien to us, both culturally and biologically, can only be understood if we grasp what is it that the practitioners value, why do they care, what's at issue for them, how can they satisfy better or worse their needs or preferences. In sum, why it makes sense for them to live their life that way. Taking an internal perspective cannot amount to sharing a way of living, at least not in most cases. But it must involve recognizing it as a way of living and that implies going beyond the ontological and into the ethical.

CONCLUSION

In this paper I have tried to offer an alternative to the tendency, sometimes implicit, to think of normativity in descriptive, ontological terms. To do so, I have brought back into contemporary post-cognitivist debates some central ideas from early analytic philosophy because I'm convinced that they target forms of representationalism that have often remained invisible and that have led to otherwise escapable dilemmas resulting from a confusion between different explanatory projects. I have pointed out as problematic some forms of descriptivism, which I have identified as a form of local representationalism, and claimed that blurring the distinction between placing something within a causal, factual network and evaluating it or, in other

words, mixing up ontological and ethical matters, opens up the door for an oppressive and objectivizing view of nature, one according to which agents can be treated as mere things, subject to prediction, control and ownership. To make normative, evaluative matters depend on factual discoveries can lead to inaction in situations that demand moral engagement.

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The author confirms being the sole contributor of this work and has approved it for publication.

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Ecological~Enactivism Through the Lens of Japanese Philosophy

Jonathan McKinney*

Departments of Philosophy and Psychology, University of Cincinnati, Cincinnati, OH, United States

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Manuel Heras-Escribano,
University of the Basque Country,
Spain

Reviewed by:

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Zuzanna Rucinska,
University of Antwerp, Belgium

*Correspondence:

Jonathan McKinney
mckinnjt@mail.uc.edu

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The enactive and ecological approaches to embodied cognitive science are on a collision course. While both draw inspiration from similar views in psychology and phenomenology, the two approaches initially held seemingly contradictory views and points of focus. Early enactivists saw value in the ecological approach but insisted that the two schools remain distinct. While ecological psychology challenged the common foes of mental representation and mind-body dualism, it seemingly did so at the cost of the autonomy of the agent. This is evidence that the early enactive and ecological approaches told different stories about how agents and environments interact. Whereas the enactive approach broadly focuses on agency and the organism's resilience to environmental perturbations, the ecological approach insists that organisms are best understood in terms of the organism–environment system and at the ecological scale. Historically, this tension created space for harsh criticisms from both sides and for some ecological psychologists to dismiss enactivism altogether. Despite their differences, both approaches use dynamic systems theory to explain the interactions between embodied agents and the environment or contextual milieu in which they are embedded. This has led some scholars to focus on the complementary elements of each approach and argue that the two schools are allies, thus rejecting the historical disagreements between the two approaches and calling for an ecological–enactive synthesis. The attempts to synthesize the approaches are noteworthy and should be considered steps in the right direction but are potentially problematic. If the two schools are merely synthesized to some form of ecological–enactivism, then something of value from both approaches could be lost. This is analogous to the hasty comparison between two seemingly similar schools of thought found in early attempts at East-West comparative philosophy. I argue that the relationship between the enactive and ecological approaches is both complementary and contrary and is thus best understood in terms of complementarity. Given the complexity of complementarity I will unpack the notion in steps. I will begin with the exploration of analogous concepts in Japanese Philosophy and gradually build a lens through which both agent environment and ecological enactive complementarities can be understood.

Keywords: embodied cognition, complementarity, Japanese philosophy, ecological psychology, enactivism

INTRODUCTION

The alliance between the enactive and ecological schools is well established, but their differences are not well understood. Broadly speaking, Enactive Cognitive Science focuses on autonomy and the rejection of mind-body dualism (Varela et al., 1991/2016; Thompson and Stapleton, 2009; Thompson, 2010; Di Paolo, 2018) and Ecological Psychology focuses on the richness of

perceptual experience and the rejection of mind-body and body-world dualisms (Gibson, 1966, 1979; Richardson et al., 2008). Both schools of thought claim that the embodied mind is embedded in its environment, although their stories are not quite the same (see Ward and Stapleton, 2012). I propose that the ways each school of thought relates the mind to the world is a crucially informative point of tension between the two programs. Whereas the traditional ecological approach provides a strong account of the organism–environment system, it struggles to explain subjective differences in our embodied experiences. The ecological approach lacks a convincing story about how individuals resonate with some affordances and not others. On the other hand, the traditional enactive approach provides a strong account of human agency and subjectivity, but provides little explanation of how environments constrain and enable action. Early enactivism thus lacks a robust account of an interactive information-rich world. Each only accounts for either the active agent or its interactive world, but not both.

Despite their differences, contemporary enactivism and ecological psychology are converging. Baggs and Chemero (2018) argue that the threads of enactivism that follow Merleau-Ponty should be synthesized with the ecological approach to form *Radical Embodied Cognitive Science* through the use of non-linear dynamical systems theory (see also Chemero, 2009). On the side of enactivism, Stapleton (2016) and Di Paolo (2016) argue that the two schools are allies, and are separated only by the *uncanny valley* of misunderstanding (see also Thompson and Stapleton, 2009). I will focus on the cooperative forms of each approach. The strongest case for an enactive–ecological synthesis was proposed by Costantini and Stapleton (2015) and Di Paolo et al. (2017) when they embed the enactive agent in the ecological organism–environment system by reframing enactive constructivism in terms of honing in on relevant affordances in an overabundant environment. While an ecological–enactive synthesis is promising and should be explored, it fails to adequately accommodate the theoretical and historical differences between the two approaches.

Instead of synthesizing the two, the enactive and ecological approaches should be analyzed with the tools of comparative philosophy, where each side is preserved as they come together to create something new. Building upon the works of Stapleton (2016), Di Paolo et al. (2017), and Baggs and Chemero (2018) I argue that the relationship between the enactive agent and the ecological organism–environment system is one of complementarity, where both sides are mutually co-dependent yet persist as individuals in tension. Understanding the ecological–enactive and agent-world relations in this way preserves the subjectivity of enactive agency, the objectivity of the ecological agent–environment relation, the tensions entailed by the relation, and mutuality between them. Unpacking the enactive~ecological complementarity will require tools from various traditions and is best understood when broken into steps.

The myriad dynamics at play between an agent and its world extends well beyond the scope of this paper. As a result, I will limit my analysis to the interaction between the agent and the world in the present moment, as this will frame the complementarity of the two approaches in

a way that's accessible to the tools of Japanese Philosophy. This relates directly to the enactive timescales of experience introduced by Varela (1999) and developed by Gallagher (2017, pp. 8–9), where the present moment is analyzed at the *integrative scale*.

Kelso and Engström (2006) have argued that complementarity (signified by the symbol “~”) is difficult to grasp, yet present in our everyday experiences of the world. I have argued elsewhere that the Japanese philosopher Nishida Kitarō's work is uniquely placed to help mediate between the enactive and ecological approaches and shed light on complementarity (McKinney et al., in press; see also Yusa, 2002, pp. 185–187) (we explore how enactivists, ecological psychologists, and Nishida discuss habits). This argument rests upon the existing works comparing William James and Merleau-Ponty and Nishida (see Yuasa, 1987; Maraldo, 2017; Loughnane, 2019). Nishida's radical nondualism is built upon the continuity of discontinuity and thus resembles complementarity, and can be used to frame the ecological and enactive approaches through the structure of the present moment. I will apply Nishida's dialectical analysis to explore the relationship between the enactive agent and the ecological environment as a form of mutual negation. From this comparison, I conclude that the enactive agent and the ecological world can be understood in figure–ground (**Figure 1**) terms. While this abstraction does not exhaust the relationship between the two approaches, it sheds light on the complementary and contrary nature of the two approaches and invites further consideration of Japanese philosophy in cognitive science.

I will then consider the insights of the Zen Master Dōgen, who developed a notion of nonduality to navigate perplexing contraries, to develop the figure–ground relationship from the mere duality of figure and ground to the complementary contrary, *figure~ground*. This is built upon Dōgen's tripartite elucidation of affirmation, negation, affirmation. To exemplify this, I briefly compare the figure–ground abstraction in **Figure 1** with the figure~ground complementarity in **Figure 2**. Whereas complementarity and nonduality can be seen in the idealization of **Figures 1, 2** is a representation with more direct relation to the real world. I conclude by applying Dōgen's wisdom to the complementarity of *ecological~enactivism* and by making suggestions for future research into cross-cultural cognitive science.

THE ENACTIVISM–ECOLOGICAL ALLIANCE

Whereas enactivists focus on the lived body of agents, ecological psychologists focus on the world agents inhabit. Ecological psychologists frame the agent–environment relationship in terms of the opportunities for action that are available for the agent. This is not to say that ecological psychologists do not care about the agent, but that they do not ground their explanations in the head or body of the agent. Enactivists, on the other hand, prioritize the experience and poesis of the *operationally closed* agent as she enacts her world (Di Paolo et al., 2017, pp. 111–120).



FIGURE 1 | This is an example of the figure–ground relation portrayed by the psychologist Edgar Rubin (See Pind, 2014, pp. 214–218). Interestingly, Rubin was influenced by Niels Bohr, the physicist responsible for complementarity in quantum mechanics. In likeness of Rubin's Vase and other figure–ground images, Niels Bohr chose the Chinese yin–yang symbol for his coat of arms upon being recognized for his achievements in Denmark. It read "Contraria sunt complementa (opposites are complementary)." For more information about the crossover of figure–ground in perception, complementarity in epistemology, and nonduality in non-Western philosophy, see Pind (2014, pp. 204–210). Image attribution – Nevit Dilmèn/CC BY-SA (<https://creativecommons.org/licenses/by-sa/3.0>).

The enactive agent is autonomous, meaning that it is resilient to the push and pull of environmental forces, and capable of shaping her world. Agents can create opportunities for themselves to act above and beyond what is available in the environment alone (Thompson and Stapleton, 2009, see also Stapleton, 2016). While the two approaches agree that we are embodied beings, they disagree about the relationship between the agent and the world (Isaac and Ward, 2019).

Varela et al. (1991/2016) briefly considered the similarities between enactivism and Gibson's ecological approach and concluded that the two are distinct. They recognized the potential for ecological psychology to challenge mind-body dualism, and thus representational cognitive science, but considered the ecological approach to be too focused on the environment. For early enactivists, the enactive agent constructed her world through her coupling with it at different timescales, but the ecological world was pre-given and thus not the product of an agent-constructed process. This kind of criticism of early ecological psychology is commonplace. Chatterjee (2011, pp. 254–257) and Ishida (2015, pp. 136–137) argue that Gibson's approach is too focused on perception and information pick-up, and thus fails to capture the complexity of agent-world interactions. Baggs and Chemero (2018) argue that the origin of the disagreement between the enactive and ecological approaches

results from opposite ends, where enactivists began with the epistemology of embodiment, ecological theorists began with the ontology of embodiment. They insist that,

Both types of explanation are necessary: the ontological strategy explains how structure in the environment constrains how the world can appear to an individual, while the epistemic strategy explains how the world can appear differently to different members of the same species, relative to their skills, abilities, and histories.

This is reflected in the philosophical commitments entailed by each approach. Whereas ecological psychology adhered to a kind of Jamesian monism, the enactive approach aimed to carve a path between dualism and monism. While this distinction held for early versions of the ecological and enactive approaches, it has become less relevant as they developed further. Whereas early enactivists rejected monism, contemporary enactivists have adopted neutral monism (Thompson, 2001, see also Chemero, 2009, pp. 184–186). This is significant because contemporary ecological psychologists also accept neutral monism, and argue



FIGURE 2 | Splashed Ink Landscape (破墨山水) Haboku sansui by Sesshū Tōyō (1420–1506). Image attribution: Sesshū (1495), Tokyo National Museum, Tokyo, Japan (Wikimedia Commons).

that this is the result of the convergence of enactivism and ecological psychology through the use of dynamical systems theory (Silberstein and Chemero, 2015, see also Silberstein and Chemero, 2011).

While there are some skeptics who reiterate the historical differences between the two schools, it seems clear that the two research programs need each other. Stapleton (2016) argues that enactive principles are compatible with the ecological approach and that their historical differences are overemphasized. Di Paolo et al. (2017), citing Thompson and Stapleton (2009), paint the best contemporary picture of the relationship between enactive epistemology and ecological ontology. They argue that Gibson's theory of affordances, and Chemero's (2009) development of it for *Radical Embodied Cognitive Science*, overcomes mind-world dualism. Like Baggs and Chemero (2018), Di Paolo et al. (2017) argue that the tension between the two approaches arises for ecological psychologists from the lack of an appreciation of how individual agents perceive the same basic ecological scene differently. What each person sees available to them (i.e., grasps through direct perception) is different based on the context, and what abilities the agent has cultivated.

Importantly, this phenomenon is well established in the ecological approach by the canonical works of Proffitt et al. (1995) and Proffitt et al. (2003). They demonstrate that an agent's perception of a hill's climb-ability varies with encumbrance. A hill to be climbed appears steeper to agents carrying more weight. Gallagher (2017, pp. 155–156) argues that this evidence can be used by enactivists to help explain the relationship between social burdens and the approachability of social situations, or social affordances. A chair may afford sitability in general, but there are many contexts in which agents will not see a particular chair or set of chairs as sitable. While it is significantly more difficult to vary social pressure than physical encumbrance in a lab, human agents are social and live in complex contextual social worlds. Whereas some ecological psychologists would opt to avoid such complications, enactivists recognize that social concerns like feeling unwelcome are ubiquitous and must be at the forefront of any science of the embodied mind.

Enactive Agent, Ecological World

While this rift persists between the two approaches, Di Paolo et al. (2017) propose the most radical and comprehensive attempt at integration. They begin with the claim that the ecological and enactive schools seem to simply look past one another. The enactive focus on autonomy and operational closure leads ecological psychologists to believe that the enactive agent is being characterized as the source of its world. Di Paolo et al. (2017) solve this problem by embedding the enactive agent in the world of ecological affordances. They claim that the ecological rejection of the impoverishment of the stimulus, and thus one major call for mental representations, should be accepted by enactivists. Indeed, they claim that such a world is overflowing with information.

We agree with ecological psychologists when they highlight that real environments are rich enough to access directly their relevant meaningful aspects. We think they are in fact too rich, in that

sense-making always involves a massive reduction of all the environmental energies that might affect the agent, to those within the dimensions of biological, sensorimotor, and social historically contingent meaning (p. 227).

They diagnose the disagreement between the two schools on the ecological side as stemming from the failure of ecological psychologists to change how they treat the information-rich world. According to Di Paolo et al. (2017), the world of affordances should be understood to extend to the social dimensions of experience.

Ecological experiments tend to de-emphasize subjectivity, and thus fail to develop the notion of affordances to include social and cultural context. Recent work in ecological psychology by Nalepka et al. (2015) has begun addressing these issues by exploring intersubjectivity in terms of coordination dynamics and interpersonal synergies (Chemero, 2016). While it is valuable to control messy variables in laboratory conditions, one must acknowledge the costs of doing so. The world is messy and social and economic hierarchies permeate our lives, shaping our experiences of the world and the opportunities available to us. In Di Paolo et al. (2017)'s interpretation, the landscape of affordances available to an agent is not contingent upon the agent itself, but is modulated by the agent's history, experiences, and social context.

In this light, the enactive agent is not creating her world from her mind or body, but carving her world of experience from the overwhelmingly informative world. The distinction is subtle but shows how two different views of embodiment have converged. It's helpful to consider this subtle distinction through an example. Consider a scene in a typical coffee house. There is a coffee machine, staff operating the machine, chairs, tables, and cups of coffee. If one were relatively familiar with scenes like this, it would be an easy environment to navigate, find a seat, and achieve the goal of acquiring and drinking a cup of coffee. If we were to consider the scene in ecological terms, the surfaces of the environment would be relatively accessible to us through what they afford us. Chairs facilitate sitting and cups afford sipping for agents that move through the visual scene. Agent's movements reveal invariant structures and opportunities available to them.

If we consider the same scene through Di Paolo et al. (2017)'s view, it becomes somewhat more complicated. Whereas all empty seats afford sitability in general, which chairs appear sitable depends on the context. Whereas some seats are open to us, others are not. One easy example of this is the *sippability* of another person's cup of coffee. Any two identical coffee cups, filled with the same amount of coffee, should be equally sippable, yet we do not see other people's coffee as sippable in most cases. This is because of the complex contextuality of the human world. While it is complex to model and reproduce, it is an everyday experience for regular coffee shop goers.

Zooming out from the two cups of coffee, there are places in the coffee shop that a customer is not welcome even though they have surfaces and tools that humans are capable of engaging with. The cups behind the coffee bar are within our power to reach, yet in most situations we will wait for someone else to get them for us, or ask for temporary permission in rare cases.

Interestingly, in many cases, we perceive the approachability of the staff as a means of accessing the cup, rather than the path to get the cup ourselves. In this and many other cases, the social path is more readily available than the sensorimotor path. This has crucially important implications for how we understand the ecological landscape and where the enactive agent comes into the picture.

The first implication is that there can be spaces which do not seem readily accessible to people, even though the visual scene devoid of social context is accessible. Much like how the employee-customer distinction informs the social affordance landscape of coffee shops, other forms of discrimination fundamentally shape what affordances we have access to. Young (1980) argues that there are places women won't go and activities that women avoid because of societal pressures and patriarchal oppression. While these are not the same kind of contextual barriers, understanding social affordances in this way sheds light onto what can be done to make space for everyone. Enactivism and ecological psychology can meaningfully contribute to our understanding of embodiment, and all of its positive and negative entailments.

The second implication is that we can create space for others and shape our social-contextual worlds. Being able to create space to act is the strongest contribution that the enactivists can bring to the ecological approach. If we step back into the coffee shop example, there's an important distinction between actions in the present moment and actions that take place over longer timescales. While it is true that I do not see the space behind the bar as walkable as a customer, I can see possibilities to cultivate the social space for myself through my friendships with the staff or my plans to apply for a job at the coffee shop. I could join the coffee community in the area and become familiar with the tools, norms, and processes of that group. In doing so, I may be welcomed behind the coffee bar, and thus break the barrier that I faced when I was merely a customer passing through. Likewise, it is possible to change the social environment of a space to be more inclusive. Ultimately, the social world is messy, but this interpretation opens the door for exploring the importance of the environment for our experiences of welcomeness. Enactivism already explores the perception of and action at multiple timescales, and an enactive-ecological perspective could do so with a strong grasp of the ontology of places and our relations to them.

In the first sections of this paper, I have sketched some points of contact and contention between the enactive and ecological approaches, as well as traced their converging paths. While the two schools often look past one another, I have provided further support for their allegiance and continued cooperation. Next, I would like to provide a lens for understanding complementarity as it plays out in both ecological~enactivism and agent~world relations. To do this, I will focus on the moment of present experience, as it serves as a paradigmatic example of an agent *enacting her world* while embedded in the ecological organism~environment system.

NISHIDA AND THE FRAME OF THE PRESENT

Like Gibson, Nishida aimed to subvert subject-object and epistemology~ontology dualisms. To do this, Nishida structured the present moment of experience in both spatial and temporal terms as the continuity of discontinuity. For Nishida, the agent is embodied and embedded in its world, yet an individual.

In order to best understand the paradoxical nature of lived experience, Nishida brings together traditional philosophical dichotomies like spatiality vs. temporality, mechanistic materialism vs. teleology, and subjectivity vs. objectivity. Each dualism meets in and forms the structure of the present moment of embodied experience. For Nishida, the past and the future are both active in the moment of experience. The embodied agent is undoubtedly the result of her past. As an embodied being, she has grown up embedded in a social and cultural context which have shaped her experiences. Likewise, her biological history involves things like the evolution of her species and the constraints and abilities of her body and bodies like hers. Nishida's agent is not merely the product of her past; she is formed by her past into a being capable of forming herself, her world, and others like her. For this to be possible, Nishida (1958) argues that the agent's past must confront her environment and present circumstances, which serve as possibilities to enact her future.

[I]n the historical-social world subject and environment confront each other and form each other. This means that past and future oppose each other in the present, as unity of opposites, and move from the formed toward the forming (p. 184).

Crucially, Nishida characterizes the dialectical tensions of experience as a process of mutual negation. This is strikingly similar to the claim made by Di Paolo et al. (2017, p. 227) that sense-making entails reducing the abundance of information available in the ecological world into an agent-relevant and actionable scene. Whereas enactivists argue that agents must overcome environmental forces to express themselves, Nishida de-emphasizes the agent and argues that poesis is impossible without a place (*basho*) in which to act. Importantly, the *basho* of our embodied actions is not merely the ground we stand on, but more akin to an event in which we are embedded. Kasulis (2018, pp. 466-467) refers to *basho* as a *how* rather than a *what*, because it is how the dynamic processes of life come about. It helps us understand how agency like ours is possible ontologically.

In Nishida's view, self-expression is achieved through the negation of the environment, but the environment is an irreducible part of that self-expression because the two cannot be meaningfully separated. This is important because it could spell out a way to pull the enactive-ecological dialectic in the direction of ecological principles through a focus on the ontological side of the ontology~epistemology dyad. This kind of constructive opposition is an important aspect of the complementarity between the enactive and ecological approaches.

I propose that the best way to understand the relationship between ecological psychology and enactivism is to bring together their conceptions of embodied perception and action in the present moment of experience. In the moment of experience,

both the past (the historical agent and the historical world) and the possible future (affordances or the environmental invitations to act) play a role. The history of the organism and the world, here analogized with the enactive conception of the evolutionary development of the *autonomous sense-making* agent, and the available space and opportunities for action, here analogized with the ecological theory of affordances, meet at the center of Nishida's present moment of experience. Both play fundamental roles in the agent's *poesis*.

Nishida and Artistic Expression

According to Nishida, the expressive act is not an enaction from the agent upon the environment, but the result of both the agent and the circumstances in which she is embedded (see Section 4.1 of Maraldo, 2015). While it is accurate to credit the painter with her creation, Nishida would argue that the painting should also be understood as an achievement of the world itself. For Nishida, creativity and consciousness are essentially embodied, but require the continuity of discontinuity of the agent and the world. In any given moment, the agent is the embodiment of her biological-social history and a figure upon the ground of her environment. At the same time, the agent would be unable to make meaningful choices and express herself if she were not faced with the teleological pull of the future. The same moment can be understood both by taking the agent as the figure and the world as the ground, and the world as the figure with the agent as the ground.

In his later works, Nishida develops agent-world nondualism ontologically. For Nishida, the place (*basho*) in which agents are embedded are not merely the grounds she stands upon (See Heisig et al., 2011, pp. 649–661). Embeddedness entails the distribution of cognition where the agent and the event she is enacting cannot be meaningfully distinguished. As a result, it would be a mistake to emphasize the agent's creativity without recognizing the constitutive effects of the myriad events and processes at work which make it possible for artists to be [Kasulis (2018) clarifies Nishida's notion of *basho* as a field akin to gravitational or electromagnetic fields that is best understood as a *how* rather than a *what*].

If we consider the relationship between the artist and her environment in this way, it forms a kind of figure–ground relation where the artist's self-expression and the aesthetic scene mutually depend on each other. While this is an abstract picture, it demonstrates the mutual importance of both sides of the agent–world relation. This is exemplified in Nishida's early works when he explores the fusion of the subject and object through the paintings of Sesshū Tōyō, see **Figure 2**.

At that point we can say that things move the self or that the self moves things, that Sesshu painted nature or that nature painted itself through Sesshu. There is no fundamental distinction between things and the self, for just as the objective world is a reflection of the self, so is the self a reflection of the objective world [This passage is from Nishida (1990), p. 135, and quoted from Loughnane (2019), p. 153.]

While the seeds of Nishida's nondualism can be found in his early work *Inquiry into the Good*, he shifted his focus from the

epistemological unity of the artist and the world to the ontological nonduality of place (*basho*) in his later works (Kopf, 2010, pp. 144–151; See also Nishida, 1987). This is crucially important for understanding complementarity and for unpacking the peculiar relationship between the ecological and enactive approaches. As I have argued elsewhere, by resisting the focus on the subjectivity characteristic of phenomenological agents, Nishida's approach pushes our analysis in the direction of ontology, and thus toward the ecological approach (McKinney et al., in press) (Nishida's work is a useful lens through which the enactive–ecological relationship can be made clearer). This is important because the best attempts to integrate enactivism and ecological psychology have come through the adaptation of the ecological approach to accommodate for the autonomy of the enactive agent, without a similar accommodation for the inseparability of agent–environment systems. While Di Paolo et al. (2017) accept and enhance the structure of the ecological world, they do so without a clear account of the distribution of cognition, which is a fundamental tool for dismantling the poverty of the stimulus position and weak forms of the extended mind hypothesis (Steffensen, 2011, see also Cowley, 2011, Cowley, 2014). While it may seem counterintuitive to accept that the world is the co-author of a poem, failing to acknowledge the real impact one's place in the world has on one's art, or even one's access to artistic expression, is problematic. To unpack this further, consider the relationship between the agent and the world in terms of the figure–ground abstraction in **Figure 1**.

ENACTIVE AGENT-ECOLOGICAL WORLD AS FIGURE–GROUND

In order to best understand complementarity, we should proceed in steps. The first aspect of complementarity worth exploring is the perplexing way two things can co-exist as a complementary yet contrary pair. To that end, it is helpful to visualize the relationship between the agent and her world in terms of figure and ground for several reasons. If one focuses on the figure, the ground fades from view. Likewise, if we focus on the background, we lose focus of the figure. In the figure–ground image in **Figure 1**, the image is neither merely of a vase nor of two silhouetted faces. It's tempting to say that it is simply an image of both, but this fails to recognize the ambiguity of the image itself. To capture the figure–ground image, and thus to distinguish it from images of a pair of unambiguous images, we must recognize that the images are co-dependent. To have one necessitates the other. Considering the images in **Figure 1**, both the vase and the pair of faces can be the figure and the ground, which forms an absolute mutuality between the two. For our comparison, this accomplishes two things. The first is that figure–ground images represent how two images can depend on each other to exist. The second is that figure–ground relations represent an abstract equality in that neither side of the relation overtakes the other. The Rubin's Vase image in **Figure 1** is useful for representing two equally recognizable idealized images in tension, but is ultimately too abstract to capture non-idealized complementarity relations. In order to understand the mutuality and tension between an

artist and her work of art or an agent and her world, we must develop the figure–ground relation further in the next step.

Although the figure–ground relation is a useful abstraction, problems remain. In order to further clarify complementarity, and hopefully bridge the uncanny divide between enactivism and ecological psychology, the figure–ground relationship should be considered in less abstract terms. Consider figure–ground relations in visual scenes in the real world. In cases when an object is in focus and well framed by its surroundings, the two are integral yet not equal contributors to the scene. In fact, the dynamic tension between the two is an essential and informative aspect of what being in relation to one another means. This is exemplified by Zen paintings.

In Zen paintings, objects of importance must overcome space to emerge as a figure, yet the image is not dominated by the figure alone. Much of the canvas is left blank on purpose, and images of prominent figures like mountains are obscured by clouds or fog. The empty space filling the canvas makes it possible for us to comprehend the partial emptiness of the fog obscuring the figure. Unlike the figure–ground abstraction (**Figure 1**), Sesshū Tōyō represents the dynamic tension between a multi-dimensional figure and the ground of the contextual scene and emptiness in several famous landscape paintings; one can be seen in **Figure 2**. Whereas the vase-face duality was an important step for contextualizing mutuality, the mountain~fog nonduality is more useful. Whereas **Figure 1** is a two-dimensional image of a vase silhouette that forms two identical faces, **Figure 2** is a painting of a multidimensional mountain in a foggy scene. The latter emphasizes the importance of both spatiality and temporality for our lived experience of the world.

Zen Philosophy and the Teachings of Nonduality

Having analogized the enactive–ecological relationship, and thus the relationship between the agent and the world, in figure–ground terms, we are now in position to fully realize the complementarity of their allegiance. This involves stepping beyond the abstract two-dimensional figure–ground image and attempting to apply this analogy in real life. This last step is designed to respond to the thoughtful criticisms of empirically minded enactivists and ecological psychologists who may appreciate the figure–ground analogy, but don't see how to use it. To help escape the abstract in favor of the real, we should turn to the insights of the practical teachings of the Zen Master Dōgen.

In Zen, apparent contradictions and dichotomies are opportunities to teach others and learn about the world. This is exemplified by Dōgen in his writings about *nonduality* [It is important to note that Evan Thompson (2020) has rightly cautioned against hastily comparing Buddhist nonduality and the rejection of Cartesian mind-body dualism. Buddhism has a long and rich history that should not be hastily sampled out of context. I propose that Dōgen's teachings of nonduality can be deployed for their pedagogical insights without committing cognitive scientists to something akin to a Zen metaphysics]. In the introduction to the text *Moon in a Dewdrop: Writings of Zen master Dōgen* (1985), Kazuaki Tanahashi introduces the

following passage to exemplify what he calls Dōgen's *Anatomy of Nonduality*.

An ancient buddha said, "mountains are mountains, waters are waters." These words do not mean that mountains are mountains; they mean mountains are mountains." (see also Schroeder, 2010, pp. 133–142)

While Dōgen's purpose is soteriological, the structure of his reasoning is most important for this project. Tanahashi writes, "Dōgen's demonstration starts with an affirmative statement, then negates the affirmation, and concludes with a negation of the negation, which is a positive statement." For Dōgen, nonduality involves the coming together of contradictory perspectives into a realization of the world *as it is*, which is the unity of the contraries. Tanahashi compares Buddhist reasoning with Western dialectics, wherein one progresses from a contrary pair to a higher synthesis. For Dōgen, each step of the reasoning process entails every other step, and there is no progression from lower to higher reasoning. Consider Dōgen's mountain. If one were to approach the mountain as an object, its emptiness is part of the experience. Likewise, if one approaches the mountain as a scene of interdependent relations, the stability of the mountain as an object is part of the experience. The mountain exists as an object and exists as an empty process, even though emptiness and substance are contradictory modes of being.

Dōgen is demonstrating the paradoxical nature of reality found in the mundane experience. He urges his students to realize that the dichotomy between existence- and emptiness-focused perspectives yield the same conclusion: the mountain is both substantive and empty. The pedagogical takeaway from Dōgen is that no matter which perspective you begin with, the affirmative, the negative, and the continuity of discontinuity are all entailed. If you focus on the importance of the ground for the existence and prominence of the figure, you will realize the co-constitutive nonduality of the figure and the ground. Likewise, if you focus on the importance of the figure for the shape and existence of the ground, you will be faced with the figure–ground nonduality.

Having considered the two-dimensional representation of the figure–ground relationship and Dōgen's notion of nonduality, we should now reconsider the figure–ground relationship in **Figure 2**. Sesshū Tōyō's famous painting emphasizes the relationship between emptiness and form. The figure, here a mountain, is painted intentionally as partially obscured by mist or fog. This exemplifies the tension between the figure and the ground and emphasizes the Zen notion of nonduality. It does this through both temporal and spatial dimensions, as the empty space around the figure draws the attention of the viewer to it, yet it partially obscures the figure as if it could disappear into the fog. The fog and blank space are designed to subvert our grasp of the importance and permanence of the mountain as the figure, without reifying the importance and permanence of emptiness as the figure. The two are co-dependent upon each other for their being, yet they are not equal. This inverts and challenges our undue focus on the figure and disrupts the sense that the figure and ground should be considered as abstract equals. In contrast with the abstraction of **Figure 1**, the tension between the mountain and the emptiness resembles the tensions

of the real world of our lived experiences. Zen teachings are often aimed at shifting the practitioner's mind away from abstractions and back into the world in all of its complexity.

The two-dimensional figure-ground image is useful for representing the complexity of mutuality that persists through tension. This idealization of mutuality fails to account for the complex dynamics at play in concrete constitutive relations, like those found between an agent and the environment she is embedded within. The complex relationship between them is dynamic, meaningful, and ever changing. For our purposes, the figure-ground abstraction is comparable with the initial attempts to synthesize ecological psychology and enactivism seen in the works of Stapleton (2016), Di Paolo et al. (2017), and Baggs and Chemero (2018). The enactive-ecological synthesis obscures the historical differences between the two approaches. This is significant because it impacts the kinds of questions that researchers ask and the experimental methods they use. It is useful to maintain some tension between the enactive and ecological approaches because there are times it is best to focus on the subjectivity of the agent, thus neglecting the objective universalizability of the empirical laboratory. Likewise, there are times it is best to neglect subjective differences and constrain autonomy to uncover the invariant structures of the ecological environment. This is the best way to frame the relationship between the ecological world and the enactive agent, and ultimately the complementarity of the two approaches. The complementary contrary ecological~enactivism is more explanatory than either approach taken in isolation or a partial synthesis of the two.

Dōgen's teachings of nonduality emphasize the importance of being able to approach contraries from multiple perspectives while still arriving in the same place. As a Zen teacher, Dōgen was pragmatic and could deploy and defend either perspective of the contrary dyad. This dispels the abstraction of symmetry found in figure-ground abstractions and instead makes room for complementary relations with the capacity for opposition and asymmetry. Life and the world of human experiences are messy, complex, and rarely well balanced. As a result, it is crucial that our models of living are equally complex and able to exhaust the many counterintuitive interactions life entails. One important takeaway from Dōgen's teachings is that it may be possible, and in many cases it may be essential, to understand the ecological~enactive complementarity with more emphasis on one perspective over the other.

In cases involving subjectivity and autonomy, an enactive framework is likely most explanatory. In cases involving environmental invariants and embodied synergies, an ecological framework is likely more useful. These are arguments already being made by ecological psychologists and enactivists to challenge one another. What remains is to realize that both sides entail the other, especially when considering the converging works of Stapleton, Baggs, Di Paolo, Chemero, Thompson, and

their collaborators. The last step is to embrace the fact that the complementary similarities and contrary disagreements between enactivism and ecological psychology entail a complementarity relation, and thus calls for the shift from ecological-enactivism to ecological~enactivism.

FROM ECOLOGICAL-ENACTIVISM TO ECOLOGICAL~ENACTIVISM

The enactive and ecological approaches are allies, but their past disagreements and the prospects of future collaboration are complicated. The works of Stapleton, Baggs, Di Paolo, and Chemero are converging, yet others are reluctant to follow. At least one reason for this is the counterintuitive nature of complementarity. The notion of nonduality in Japanese Philosophy provides an informative framework to engage with complementary contraries like epistemology-ontology, self-other, and self-world. This is particularly helpful for contextualizing the relationship between the enactive agent and the ecological organism-environment system. I first proposed that the agent-world relationship, and thus the enactive-ecological synthesis, should be understood in figure-ground terms. This helped contextualize the importance of the agent's embeddedness in the environment, and the non-decomposability of agent-environment systems. While the figure-ground relationship is useful, it's too abstract. To move away from models and abstractions and toward the world of everyday experience, I next invoked Dōgen's tripartite method of reasoning to develop the figure-ground relation into the nonduality or complementarity: figure~ground.

The figure~ground relation is one of complexity, interdependence, and double-negation and can be used to help frame the agent~world relation entailed by ecological~enactivism. This frame provides two key takeaways. The first is that the complex dynamics of living as an enactive agent embedded as a part of the ecological organism-environment system entails an ongoing tension between the autonomy of agency and the obstacles and opportunities of an information-rich world. While this relationship can be complementary and symmetrical, it can also be asymmetrical, where one side temporarily overtakes the other. The second is that the tension entailed by the agent~world complementarity necessitates a similar tension between the enactive and ecological approaches, and thus a shift from an ecological-enactive synthesis to an ecological~enactive complementarity.

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The author confirms being the sole contributor of this work and has approved it for publication.

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Locating the Inexhaustible: Material, Medium, and Ambient Information

Tetsushi Nonaka*

Graduate School of Human Development and Environment, Kobe University, Kobe, Japan

The fundamental difference between the enactive approach and Gibson's ecological approach lies in the view toward our shared environment. For Varela et al. (1991), a pre-given environment that exists "out there" is incompatible with the worlds enacted by various histories of life. For Gibson (1979/2015), the environment with its unlimited possibilities that exists out there offers many ways of life. Drawing on the recent empirical studies on the mechanical basis of information and pattern formation in a wide range of fields, this paper illustrates a principle regarding how pattern and change that are formed in an environmental medium, under certain conditions, could serve as the reservoir of information that makes available a variety of opportunities for perception. The second part of this paper offers a discussion about how the consideration of the materials that make up the terrestrial environment—the particles in the atmosphere and the textured surfaces—led Gibson to replace the concept of "space" with the notion of "medium" that allows for the open-ended activities of perception. Finally, I argue that given due consideration of the ambient information available in the medium, the apparent incompatibility between the world independent of the perceiver that exist out there and the worlds enacted by various histories of life could be resolved.

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Fred Cummins,
University College Dublin, Ireland
Vicente Raja,
University of Western Ontario, Canada

*Correspondence:

Tetsushi Nonaka
tetsushi@people.kobe-u.ac.jp

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"Get rid, thoughtful Reader, of the Ockhamistic prejudice of political partizanship that in thought, in being, and in the development the indefinite is due to a degeneration from a primary state of perfect definiteness. The truth is rather on the side of the scholastic realists that the unsettled is the primal state, and that definiteness and determinateness, the two poles of settledness, are, in the large, approximations, developmentally, epistemologically, and metaphysically."

—Peirce (1934, CP 6.348)

THE MANY AND THE REALITY

On August 22, 1970, Gibson wrote a letter to his colleague at Cornell University, a philosopher Norman Malcolm (Nonken, 2008, p. 288):

Dear Norman,

I meant that "the same stimulus array" will always afford the same perceptual experience insofar as it carries the same variables of structural information (Gibson, 1966).

In the case of your example, I would argue that structural sequence of sounds may in fact be music, 18th century music, Mozart, badly played Mozart, a sonata, etc. All of them are in the structure of the sounds. When a listener "hears" one rather than another, he does not detect a difference in the structure for the different perception, he only abstracts different features of the available structure. I do not mean that he detects different structures in each case. Structure, in sound and light, is inexhaustibly rich.

This is one case of perceiving as, only one.

Yours
Jimmy

The original context of the discussion between Malcolm and Gibson that led to the above Gibson's response is unknown. However, the point that Gibson is making here referring to his previous work (Gibson, 1966, p. 248) is clear. Gibson argues that the multiplicity of perceptions of the same sequence of sounds derives from the richness of the available structure of the sounds in the air. Perception of sounds in the environment is direct, in the sense that it is the act of detecting the information from the available structure of sounds. However, at the same time, what is perceived would not be fixed like an automatic response to a stimulus. This is simply because the structure of sounds in the air is so rich that different invariant features can be selectively picked up from the same available structure. A music critic may be able to tell that a sequence of sounds is 18th century music, composition by Mozart, badly played Mozart, and a sonata, by picking up the subtle relations between notes with certain frequencies and how they unfold over time at different temporal scales (from vibratos to recapitulations in sonatas) in the air. On the other hand, a 5-year-old child who has never been exposed to classical music may not be able to distinguish the subtle difference in the style of playing Mozart, but only notice a certain orderliness of the temporal structure of the auditory event. Yet, there is still a possibility that, in the future, this same child will be able to discriminate a subtle combination of an enormous number of variables from another combination just like the music critique. This possibility is not entirely groundless, but is based on the fact that the available information in the structure of sound in the medium is inherently rich, with full of higher-order patterns and changes in a complex hierarchy of inter-nested levels of parts and subparts. "Structure, in sound and light, is inexhaustibly rich" even in the man-made artificial arrays like music.

At the first blush, what Gibson says plainly in this letter may not seem controversial. After all, no one would disagree with the fact that different people, or the same person on different occasions, sometimes pay attention to different features of the same thing in the environment. People do get better at discriminating something, find different use-values of the same thing, and take advantages of the different offerings of the environment depending on different situations and on different histories of life. But when Gibson went on to argue that what exists out there in the environment itself provides the basis of the multiplicity of perceptual experiences, Gibson's remark might sound unsettling to representationalists and enactivists alike.

Traditionally, there has been a strong motivation to regard the incompatibility of multiple perceptual experiences as evidence that the world that exists "out there" is not perceived directly. Addressing this point, Smith (2009) wrote as follows: "our commonsense perceptual space, for example, has a Euclidean structure. The space of the physicist has another, quite different structure. And it may well be that the perceptual spaces of mice, of spiders, of clams, have other structures again. Not all of these structures can be true of space as it is in itself. Hence, the

argument goes, our (and the mouse's, and the spider's) perceptual space are mere 'mental representations.' And what goes for space holds for other features of the manifold environments of perception, too—so that it is as if each species lives in its own special world (p. 128)." In order to reconcile "many" perceptual experiences with a "single" reality, the epistemic mediators such as mental representations are thus introduced. Thereby, we are left with another problem, that of how the environment and the mental representations can be matched and reintegrated.

Varela et al. (1991) maintained that both Gibson's ecological approach and their enactive approach "deny the representationist view of perception in favor of the idea that perception is perceptually guided action (p. 203)."¹ But at the same time, unlike Gibson, they also denied the idea that the objective world is known to us. In their influential book, Varela et al. (1991) proposed "as a name the term enactive to emphasize the growing conviction that cognition is not the representation of a pregiven world by a pregiven mind but is rather the enactment of a world and a mind on the basis of a history of the variety of actions that a being in the world performs (p. 9)." The name "enactive," for them, derived from the conviction that "a pregiven world" and the worlds enacted "on a basis of a history of the variety of actions that a being in the world performs" are not compatible. This point was repeatedly emphasized in the aforementioned book, often in the context of criticism against Gibson's ecological approach: "whereas Gibson claims that the environment is independent, we claim that it is enacted (by histories of coupling)... From the fact, however, that there is a mutuality between animal and environment—or in our terms the two are structurally coupled—it simply does not follow that the act of perceiving is direct in the Gibsonian sense of "responding" or "resonating" to optical invariants (Varela et al., 1991, p. 204)."

The fundamental difference between Varela, Thompson, and Rosch's enactive approach and Gibson's ecological approach lies in the view toward our shared environment. Gibson emphasized that the environment offers many ways of life. "There are all kinds of nutrients in the world and all sorts of ways of getting food ... all kinds of locomotion that the environment makes possible ... But, for all we know, there may be many offerings of the environment that have not been taken advantage of, that is, niches not yet occupied (Gibson, 1979/2015, p. 121)." Thereby, in Gibson's ecological approach to perception, the theory of two worlds, in any form, is rejected. "There is only one environment, although it contains many observers with limitless opportunities for them to live in it (Gibson, 1979/2015, p. 129)." By contrast, Varela et al. (1991) did not acknowledge the rich possibilities offered by the environment, but attributed the different experiences by different agents to intrinsic factors and their corresponding worlds that are not "out there," which is apparent in statements such as follows: "According to traditional wisdom, the environment in which organisms evolve and that

¹In the present article, I deliberately chose to limit my discussion on ecological psychology and enactive theories to the original approaches proposed by Gibson (1979/2015) and Varela et al. (1991), respectively, for the purpose of comparison, although I'm aware that diverse views are present in both approaches (e.g., Di Paolo et al., 2018). A comprehensive review of the literature on both approaches is beyond the scope of the present article.

they come to know is given, fixed, and unique. Here, again we find the idea that organisms are basically parachuted into a pre-given environment. . . . The key point, . . . , is that the species brings forth and specifies its own domain of problems to be solved by satisficing; this domain does not exist ‘out there’ in an environment that acts as a landing pad for organisms that somehow drop or parachute into the world. . . . what we describe as environmental regularities are not external features . . . (Varela et al., 1991, p. 198).” Without questioning the traditional characterization of the real environment as something that fixes what organisms come to know, they found the environment that exists “out there” simply incompatible with “the worlds enacted by various histories of structural coupling (Varela et al., 1991, p. 217).” This conviction further led them to abandon the idea of the world as independent and extrinsic. The crucial step taken here was the decision not to “retain the notion of an independent, pre-given environment but let it fade into the background in favor of so-called intrinsic factors (Varela et al., 1991, p. 198).” But, what if the environment that exists out there is not something that determines what is perceived by a perceiver, but proves to be itself sufficiently rich to provide the perceiver with open-ended possibilities of further exploration? As Gibson said in his letter to Malcolm, what if the variation found in perceptual experiences is not just the expression of the worlds enacted by various histories of life, but also an expression of the richness of the structure in ambient energy arrays that lies open to further scrutiny?

Of course, the latter Gibson’s view does not stand or fall on the basis of logical considerations, but is a matter for empirical inquiry. Two issues stand out for empirical inquiry: Where is the information for perception? Is the information sufficiently rich for the act of perception to be open-ended? Drawing on the recent empirical studies on the mechanical basis of information and pattern formation in a wide range of fields—mechanobiology, soft robotics, and sensory ecology—this paper illustrates a principle how pattern and change that are formed in an environmental medium, under certain conditions, could serve as the reservoir of information that makes available the open-ended opportunities for perception. Then, I shall discuss how the explicit consideration of the materials of the terrestrial environment—the particles in the atmosphere and the textured surfaces—led Gibson to replace the concept of “space” with the notion of “medium” that allows for the open-ended activities of perception. Finally, I argue that given due consideration of the ambient information available in the medium, the apparent incompatibility between the world independent of the perceiver that exist out there and the worlds enacted by various histories of life could be resolved.

INFORMATION IN LIQUID

As an illustration for the pattern and change that exist independent of perceivers that are potentially informative about the eventful world, let us first consider the case of so-called hydrodynamic perception—mechanosensing of water movements by aquatic animals. Most aquatic animals have developed perceptual systems to discriminate water disturbance

(Hanke and Bleckmann, 2004). These water disturbances arise from a variety of sources such as other animals including predators, prey, conspecifics, inanimate objects and events, and the swimming movements of the perceiving animal itself (Hanke, 2014). For example, water disturbances caused by swimming fish of different species have been shown to have different wake signatures, which can last for several minutes (Figure 1). These water movements provide valuable sources of information for piscivorous predators at a distance not only about the presence of a fish of suitable size but also about the species or the swimming style of the fish that have passed by at an earlier point in time (Hanke and Bleckmann, 2004). A recent study showed that the flow structures caused by the fast-starting fish consisted of multiple jets that contain directional information, which are suited to provide aquatic predators not only with information on the presence of a fish of suitable size, but also on the direction of its escape (Niesterek and Hanke, 2013). Harbor seals—piscivorous mammals—are known to use their vibrissae to haptically discriminate the water movements left behind by prey or predator, and perceive the motion path, size and shape of the object that caused the trail (Hanke, 2014).

A point worth emphasizing is the fact that although the informative patterns of water movement are there to be perceived by an animal, there are many reasons that the animal may not attend to the information. The harbor seal running away from the white shark may not attend to a pattern of water movement that specify the presence of salmon that can be preyed upon. Near the surface of clear water during daytime the animal may attend to optical information without taking advantage of hydrodynamic information. The flow patterns that are informative about various aquatic events exist out there in the water. However, at the same time, the patterns of water movement do not fix what is perceived by perceiving animals. Instead, the ambient water makes available the open-ended opportunities for selectively picking up different features of the flow pattern depending

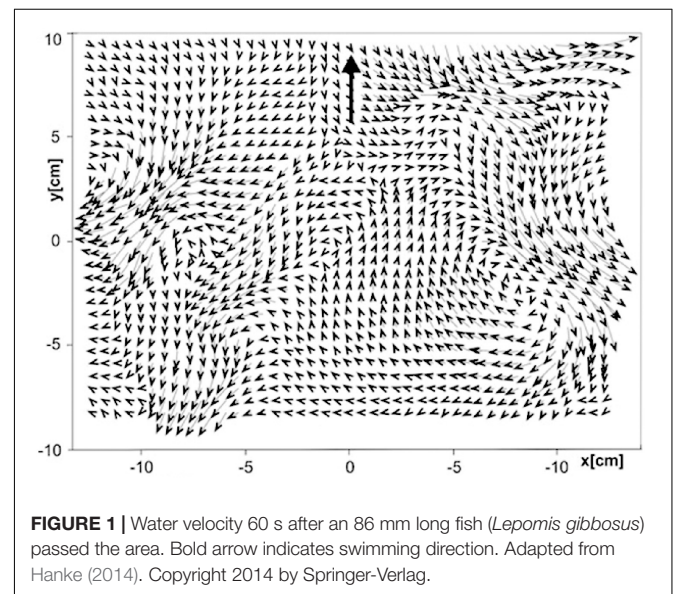


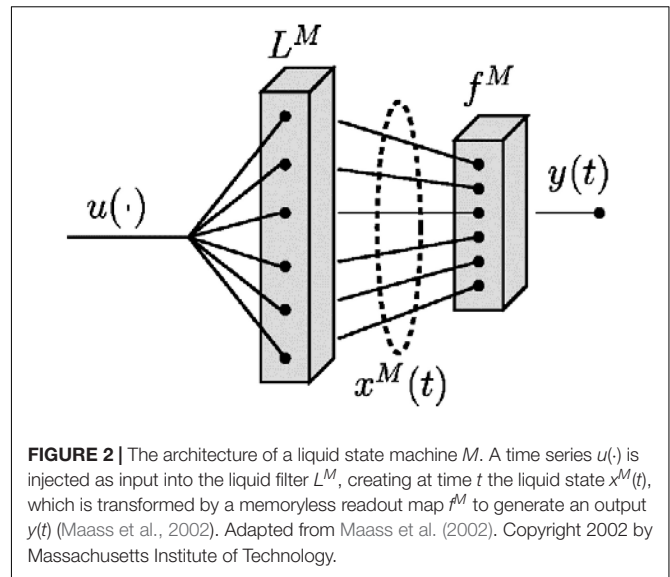
FIGURE 1 | Water velocity 60 s after an 86 mm long fish (*Lepomis gibbosus*) passed the area. Bold arrow indicates swimming direction. Adapted from Hanke (2014). Copyright 2014 by Springer-Verlag.

on various life histories of perceiving animals. Hydrodynamic perception is possible provided the following two conditions are met: (1) the water movements are sufficiently sensitive to differentiate different source events, and (2) the perceiver has the skill and sufficient resolution to detect the difference between different water movements.

Quite independently from hydrodynamic perception research, the computational neuroscientist Maass has arrived at some similar viewpoints that the perturbed states of the medium could potentially make available the reservoir of information from which different task-specific information could be extracted. Maass et al. (2002) identified that the key challenge to understanding perception is to find the right conceptual framework that could explain how animals detect in real-time the equivalent state from the continuously changing stimulation which may never repeat. In tackling this challenge, Maass took seriously the material environment of neurons—the fact that “the neurons in our brain are embedded into an artificial sea-environment, the salty aqueous extracellular fluid which surrounds the neurons in our brain (Maass, 2002, p. 33).” Using the metaphor of liquid, Maass et al. (2002) wrote as follows:

... consider a series of transient perturbations caused in an excitable medium (see Holden et al., 1991), for example, a liquid, by a sequence of external disturbances (inputs) such as wind, sound, or sequences of pebbles dropped into the liquid... the perturbed state of the liquid, at any moment in time, represents present as well as past inputs, potentially providing the information needed for an analysis of various dynamic aspects of the environment. In order for such a liquid to serve as a source of salient information about present and past stimuli without relying on stable states, the perturbations must be sensitive to saliently different inputs... (Maass et al., 2002, pp. 2533–2534).

Using perturbations caused in a medium as informational resources, Maass et al. (2002) proposed a computational model called the Liquid State Machine, which maps some function of time (e.g., an aspect of the environment that changes continuously) onto other functions of time (e.g., continuous adjustments of action in relation to the changing aspect of the environment) in real-time. Although the framework has been applied to modeling computation in neural microcircuits, the implications of the liquid state machine are general and can be applied to different material systems. Like the Turing machine which has universal power for off-line computing on discrete inputs, liquid state machines are supported by a rigorous mathematical framework that guarantees, under idealized conditions, universal power for real-time computation with fading memory on continuous functions of time (Maass et al., 2002). In terms of architecture, a liquid state machine M consists of the following two components: The first component is a medium called a liquid filter L^M which generates, at every time t , perturbed “liquid state” $X^M(t)$ in response to a preceding continuous sequence of disturbances $u(\cdot)$ (Figure 2). A liquid filter has the time-continuous property of fading memory whose state depends on the disturbances from some finite time window into the past, just as the perturbed states of the sea water lasts for some finite amount of time after a fish has passed by. A liquid



filter needs not be customized for a specific task, just as sea water is pre-given and not customized for a specific task of each aquatic animal. The second component of a liquid state machine M is a memoryless readout map f^M that transforms, at every time t , the current liquid state $X^M(t)$ (which reflects the past as well as the current events because of the fading memory property of the liquid filter) into task-specific output $y(t)$. In other words, a readout map f^M extracts the task-specific information from the reservoir of information available in the current liquid state, and continuously adjusts the output in relation to the task goal. Depending on the task, the readout can generate an invariant response quite independent from high-dimensional transient states of the liquid, by learning to define the task-relevant equivalence classes for the dynamic liquid states (Maass et al., 2002). Moreover, it is possible to add multiple readouts to a single liquid filter so that each readout extracts different task-specific information from the rich liquid state in such a way to support completely different, multiple real-time controls in parallel.

A liquid state machine is a time-invariant filter with fading memory that maps input stream onto an output stream. It has the universal power for real-time computing on perturbations regardless of specific implementation or structure, provided that the following two macroscopic properties are satisfied: a separation property and an approximation property (Maass et al., 2002). A separation property addresses the amount of separation between the trajectories of perturbed states of the liquid that are resulting from two different input disturbances (i.e., the difference between the wave patterns caused by different sequences of disturbances). An approximation property addresses the capability of distinguishing and transforming different perturbed states of the liquid into given target outputs (Maass et al., 2002). Whereas a separation property depends largely on the material characteristics of the liquid, an approximation property depends largely on the adaptability of the readout mechanism to the required task (Maass et al., 2002).

Theoretically, the performance of liquid state machines improves with any improvement in their separation or approximation property (Maass et al., 2002).

The conceptual framework of a liquid state machine was later unified with so-called Echo State Networks—a machine learning approach independently developed by Jaeger that shares the fundamental operating principle (Jaeger and Haas, 2004)—under the overall label of *reservoir computing*. The framework of reservoir computing suggests that the reservoir (i.e., a medium such as a liquid filter in liquid state machines) that exists independent of the task-specific readouts, if it has rich and diverse enough dynamics to differentiate the different sources of disturbances, could make available the opportunities for real-time, task-specific control of the medium-readout system. In reservoir computing, the only task of the reservoir is to have its dynamic state perturbed by some event (Seoane, 2019). In doing so, through its non-linear, convoluted dynamics, the reservoir is picking up the event and projecting it into the high-dimensional space that consists of various possible dynamic configurations of the reservoir, which could potentially render relevant features from the event more easily separable. Provided that the separation property is satisfied, the implementation of the reservoir can be quite arbitrary—be it spider web sensitive to mechanical disturbances or a recurrent circuit of integrate-and-fire neurons with rich recurrent dynamics. This suggests the possibility that an arbitrary material system could be “found” and used as the reservoir in the course of evolution or development (as opposed to being “determined” by animals), from which information about different aspects of the eventful environment could be extracted.

THE BODY AS A RESERVOIR

In engineering, structures with high degrees of dynamical coupling are known to be difficult to control, because these couplings tend to produce undesirable non-linear interactions that are difficult to predict (Rieffel et al., 2009). But what if there's a possibility that these structures rife with dynamical coupling can be harnessed not as something whose movement is to be governed by a commander, but as a medium which provides the reservoir of information? Based on the framework of a liquid state machine, Hauser et al. (2011) used a simple generic model of physical body based on mass-spring systems to implement a liquid filter in a simulation experiment, in which the system learns the complex mapping of the movements of the end-effector of a robot arm on a horizontal plane to the joint torques required to produce the movements (i.e., inverse dynamics). They randomly positioned 30 mass points in a two-dimensional plane, which were then connected by 78 non-linear springs with randomly chosen heterogeneous properties (Hauser et al., 2011). Two sets of randomly chosen six mass points received linearly scaled horizontal disturbances F derived from the target x and y position in the plane, respectively, whose scaling factors were again randomly selected and fixed (Figure 3). Just like spider web, the entire mass-spring network responded to these disturbances in real-time by changing the 78 spring lengths, which were the

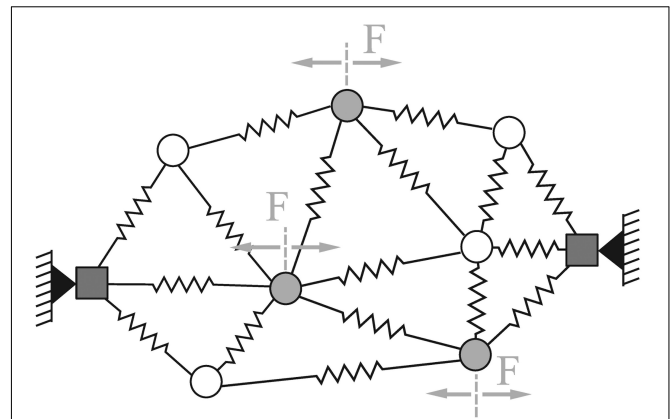


FIGURE 3 | Schematic example of a generic mass-spring network. The mass points are connected by non-linear springs. The square masses are fixed in order to hold the network in place. The gray mass points are randomly chosen inputs nodes, which receive the input in form of horizontal forces scaled by randomly initiated weights (Hauser et al., 2011). Adapted from Hauser et al. (2011). Copyright 2011 by Springer-Verlag.

78-dimensional “liquid states” of the body. The linear readout of the system was defined as the weighted sum of continuously changing 78 spring lengths whose weights were adapted to the corresponding target torque in the learning process. After learning, the mass-spring networks successfully performed the complex mapping of the target movement of the end effector to the torque time series with extremely high accuracy (Hauser et al., 2011). When no mass-spring body was available and linear regression was applied on the raw input signals (i.e., x and y positions of the end effector) instead of the 78 spring lengths, the system was not able to adjust the momentary torque according to the target position. Interestingly, even when the mass-spring body was available, when all the spring properties were made homogeneous, the performance of the system severely deteriorated, implying that diversity is an important material property of the body that allows real-time guidance of movement (Hauser et al., 2011).

In a subsequent experiment, Nakajima et al. (2013) used an actual soft robotic arm, inspired the anatomy of an octopus, to control the movement of the arm in a closed-loop manner in such a way to embed non-linear limit cycles (e.g., the Van der Pol limit cycle). Using the similar mass-spring network as Hauser et al. (2011), they fed the output generated by the system (weighted sum of all the spring lengths of the arm) back into the system as a motor command for the next timestep which generated the rotation movement of the arm (Nakajima et al., 2013). And then the spring lengths of the arm perturbed by the self-movement were in turn used as resources to adjust the torque that controls the movement of the arm. In the experiment, they trained the linear readout to obtain the optimal readout weights to emulate a non-linear limit cycle, and then switch the motor command to the system output generated by the trained readout weights. They found that the motor output of the arm exhibited almost a complete fit with the target trajectory for some types of limit cycles,

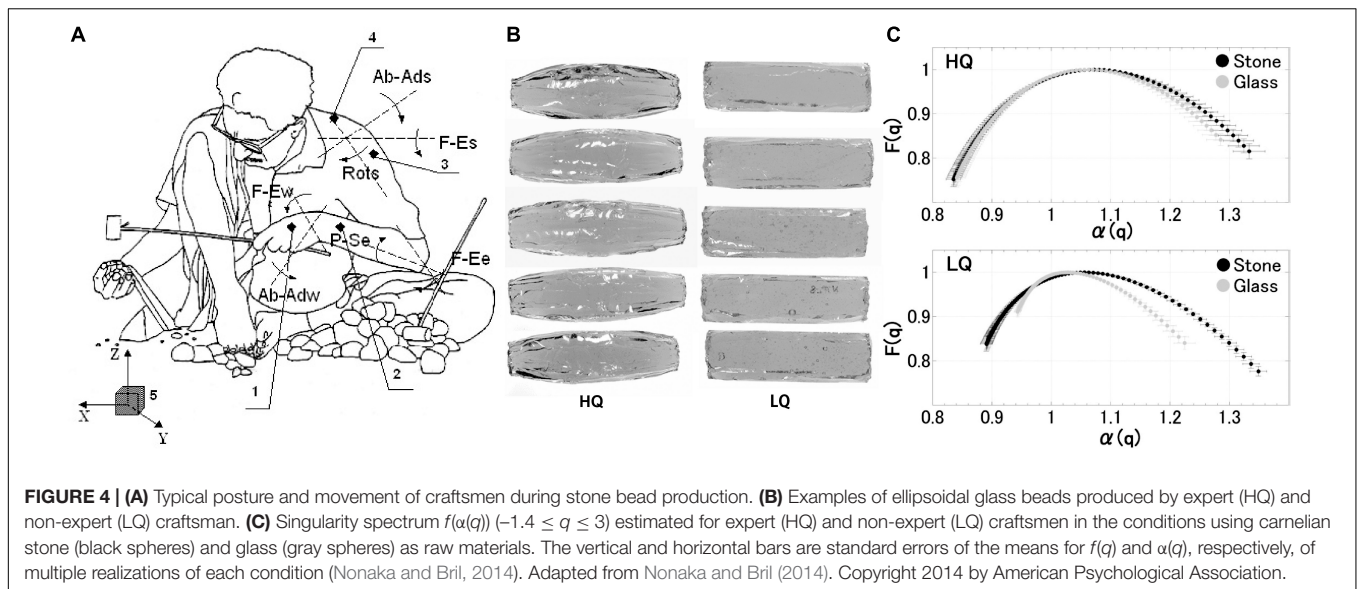
which was robust against external noise over an extended period of time (Nakajima et al., 2013). These studies implied that a complex structure rife with dynamical coupling can be harnessed as a medium that provides rich resources for controlling the *movements* of the system of which such structure is a part. However, it should be noted that whether and how task-specific information could be actively sought after in the reservoir so as to control the system's *encounters* with a cluttered environment still remains to be seen.

The manner in which reservoir computing is conventionally discussed is as a model of computation to perform complex mappings from input sequences to output sequences (e.g., to emulate dynamical systems). In this context, the main concern has been the information provided by the states of a medium perturbed by *passive* input. We shall now turn to *active* exploration that brings about disturbances in a medium in such a way to isolate informative structures. Gibson's classic paper on active touch offered a stark illustration of the contrast between a passive receptive channel of sensory input and an active system that hunt for information (Gibson, 1962). The haptic apparatus of animals incorporates mechanoreceptors that are distributed across different parts and organs of the body—in and below the skin, the ligaments connecting the joints between the movable bones, and the muscles and the tendons. It is notable that what all these parts and organs have in common is that they can be moved and deformed, actively as well as passively (Gibson, 1966, p. 108). Recently, Turvey and Fonseca (2014) hypothesized that interconnected structural hierarchies composed of tensionally prestressed networks of our bodies that span from the macroscale to the microscale—from muscles, tendons, and other connective tissues to various micro-elastic structures such as a network of collagen fibers—constitute the medium for the haptic sense organs of animals. Because the form of any structure, whether a vortex flow of water or a living tissue, is determined through a dynamic interplay of physical forces, the distinct pattern of forces characteristic of a mechanical disturbance may convey a physical form of information that constrain perception and behavior of an agent (Ingber, 2005). Like the air being the medium for sound, odor, and reverberating flux of light, despite being on the other side of the skin, Turvey and Fonseca (2014) argued, the presence of isometric tension distributed throughout all levels of interconnected, multiscale networks make available the opportunities for an active perceiver to spontaneously perturb the tensionally integrated system in such a way to isolate the invariant patterns that specify the source of mechanical disturbances.

For the haptic perception of the properties of hand-held objects, evidence to date suggests that different properties of a held object are independently perceivable (for reviews, see Turvey and Carello, 2011). Wielding an object exerts reactive forces and torques on skin, muscles, ligaments, and tendons. From this array of deformation, perceivers are shown to be able to selectively pick up information that specifies properties such as length, width, and crude shape of the hand-held object. The manner of active exploration has also been shown to differ systematically as a function of the particular property to be

attended to. For example, when perceiving how far a hand-held object extends from hand (i.e., the object's length), wielding movement about the wrist joint is typically observed (Carello and Turvey, 2017). Thereby, a rotation point defined in the wrist is always at a fixed distance from an object held in the hand, enabling the invariant rotational inertia specific to the length of the object to be isolated over the time-varying motions of the limb and accompanying deformation of tissues. By contrast, when perceiving the width of a hand-held object such as a tennis racket, twisting movements about the longitudinal axis of the object is typically observed, allowing the invariant rotational inertia specific to the width to be isolated over the time-varying motions of the limb (Arzamarski et al., 2010). Moreover, a variety of available opportunities for exploration is related to the fact that the same property of the object is perceivable by means of different neuromuscular patterns of movement. Silva et al. (2009) reported that a patient with stroke-induced motor impairment who had restricted movements of the wrist was nevertheless able to perceive the length of the rod secured to the hand with an elastic band with the same accuracy and reliability as individuals without movement disorders. This patient wielded the rod not about the wrist but about the longitudinal axis of the arm through the shoulder joint, which was kept at a fixed distance from the end of the rod. Despite the very different kinematics and transformation of tissue deformation arrays, the wielding movement apparently contributed to separating off the same invariant as did the wrist movement (Silva et al., 2009).

In recent years, there has been a growing interest in the problem concerning the transformation and variation produced by active exploratory movement to separate the information about aspects of the environment relevant to the task at hand (Nonaka, 2019). In general, exploration requires fluctuations, and fluctuations increase in time. A growing body of evidence indicates that the fluctuations in exploratory behaviors exhibit the property of superdiffusion, where the fluctuation grows faster than normal diffusion governed by a Gaussian probability density function (e.g., Stephen et al., 2010; Viswanathan et al., 2011). Nonaka and Bril (2014) studied the exploratory movement of expert stone beads craftsmen in India who shape a bead by a series of hammer strikes on a stone held against the pointed tip of an iron bar (**Figure 4**). In the field experiment, the craftsmen shaped the ellipsoidal beads made of two different materials (carnelian stone—familiar material, and glass—unfamiliar, much more fragile material) in the studios they normally work. The use of the unfamiliar material must require an acute sensitivity to the properties of the material, where the finer the exploration, the better the probable outcome of the activities that follow. In the exploratory tapping movement of the craftsmen during the preparatory phase of the task, they found (a) the presence of long-range correlations where the variance of the displacement time series of the hand wielding the hammer grows superlinearly in time, and (b) underlying multiplicative interactions between fluctuations at different temporal scales indicated by the heterogeneity of scaling properties over time. When faced with the unfamiliar condition using unusual, fragile material, the exploratory hammer tapping movement of highly skilled experts who were able to cope with the



situation exhibited a pronounced increase in the long-range temporal correlations. By contrast, the wielding behavior of less skilled experts—those who could not shape the glass beads—exhibited a significant loss of long-range correlations and reduced heterogeneity of scaling properties over time, which robustly discriminated the groups with different skill levels (**Figure 4**). Alterations in multiscale temporal structure of movement fluctuations were apparently associated with changes in the situation differently depending on the level of expertise (Nonaka and Bril, 2014).

The empirical evidence derived from this field experiment, albeit a special case of an unusually complex skill, may well serve for the purpose of constraining the possible accounts of active touch. Traditionally, corollary discharge from motor areas to somatosensory regions of the cortex has been considered to play a key role in active touch, which provides posterior parietal neurons with information on intended actions, allowing these neurons to compare planned and actual neural responses to tactile stimuli (Kandel et al., 2013, p. 524). Such an account focuses on sensory receptors and nervous system without reference to the architecture of the body where they are embedded. However, the problem expert craftsmen face is unlikely to be that of associating central and peripheral signals. The presence of non-linearity arising from multiplicative interaction across fluctuations at different timescales would greatly complicate such a process, with no simple correspondence between central motor commands, resulting movements and peripheral sensory feedback arising from them (Nonaka, 2019). Instead, the result is a much better fit to the alternative scenario of active touch that takes into account the medium for the haptic perceptual system (Turvey and Fonseca, 2014), in which efficacy of active touch depends on the tuning of the whole system including the multiscale tensile states of the body, the structures of which are transformed by exploratory behavior in such a way to differentiate the invariant patterns that specify the source of mechanical disturbances

from all the other patterns that do *not* specify the source (Gibson, 1966, p. 55).

THE MEDIUM

The notion of medium is the centerpiece underlying Gibson's claim that the activity of perception is open-ended. Gibson used the term *medium* to refer to the material through which energy flows (e.g., wave propagation) and an animal travels, which is, after all, the dictionary meaning of the word. Gibson liked to contrast "space" with "medium." "Space" is often regarded as an empty room that is blank and immaterial as opposed to the material objects. For example, the influential geographer Tuan (1977) wrote, "space means room (p. 51)" where material objects can be put in, and "space is experienced directly as having room in which to move (p. 12)," while "place and objects define space (p. 17)." By contrast, Gibson argued that what allows movement is not empty space but the gaseous atmosphere with specific material properties that offer low resistance to animal movement. The environment of animals consists of matter in the solid state and matter in a liquid or gaseous state, as well as the surfaces between them. Solid surfaces generally reflect rather than transmit light. They also generally prevent rather than permit locomotion. In contrast, through the liquid or gaseous regions of the environment, a detached solid body can move without much resistance. "It thus affords locomotion to an animate body. A gas or a liquid, then, is a medium for animal locomotion. Air is a better medium for locomotion than water because it offers less resistance (Gibson, 1979/2015, p. 12)." Gibson rightly recognized that the distinction between that which allows movement and that which does not has nothing to do with the empty/filled or material/immaterial dichotomy. Instead, this distinction is connected with the states of the surrounding material (e.g., solid, liquid, and gas). "Objects do not fill space, for there was no such

thing as empty space to begin with. . . . The world was never a void. As for the medium, the region in which motion and locomotion can occur, where light can reverberate and surfaces can be illuminated, this might be called room but it is not space (Gibson, 1979/2015, p. 93)."

Not only allowing movement and locomotion, a terrestrial medium is a region in which light not only is transmitted but is scattered by particles in the atmosphere that is never perfectly transparent. Unlike mechanical waves mentioned in the example of hydrodynamic perception, electromagnetic waves such as light may occur in a vacuum as well as in a material medium. When light gets transmitted not in a vacuum but through the material medium of the atmosphere, the light is scattered by particles in the atmosphere, the amount of which depend on atmospheric conditions. This light is even more thoroughly scattered when it strikes the textured terrestrial surfaces. The scatter-reflected light is in turn reflected back from the particles in the atmosphere. Each new reflection further disperses the incident rays. The light thus finds its way into cluttered environment that are not open to the light source, "through chinks and crevices and into caverns (Gibson, 1979/2015, p. 44)." In semi-enclosed spaces the light continues to bounce back and forth at enormous velocity, and the reverberation of multiple-reflected light in a terrestrial medium reaches a steady state almost instantly. "This light can hardly be thought of as radiation now; it is illumination (Gibson, 1979/2015, p. 44)." Illumination is a fact of higher order than radiation. Many-times reflected light in a medium has a number of consequences important for visual perception. Chief among them is the fact of ambient light, that is, light that surrounds a point, any point, in the medium where an observer could be stationed (Gibson, 1979/2015, p. 45). The reverberating flux of light in the medium brings about the condition in which there is light coming to the point from all directions.

Although important for the act of visual perception, the distinction between the light which affords active exploration and the light which does not is rarely stated. There is experimental evidence that seeing the surfaces depends on the structure of the ambient optic array which has different intensities in different directions (Gibson et al., 1955). There is also evidence that the eye would be unable to focus in homogeneous ambient light (i.e., in the unusual case where light that surrounds a point of observation would not be different in different directions). If the light coming to the nodal point of the eye has no discontinuities of intensity in different directions, then it is impossible to accommodate your eyes (Gibson, 1982a, p. 92). In consequence, "the possessor of the eye could not fix it on anything, and the eye would drift aimlessly" (Gibson, 1979/2015, p. 47). When the light available to the eye is wholly undifferentiated, then you cannot actively explore the array, even though you may have a sensation of light. A vertebrate eye can extract information from ambient light only when the ocular system can accommodate, and for this the ambient light must be structured. It must constitute an optic array having an arrangement (Gibson, 1982a, p. 92).

In a terrestrial medium, radiant light becomes ambient light with full of higher-order patterns and changes in a complex

hierarchy of inter-nested levels of structures and substructures. Ambient light is not to be confused with radiant light. Radiant light from the light source traveling in *space* itself does not carry informative structures about the surfaces of the environment. By contrast, radiant light traveling in the atmospheric *medium*, due to the multiple scattered reflections between surfaces of the particles in the air and those of the cluttered environment, results in ambient light where any point in the medium is structured by the light reflected from surfaces so that these characteristics are specified, which could render features of the substances, surfaces, places, things, and events potentially separable.

We are tempted to call the medium "space," but the temptation should be resisted. For the medium, unlike space, permits a steady state of reverberating illumination to become established such that it contains information about surfaces and their substances. That is, there is an array at every point of observation and a changing array at every moving point of observation. The medium, as distinguished from space, allows compression waves from a mechanical event, sound, to reach all points of observation and also allows the diffusion field from a volatile substance, odor, to reach them (Gibson, 1979/2015, p. 216).

The notion of medium allows the distinction between potential and effective stimulation. We can now talk about *potentially* visible surfaces that could be looked at from some place in the medium where an animal might be, without making slightest reference about the actual stimulation of an eye and sensations of vision (Gibson, 1979/2015, p. 19). Radiant, acoustic, and chemical energy that are propagated through the medium provides the ambient sea of stimulus energy in which animals can move about. Instead of inquiring whether one model of inferring the causes of sensation aroused by stimuli is better than another, with the notion of medium we can now begin to study activity before sensations have been aroused by stimuli, an activity that orients the organs of perception and explores the sea of potential stimulation for the information external to the perceiver (Gibson, 1982b, p. 398). Unlike points in space defined by an arbitrary frame of reference, the ambient energy array surrounding each potential point of observation is unique (Gibson, 1979/2015, p. 14). As the observer moves from one point of observation to another, the optical array, the acoustic array, and the chemical array are transformed accordingly (Gibson, 1979/2015, p. 13). This provides the opportunities for an *active* observer to move in the medium to detect invariants underlying the transforming perspectives in the ambient array surrounding a moving point of observation.

The kind of information that may be obtained by exploration in the medium is fundamentally different from the kind of information available in a so-called visual image (e.g., a retinal image). For example, consider the case of distinguishing an obstacle from an opening in a cluttered environment. An obstacle affords collision. An opening affords passage. Both have a closed or nearly closed contour. The contour could be the edge of an obstacle such as a goblet, or could be the edge of an opening between a pair of faces as in the goblet-faces display described by Edgar Rubin. The way to tell the difference between an obstacle and an opening is inextricably tied to the manner of

exploration by the perceiver in the medium: Loss (or gain) of structure outside a closed contour during the perceiver's approach (or retreat) in the medium specifies an obstacle. Gain (or loss) of structure inside a closed contour during the perceiver's approach (or retreat) in the medium specifies an opening (Gibson, 1979/2015, p. 219). As the perceiver come up to the obstacle it hides more and more of the vista, and as you come up to the opening it reveals more and more of the vista. A closed contour as such does not specify an obstacle or an opening in a cluttered environment. But deletion outside the occluding edge and accretion inside the occluding edge will distinguish the two. A certain manner of exploration in the medium results in a unique optical transformation that provides access to these invariants under transformation that specify an obstacle or an opening. Thereby, the perceiver tunes in on the invariant structure of the ambient optic array that underlies the changing perspective structure caused by her own exploratory movements (Gibson, 1979/2015). The whole flux of reverberating light pervading the medium is a potential stimulus which can be sampled at various points of observation in the medium, although it must be explored by embodied locomotor action of a perceiver. There are families and super-families of invariant information in a transforming ambient optic array at a moving point of observation in the medium, and by separating off such information, the perceiver in turn guides and controls locomotion, steers away from an obstacle, and enters an opening (Gibson, 1958/1998).

If we understand the notion of medium, I suggest, we come to an entirely new way of thinking about perception and behavior. The medium in which animals can move about (and in which objects can be moved about) is at the same time the medium for light, sound, and odor coming from sources in the environment. An enclosed medium can be "filled" with light, with sound, and even with odor. ... As the observer moves from point to point, the optical information, the acoustic information, and the chemical information change accordingly. Each potential point of observation in the medium is unique in this respect. The notion of a medium, therefore, is not the same as the concept of space inasmuch as the points in space are not unique but equivalent to one another (Gibson, 1979/2015, pp. 13–14).

The fact is worth remembering that normal perception always involves the possibility of further exploration (of scrutinizing, of looking more carefully) whether or not the possibility is taken advantage of (Gibson, 1978). But, what makes us aware of the possibility of further exploration in the first place? What makes us aware of the layout of the environment in and out of sight? What makes it possible for animals to discover the potentially meaningful features of the environment that have not yet been taken advantage of? These questions share concerns regarding the same fundamental issue which cannot be resolved without restoring the following two terms: (1) an active perceiver that explores the environment, and (2) a reservoir of potential information about the environment that exists independent of the active perceiver. Without them, it would be impossible to disentangle a set of variables that are specific to the world out there (i.e., independent of the point of observation). With the notion of medium, at which Gibson

arrived through the reconsideration of the materials that make up the terrestrial environment, we can locate the region in which information is sought after by an active perceiver, as well as the flowing array of energy that provides the opportunities for the activity of perceiving.

EPILOGUE

Varela et al. (1991) viewed perception as follows: "perception consists in perceptually guided action. ... the reference point for understanding perception is no longer a pre-given, perceiver-independent world but rather the sensorimotor structure of the perceiver (the way in which the nervous system links sensory and motor surfaces). This structure—the manner in which the perceiver is embodied—rather than some pre-given world determines how the perceiver can act and be modulated by environmental events (p. 173)." Yet, despite their characterization of perception as perceptually guided action, they did not mention the embodied act of perceiving—exploratory activity—that orients the organs of perception such as looking, listening, touching, tasting, and sniffing which involves muscular adjustments of organs to explore the rich structure of ambient energy arrays. What they also left out in their criticism against Gibson was the notion of medium. The lack of mention of these two notions in their book was probably not a coincidence. Failing to locate the ambient information available in a medium, Varela et al. (1991) did not have a means to clearly disentangle the existing information available to a perceiver from the information selectively picked up by the perceptual activity of the perceiver. Accordingly, they could not find where the embodied act of perceiving could literally *take place*. By virtue of not having a proper characterization of rich possibilities offered by the environment, Varela et al. (1991) were not able to talk about what perception is *after*. As a consequence, they could only talk about perceptually guided action, but not about what the activity of perception (e.g., the accommodation of the ocular system) is a constant function of (c.f., Holt, 1915).

Luminous, mechanical, or chemical energy is structured by the substantial environment and becomes ambient in the medium. The ambient sea of energy around each of us is usually very rich in what we call pattern and change, which is limitless in variables of higher order. The variables and co-variables and invariables of this stimulus environment are inexhaustible (Gibson, 1979/2015, p. 233). The environment, so considered, would consist of a reservoir of possible stimuli for both perception and action (Gibson, 1982c, p. 344). Taking into account the inexhaustible reservoir of information, what has been known tacitly is made explicit: The activity of perception is "open-ended," and you can keep discovering new features and details about the environment by the act of scrutiny (Gibson, 1979/2015, p. 245).

... whether or not a potential stimulus becomes effective depends on the individual. It depends on the species to which he belongs, on the anatomy of the sense organs, the stage of maturation, the capacities for sense organ adjustment, the habits of attention, the activity in progress, and the possibilities of educating the attention of the individual (Gibson, 1982c, p. 346).

The present paper reviewed empirical evidence that supports the idea that the environment that exists out there is itself sufficiently rich to provide the perceiver with open-ended possibilities of further exploration. I believe that Varela et al. (1991) criticism against Gibson mentioned in the introduction was based on misunderstanding of Gibson's "new" description of the indefinitely rich environment on which his approach was founded. The notion of the environment as a reservoir of limitless opportunities for both perception and action effectively eliminates any need to invoke the notion of *two worlds* or *many worlds* to rationalize the multiplicity of viable histories of structural coupling. With an adequate description of what the environment may offer to perception, the environment that exists out there and various viable streams of perceptual experience would turn out to be compatible. What the recognition of the environment with its unlimited possibilities brings to us is a theory of unlimited further discovery for perception, in which the apparent incompatibility between the many and the reality is resolved.

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Enactive Pragmatism and Ecological Psychology

Matthew Crippen^{1,2*}

¹Department of Philosophy, Grand Valley State University, Allendale Charter Township, MI, United States, ²Berlin School of Mind and Brain, Humboldt University of Berlin, Berlin, Germany

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*Correspondence:

Matthew Crippen
matthewjcrippen@gmail.com

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A widely cited roadblock to bridging ecological psychology and enactivism is that the former identifies with realism and the latter identifies with constructivism, which critics charge is subjectivist. A pragmatic reading, however, suggests non-mental forms of constructivism that simultaneously fit core tenets of enactivism and ecological realism. After advancing a pragmatic version of enactive constructivism that does not obviate realism, I reinforce the position with an empirical illustration: *Physarum polycephalum*, a communal unicellular organism that leaves slime trails that form chemical barriers that it avoids in foraging explorations. Here, environmental building and sensorimotor engagement are part of the same process with *P. polycephalum* coordinating around self-created, affordance-bearing geographies, which nonetheless exist independently in ways described by ecological realists. For ecological psychologists, affordances are values, meaning values are external to the perceiver. I argue that agent-enacted values have the same status and thus do not obviate ecological realism or generate subjectivism. The constructivist-realist debate organizes around the emphasis that enactivists and ecological theorists respectively place on the inner constitution of organisms vs. the structure of environments. Building on alimentary themes introduced in the *P. polycephalum* example and also in Gibson's work, I go on to consider how environment, brain, visceral systems, and even bacteria within them enter perceptual loops. This highlights almost unfathomable degrees of mutually modulating internal and external synchronization. It also shows instances in which internal conditions alter worldly configurations and invert values, in Gibson's sense of the term, albeit without implying subjectivism. My aim is to cut across the somatic focus of enactive constructivism and the external environment-oriented emphasis of ecological realism and show that enactivism can enrich ecological accounts of value.

Keywords: affect and value, central and peripheral nervous system, ecological psychology, enactivism, gut microbiome, pragmatism and phenomenology, *Physarum polycephalum*, realism vs. constructivism

INTRODUCTION

This article starts with a commonly cited conflict: that ecological psychologists hold that environmental openings and closures for action – or affordances – remain independently of whether or not an organism is present, whereas enactivists insist that agents energetically bring forth qualities that are available to perception (see Varela et al., 1991, pp. 203–204;

Fultot et al., 2016; Baggs and Chemero, 2018, 2020; Feiten, 2020; Heft, 2020; Nonaka, 2020; Segundo-Ortin, 2020). Ecological psychologists are accordingly said to favor realism and enactivists tend to lean toward quasi-idealist, constructivism.

Some commentators reject this debate as unfruitful and circumnavigate it by differentiating between environments as real affordance possibilities shared by a species and lived-worlds as constructed according to individual capacities (Baggs and Chemero, 2018, 2020). Outlooks advanced by Dewey a century ago, however, flatly suggest that constructivism need not be anti-realist in the first place. Put simply, Dewey (1920, 1925) advances a non-mental constructivism, wherein perceiving and knowing necessitates changing things or at least conditions under which they are encountered. He thereby sketches an account that retains core ideas shared by different varieties of enactivism. Simultaneously, a Deweyan rendering jettisons aspects that ecological psychologists find problematic – for example, the notion that perception arises through emergent patterns of neuronal activity (Varela et al., 1991, Ch. 8), a view not advanced by all enactivists (e.g., O'Regan and Noë, 2001). A Deweyan interpretation, moreover, offers a version of constructivism that does not obviate realism since ecological alterations, once introduced, really are there.¹ A biological illustration is *Physarum polycephalum*: a communal unicellular organism that marks where it has been with slime secretions that it then avoids, thereby enacting or bringing forth its own geography and affordances in it. This case is typical of what enactivists cite (e.g., Thompson, 2004, Ch. 4; Noë, 2009, pp. 40–43; Di Paolo et al., 2017, Ch. 5). It is constructive insofar as *P. polycephalum* literally builds a chemical environment that immediately scaffolds its sensorimotor activity. It is simultaneously realist in senses described by ecological psychologists inasmuch as *P. polycephalum* can leave an area, with the affordance-bearing chemical barriers remaining.

For ecological psychologists, affordances are values. This means values are properties in environments, albeit defined in relation to organisms (see Gibson, 1966, p. 285, 1979, p. 127). In stripped-down form, values characterize what is favorable or hostile to an organism – a conception shared by enactivists (e.g., Thompson, 2004, Ch. 4; Colombetti, 2014, Ch. 1). Inasmuch as *P. polycephalum*'s food foraging gravitates toward unmarked and hence unexplored areas, it supplies an enactive iteration of agent-constructed values that nonetheless fits ecological definitions, which are non-subjective. Unicellular examples, however, are relatively simple, and I expect entrenched ecological psychologists to reject the *P. polycephalum* illustration as genuinely constructive, so I also examine enactive and ecological conceptions of value in cephalic creatures such as humans. The aim, once more, is to show that enactive and ecological views are not fundamentally at odds and that we need not dogmatically suppose that constructivist and realist labels obviate one another.

Though enactivists and ecological psychologists both reject representational theories, the constructivist-realist debate

organizes in significant degree around the emphasis that they respectively place on the inner constitutions vs. the environments of organisms. Later portions of this article attempt to cut across this divide by examining nutritive life in cephalic creatures, articulating how visceral systems and bacteria within them alter sensorimotor activity and, by extension, values and affordances, but without diminishing their objective status. Key points advanced are (1) that gut and bacteria generated hormones and neurotransmitters alter mood, therewith environmental attunement and behavior, thus openings for action, hence perception and cognition; (2) that viscera, gut microbiota, and brain communicate reciprocally, especially around gustatory needs; (3) that gut-brain-environment activity signifies almost unfathomable degrees of mutually modulating internal and external coordination; and (4) that alimentary processes entail the detection of structure in chemical arrays inside and outside the body and, in some cases, radically change values and worlds of animals. The first two points are important to embodied cognitive science generally. The second two are specifically relevant to ecological psychology and enactivism, which are at core theories of coordination, albeit with enactivists more willing to attend to the internal milieu. Together and especially with the last point, the account cuts across body-internal and environment-external dynamics, highlighting how enactivism can enrich ecological accounts of values, while garnering a broader ecology that can accommodate both schools.

NEGOTIATING CONSTRUCTIVISM AND REALISM

On classic renderings of enactivism, organisms “bring forth” and “enact” things rather than representing properties existing independently in the world (Dupuy and Varela, 1991; Varela, 1991; Varela et al., 1991, Chs. 8–9). Though there are different varieties of enactivism, all agree on the following: that bodily structure and objects encountered limit the way we manipulate and alter things, bringing rhythm and form to doings and undergoings and hence to the experiences arising out of them. This is not an entirely new idea but is expressed earlier by figures such as Dewey (1896) and Merleau-Ponty (1945/1962). As Dewey (1896) and enactive figures such as O'Regan and Noë (2001) reason, experience is not simply the world eliciting sensory excitations that are then wired to and interpreted by the brain. It is instead an outcome of the way sensory stimuli coordinate with motor activity and thus also around environmental contours. For this reason, perception is said to be “sensorimotor” (e.g., Dewey, 1896; Varela et al., 1991; O'Regan and Noë, 2001; Di Paolo et al., 2017); it is shaped by immediate movements and also by the history of structural coupling, along with habits, emotions, and anything else relating to actions. The key point for enactivists is that perception involves changes within local situations: “Since these local situations constantly change as a result of the perceiver's activity, the reference point for understanding perception is no longer a pregiven, perceiver independent world but rather the sensorimotor structure of the perceiver” (Varela et al., 1991, p. 173).

¹Michael Beaton (2016) offers a worthwhile account of enactive realism, but his arguments are not especially relevant to mine. Hence, while acknowledging his work, I do not integrate it into this article.

Enactivists offer a range of standard illustrations, which are not obviously antagonistic to ecological psychology, but nonetheless typify non-mental or “out of the brain and head” constructivism (see Noë, 2009). One example is hands coordinating around objects to bring forth shape and texture (e.g., O’Regan and Noë, 2001, p. 945; Noë, 2004, p. 73; Myin and Degenaar, 2014, p. 91; Di Paolo et al., 2017, Ch. 3; also see Peirce, 1878; Dewey, 1920, pp. 114–115; Mead, 1938/1964, Ch. 1; Merleau-Ponty, 1945/1962, pp. 367–368). Seen enactively, pliable roughness and glassy smoothness are not in sponges or bottles alone or in brains; they are enacted by fingers sinking into knobbly pliability or caressing surfaces not biting flesh; hence, these qualities are agent-generated outcomes of interactions with surroundings. Something similar holds for the sinewy toughness that a cat’s claws realize in wood or the yielding vs. unyielding property of water that emerges depending on speed of contact. Perceived properties are accordingly not represented in creatures but instead are qualities of interactions in which organisms and things outside of them partake (cf. Dewey, 1925, p. 159). The position extends to modalities such as sight. Among other attesting examples are sensory substitution devices where head-mounted cameras stimulate skin or tongue, and people actively exploring surroundings acquire an analog of vision (e.g., Varela et al., 1991, Ch. 8; O’Regan and Noë, 2001; Noë, 2004, Ch. 2; Di Paolo et al., 2017, Ch. 5). Here, perception is not reduced to sensation since a vision-like modality can be achieved without stimulating retinal cells. Perception is instead an outcome of the manner in which sensation and motor activity coordinate around environmental contours. For such reasons, enactivists identify perception as skilled acting (e.g., O’Regan and Noë, 2001; Noë, 2004; Thompson, 2004; Di Paolo et al., 2017), repeating Dewey (1917, p. 11, 1920, p. 79, 1925, p. 330) who argued that having experience means being experienced with consciousness only incidental.²

By virtue of arising in this way, perception characteristically entails a gross synchronization of bodily capacities around environmental structures as when legs, feet, arms, hands, and eyes collaboratively work to keep a car on the road ahead. Through such histories of structural coupling, we develop habits or skills that allow us to perceive avenues for action, even when we happen to be sedentary (see Varela et al., 1991, Ch. 8; O’Regan and Noë, 2001; Di Paolo et al., 2017, throughout). Enactivists sometimes extend this to an evolutionary level. Varela et al. (1991), for example, have argued that bee ancestors had sensitivity to UV light and that flowers with higher reflectance in this bandwidth pollinated more successfully. Bees with more sensitivity to UV frequencies likewise gathered more food, fostering the spread of their hive’s genes. This combination of pressures led to increases in UV reflectance in flowers and sensitivity in bees. Though an uncontroversial account of coevolution, Varela et al. (1991, p. 202) cite it – somewhat contentiously – as an “example of how environmental regularities are not pregiven but are rather enacted or brought forth by a history of coupling.”

²Though I obviously think my account of enactivism is defensible, see Heft (2020) and Read and Szokolszky (2020) for excellent contrasting views.

As with enactivists, ecological psychologists embrace evolution and maintain that perception occurs in a total system that includes agents and environments (see Gibson, 1966, 1979, 1992) and that we learn to perceive (Gibson, 1969; Jacobs and Michaels, 2007; Joh et al., 2007; Walter et al., 2017; Adolph et al., 2020). They are adamant that perception is not built up from sensory units akin to pixels, reinforcing the claim with Gestalt diagrams where we register entire shapes despite occluded portions (Gibson, 1979, Ch. 11; Heft, 2020). Ecological psychologists also stress the organism’s role in revealing environmental information as when discovering affordances by palpating soft objects (Gibson et al., 1987). However, they differ from enactivists in holding that perceivers do not add organization to what is received from the environment but register pre-existing structure. This means detecting affordances for action that are specified in an ambient array of energy (Gibson and Pick, 2000, pp. 15–16). An affordance, in turn, is said to be

neither an objective property nor a subjective property; or it is both... An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behavior. It is both physical and psychical, yet neither. An affordance points both ways to the environment and to the observer (Gibson, 1979, p. 129).

At the same time, affordances “are in a sense objective, real” (Gibson, 1979, p. 129). That is, they are really in the world but are co-determined by an organism’s capacities, so that water is walkable for some insects, yet not for humans (Gibson and Pick, 2000).

Ecological psychologists thus ally themselves with realism, arguing that “since an affordance is an objective property of the environment, it exists whether or not it is perceived or realized” (Gibson and Pick, 2000, p. 16). Realism is the view that properties exist independently of agents, so that wood is smooth or sinewy regardless of whether human fingers caress it or cat claws dig into it. In the case of ecological psychology, the position is a little more nuanced since affordances are relative to organisms, yet nonetheless independent. On this view, a chair affords sitting, regardless of whether anybody is there. As Heft (2020, para. 41) writes: “It is independent of me in the respect that it is in the next room; nothing that I do from here will affect it. But it only exists as an affordance possibility relative to me (or some other person).”

Ecological psychologists are accordingly antagonistic to enactive views – for instance, the claim that “the properties that specify what colors are simply have no nonexperiential, physical counterparts” (Varela et al., 1991, p. 166). They are hostile, first, because they do not stress phenomenal sensations, and second, because they hold that perception is grounded in the physical environment. It should be added as a caveat that colors are here not understood as sensations, but as emergent phenomenal attributes of things, volumes, and so forth, though this does not dispense with the objection. Yet, the objection can be dealt with if “experience” is understood in

Dewey's sense of being a quasi-skilled interaction, which is also the view of enactivists such as O'Regan and Noë (2001). This still leaves the constructivist-realist debate that the founders of enactivism – Varela et al. (1991) – aggressively introduced and that has been steadfastly maintained by proponents on both sides. As proposed at the outset, however, Dewey offers a way out of this.

Dewey is occasionally acknowledged as a forerunner to ecological psychology (Gibson, 1982, 1988) with other pragmatists such as William James more squarely recognized (Gibson 1979, p. xiii; Heft, 2020). It is also widely accepted that Dewey anticipated enactivism (see Gallagher, 2009, 2017; Crippen, 2016, 2017; MacKenzie, 2016; Barrett, 2019). In line with this, Dewey's (1920, 1925, 1934) work is unequivocally constructivist (see Hickman et al., 2009). Taking a cue from quantum mechanics, Dewey (1929, p. 84; also see pp. 87, 202–203) centrally argues that perceiving and knowing entails introducing changes to the world or altering conditions under which we observe it, which he regards as “the same thing in principle”. Such occurs when we thump things, hit one particle with another in quantum experiments, illuminate objects, or bend starlight with magnifying mirrors. It occurs when agents perceive and realize the properties of smoothness or sinewy toughness by caressing fingers over sanded wood or digging claws into it.

Echoing Gibson's observation that affordances are neither subjective nor objective while simultaneously advancing a proto-enactivist view, Dewey (1934, p. 177) accordingly notes: “We speak of perception *and* its object. But perception and *its* object are built up and completed in one and the same continuing operation.” He observes more broadly that most properties are already standpoint-dependent even before agents are introduced, citing non-classical physics (see Dewey, 1929, pp. 128–129; also see Crippen, 2010, 2019a). Thus, even properties such as mass and length vary according to relative velocity, meaning they, too, are unspecifiable outside of specific points of observation. On this view, the emergence or realization of properties depends on interaction since an isolated object is potentially many different lengths, masses, textures, and so forth. One might call the position idealist since there is a sense in which properties depend on observers; only for Dewey none of this is contingent on what occurs inside the head. So, to bring the discussion down to earth, when he speaks of “social construction,” he is not referring to mental projections but to actual arrangements in the cultural fabric, good or ill, advancing a position that can be trivially read as ecological or enactive. Hence, a woman might see a setting as more threatening by virtue of it posing more objective risk to her than it does to men (Crippen and Klement, 2020). Her perception of the risk has to do with the physical arrangement of the place, but also rhythms of human movement and contact enacted in the space, which give the environment specific value relative to the woman.

The key, for Dewey, is that determinable qualities arise by changing reality or adopting a specified stance toward it, and he specifically maintains that perception emerges out of doings and effects undergone in consequence. Though not said in

reference to Dewey, Chemero (2009, p. 152) nicely expresses the point when he writes that “an animal's activities alter the world as the animal experiences it, and these alterations to the phenomenological-cognitive-behavioral niche, in turn, affect the animal's behavior.” The view seems to be a kind of constructivism and thus to align more with enactivism than ecological psychology (see Fultot et al., 2016). However, Dewey (1925, Ch. 9) clarifies by adding that objection from the alleged side of realism that constructivism makes perception and knowledge a distortion follows simply from a confusion of tense. It is not that agents bestow upon things traits that *do not* belong to them; it is instead that activity confers characteristics that *did not* belong to things, and when bestowed, these properties are really there in the world. Seen accordingly, the constructivist-realist debate is overstated with the two positions implying practically the same thing in at least some contexts. Moreover, to the extent that properties are brought forth in the world, Dewey's pragmatism and closely allied enactive stances do not imply subjectivism, a concern for some ecological psychologists.

This does not mean that ecological psychology and enactivism are interchangeable; they focus on overlapping but still different scales and sides of phenomenon (see Stapleton, 2016; Gastelum, 2020). Whereas enactivism, for example, explains the microstructures of immediately unfolding experience (see Varela, 1999, pp. 9–11; Kiverstein and Rietveld, 2018), affordance theory offers a good macro-level understanding of perceptual functioning; it also helps account for prospective perception (Gibson and Pick, 2000, throughout) since avenues for action are, by definition, future possibilities. Thus, if scanning a field with pear trees and wild strawberries, we register prospects for walking, climbing, and eating. Suppose we next reach for a pear, bringing it to our mouth and biting into it, our jaw and tongue coordinating around it, our saliva converting starches into sugars. Explaining how these actions integrate into experience falls more within the purview of enactivism, which has more to say about the experiential side, though ecological psychology is hardly averse to such elucidations. Gibson (1966, pp. 138–139) illustrates this when he characterizes gustatory engagements as “exploratory and stimulus-producing, since chewing releases fluids and aromas, and the movements of the tongue bring them to the chemically receptive areas. Tasting is a kind of attention, and the mouth can be said to focus on its contents.” Tasting also changes foods encountered, engendering properties.³ However, if this is constructive, it is simultaneously realist because new traits, once introduced, really are there. Hence, constructivism vs. realism does not appear to present an insurmountable divide between enactivism and ecological psychology and should not prevent cognitive scientists from building bridges in order to render a more complete understanding of embodied life.

³Some may object that eating only exploits properties that are already afforded and does not engender them, yet it then may be asked where exactly the line is drawn between exploiting and engendering. Do we say, for example, that seawater already affords cutting since trace elements in it can be processed into steel and then a knife?

CONSTRUCTING REAL WORLDS

Dewey (1920, p. 91) maintains that the body performs operations traditionally attributed to inner mechanisms of mind by means of “adaptive courses of action, habits, active functions, connections of doing and undergoing” and “sensori-motor co-ordinations.” Citing an amoeba as an example, he observes it must interact with its environment, else perish, and that this cannot happen any way whatever. Its capacity to move materials in and out of itself, its locomotive powers, size, shape, and things encountered in its environment all constrain and enable its behavior. Consequently, its activity has “organization,” “reference to its surroundings” and “continuity in time.” Examples like this are popular among enactivists (see Thompson, 2004, Ch. 4; Noë, 2009, pp. 40–43; Di Paolo et al., 2017, Ch. 5) with ecological psychologists also exploring unicellular life (e.g., Turvey and Carello, 2012). Examples like this, moreover, can be adapted to illustrate that constructivism does not inevitably violate realism.

Physarum polycephalum, a variety of slime mold, supplies a detailed case study with biologists linking its behavior to Rodney Brooks’s robotics models (Reid et al., 2012), in turn emphasized by enactivists (see Varela et al., 1991, Ch. 9). In particular, enactivists lay weight on Brooks (1999, p. 115) claim that the world – and not representations of it – is “its own best model,” and the “trick is to sense it appropriately and often enough.” With programing layers in play, and the world constraining sensory-action dynamics, intelligent patterns emerge. *P. polycephalum* responds to information in the chemical and ambient energy array and also parallels Brooks’s random wandering programs by engaging in exploratory expansion when nourishment is depleted (Latty and Beekman, 2009). Brooks’s robots have approach-avoid programs, and *P. polycephalum* achieves the same *via* chemo-attractant and chemo-aversive interactions. Binding receptors on outer membranes respond to food molecules, increasing oscillation and reducing tension in areas nearest to nutrients, provoking movement toward attractants (Ueda et al., 1980; Latty and Beekman, 2011). Upon detecting excessive salt, light, and other repellents, membrane tension increases and oscillations decrease, causing withdrawal (Ueda et al., 1980). These patterns, moreover, depend on adjustments of neighboring cells (Reid et al., 2012), meaning they are collectively brought forth and thus are proto-social. These processes also depend on molecular binding and hence introducing minor alterations to the environing chemistry.

P. polycephalum additionally shows capacities to anticipate periodic timing of hostile conditions (Nakagaki et al., 2000). These creatures also display remarkable foraging abilities, preferentially migrating toward optimal combinations of carbohydrates and proteins (Dussutour et al., 2010). As impressively – and this is key – they collectively navigate labyrinthine mazes and solve shortest-path problems (e.g., Nakagaki et al., 2007). One navigation mechanism is the secretion of non-living slime, which they avoid in future explorations until exhausting other alternatives. Along comparable lines, they retract cytoplasm from areas not containing nutrients, leaving tubules efficiently connecting food sources. Using these mechanisms – slime and cytoplasmic tubules – these organisms

record past movements externally (Reid et al., 2012, 2013); they thereby organize their space, their local situation, and hence their sensorimotor engagements, largely according to resource availability. This means that they construct affordance-bearing chemical geographies that function as external memory traces in the vein of Clark and Chalmer’s (1998; also see Clark 2008) extended mind thesis (Crippen, 2019a).

Gibson (1966, p. 285) frames affordances as values, so his outlook would imply that *P. polycephalum*’s behavior is valuative. His book *The Senses Considered as Perceptual Systems* states that the term “affordance” was coined “as a substitute for values” to avoid subjective connotations that traditionally go with the latter. “Values” here connote “simply what things furnish, for good or ill. What they afford the observer, after all, depends on their properties.” Gibson’s (1979, p. 127) last book adds: “This is a radical hypothesis, for it implies that the “values” and “meanings” of things in the environment can be directly perceived. Moreover, it would explain the sense in which values and meanings are external to the perceiver.” Enactivists have likewise suggested that single-celled life is valuative (e.g., Thompson, 2004, Ch. 4; Thompson and Stapleton, 2008; Colombetti, 2014, Ch. 1) and for roughly the same reasons as ecological theorists. Colombetti (2014) writes: “The important point is that the sugar gradient, for the bacteria, is not just a neutral physiochemical world.” It is also “an Umwelt with a specific range of values for them: sugar is good, more sugar is better, less sugar is worse, noxious substance is bad, and so on” (p. 17; cf. Gibson, 1979, p. 140).

In sensorimotor explorations for food, which entail negotiating values and are perceptive for enactivists, *P. polycephalum* solves wayfinding problems that people would find difficult if navigating without an aerial view. So, in addition to and by virtue of being value-oriented and unambiguously sensorimotor, its behaviors are also cognitively intelligent. As importantly, a single response – for instance, foraging movements away from an area already marked as explored with slime – is all of this at once, suggesting that action, cognition, perception, and valuation fuse in even relatively simple instances of life. These creatures, then, actively shape perceptually and cognitively available, value-laden environments. They do this by laying down openings and closures for movement – in other words, affordances – which scaffold their behavior and delineate their worlds (Crippen, 2019a). These occurrences are rather unlike a beaver building a dam or other affordance structures and then perceiving them – an example that the ecological theorists Fultot et al. (2016, p. 303) deploy to undermine enactive and hence constructive accounts of perception. Specifically, they argue that “perceiving the dam, even if one wishes to characterize perception as a form of construction, is entirely different from building it.” Only in the case of *P. polycephalum*, building and what enactivists see as perceiving are entirely connected. They are entirely connected because *P. polycephalum*’s construction of slime trails simultaneously entails sensing and repulsing from them, that is, sensorimotor coordinations. The laying down of slime is therefore constitutive of sensorimotor activity, which is equivalent to perception for enactivists. Notice, however, that the constructed chemical geographies and indeed affordances

retain independent existence in the same sense that furniture in an empty room does. *P. polycephalum*'s behavior is accordingly archetypically enactive and ecological at the same time and shows that constructivism need not violate realism.

While the compatibility of constructivism and realism, and accompanying lack of subjective dimensions, is straightforward in the case of *P. polycephalum*, affairs become more complicated for cephalic organisms such as humans. One factor is that values, insofar as we can tell, are more or less the same for all members of *P. polycephalum*, which is not the case for humans. A gorge might afford flying and have that value to a youthful paraglider in an energetic mood and having requisite tools and training, and something different to an exhausted octogenarian lacking appropriate skill, desire, and equipment (see Witt et al., 2005; Witt and Proffitt, 2008; Gallagher and Bower, 2014; Jensen and Pedersen, 2016). The same holds on a more temporary basis with studies suggesting that fatigue, low blood sugar, poor health, and heavy backpacks make hills look steeper or remoter because they are objectively less approachable and climbable in these circumstances (Proffitt et al., 1995; Bhalla and Proffitt, 1999; Schnall et al., 2010; Zadra et al., 2010). Positive and negative affect – corresponding to higher or lower energy and hence objective mobility – similarly alters affordances with sadness increasing perceived steepness (Riener et al., 2011). So similarly in social-political situations: citizens of an authoritarian regime may face greater danger than tourists and hence register a space such as Tahrir Square differently (see Crippen, 2019b; Crippen and Klement, 2020).

The above cited experiments and examples accordingly reiterate that affordances vary with capacities, while stressing that valuative encounters need not be subjective impressions and can instead mark real differences in ecological relations (see Gibson, 1979, pp. 134–143). They simultaneously indicate ways of more thoroughly integrating affordance theory and enactivism, particularly attempts to elaborate on the role of affectivity in perception, cognition, and action (see Colombetti, 2014; Shargel and Prinz, 2018). What is at stake in Gibson's realist stance is his claim that affordances and values are not representations of the world, but objective properties in ecological systems (Gibson, 1979, pp. 138–140), a position that enactivism does not threaten. An illustration can be drawn from Colombetti (2014, p. 12), who cites Heidegger's (1927/1962, p. 177) suggestion that a mood is neither subjective nor objective; it assails us and comes neither from within nor without but arises from what Heidegger calls being-in-the-world (also see Förster and Strack, 1997; Shargel and Prinz, 2018). Expressed in squarely enactive terms, mood changes how we perceive and conceive things by rearranging rhythms of action – or what might be called world grammar, understood as configurations of movement and patterns of contact that generate definition in space (see Crippen, 2010, pp. 491–492); hence, affective disposition alters our capacities and therewith the affordances and values available to us, and indeed our worlds.

For phenomenologists (e.g., Heidegger, 1927/1962; Merleau-Ponty, 1945/1962), worlds and experiences are taken to be synonymous, an idea getting close to Dewey's (1923/1983, 1951/1981)

notion of experience as culture. Keep in mind, however, that Dewey and phenomenologists typically do not understand experience as conscious awareness, but as a manner of coping that engenders different ways of perceiving and cognizing. We in fact speak of the “world” or “experience of parenthood” or “parenting culture,” and likewise of “French culture,” “the French world” or “the French experience.” Worlds, in this sense, refer to the totality of habits and comportment in surroundings that are adjusted and brought out, for example, when one switches from an academic frame to a childrearing one or as one gradually learns to enact shared French cultural practices. This points to another way in which enactivists such as Thompson (2004) and Colombetti (2014) – who are especially indebted to phenomenology – argue that organisms build their own worlds. Such occurs when depressed and lacking energy to handle things in customary ways with surroundings manifesting as less accessible. In addition to this, affectivity modifies attention, therewith the cues noticed, their parsing, and how we accordingly deal with things and change them (e.g., James, 1879; Fredrickson and Branigan, 2005; Huntsinger, 2013). Modified action adjusts focus, which loops back to modulate perception and cognition (see Dewey, 1896; Förster and Strack, 1997; Clark et al., 2015).

Comparing a happy and depressed cross-country skier possessing roughly the same skills, the latter may be less sure-footed because of mood-related fatigue that in fact shows up partly in consequence of changed bodily disposition. The depressed skier may, therefore, perceive an icy hill as steeper and more forbidding because it in fact poses more risk to the weary (see Crippen, 2018). The threatening nature of the hill is again brought forth partly by the skier attacking it with greater hesitancy, not poling hard to build speed, falling into slower rhythms of doing and undergoing, perhaps plowing the snow to the side. The skier may, thereby, actualize the hill differently than the happier companion, enacting different environmental and bodily alterations, hence bringing forth different properties of snow and generating a different overall experience.

From Dewey's standpoint – and I think from any standpoint – none of this obviates realism even while some of it is constructive. However, the mood-based behavioral dispositions do push the happy and depressed skier into somewhat different worlds to the extent that they have different capacities and thus face varying constraints. We can imagine, therefore, that the two perceive and value their worlds differently, but this is because they enact and hence find themselves in objectively different situations. So the differences are not merely in their heads. There is an additional reason that the enactive position articulated here does not entail subjectivism: because the skiers, in spite of their mood-based enactments, are still embodied similarly, retaining many of the same needs and capacities, which cultivate overwhelmingly similar environmental enactments, experiences, and indeed affordances and values. Without any complicated philosophical maneuvers or denying individual difference, we can therefore conclude that the two skiers remain in predominantly shared worlds with the same objective goods and ills.

BROADENING ECOLOGIES

The last section examined agent-engendered affordances and values with the discussion of *P. polycephalum* focusing on active structuring of the external chemical array. Gibson's (1966, Ch. 8) accounts of animal life attend to the chemical array, discussing food values and the difficulty detecting them. In cephalic organisms, alimentary activity involves almost inestimable levels of mutually modulating internal and external synchronization, oriented around exploiting environmental resources in order to maintain homeostasis. Gibson (1966, pp. 141–142) accordingly stresses the importance of detecting structure of the chemical array inside the body, in addition to registering it externally. Thus, Gibson himself has laid groundwork for incorporating the internal milieu into ecological psychology. This opens additional linkages between the environment-oriented emphasis of ecological realism and the more somatic-engendered thrust of enactive constructivism. For example, microbes introduced to the alimentary system can invert what Gibson calls positive and negative affordances, understood as resource openings, such as food or escape paths, and closures, such as dangerous cliffs or predators (Gibson, 1966, p. 146, 1979, pp. 137, 157, 233). These shifts entail changes in habitual handlings and hence worlds configurations, defined again as rhythms of movement and contacts enacted that fundamentally alter – or, one might say, reconstruct – the situations in which organisms find themselves. This does not threaten ecological psychology, but it arguably makes room for the inclusion of enactive ideas. It also goes some way cutting across the environmental-external and body-internal emphases of the two schools.

Note, by way of introduction, that appetitive models of psychic life are longstanding and they are fundamentally valuative (e.g., Spinoza, 1677/1996, p. 73; Aristotle, 1941; Simon, 1967; Miller, 1983; Loewenstein, 1994). Everyday language suggests awareness of this, as Johnson (2017, p. 162) notes, cataloguing numerous examples: we thirst and have insatiable appetite for knowledge; we chew the fat, and swallow proposals; someone shits out a bad, rotten, and unsavory idea – it smells fishy, leaves a foul taste; certain notions are warmed over, sugar coated, made palatable, fed to us, and forced down our throats; politicians cook up half-baked facts that we take with a grain of salt; professors digest meaty issues; students sink their teeth into food for thought, occasionally watering it down, regurgitating and spitting it back; a sleek sports car is sweet; poor décor makes us want to puke; colloquial Egyptian Arabic calls good-looking people “tasty.”

The sheer wealth of gut feelings, thoughts, and percepts is not unexpected given gustation is central to animal life and also because the gastrointestinal system is innervated in degree that some call it the “second brain” (Gershon, 1998). Consistent with this, the gut communicates reciprocally with the brain and functions as an internal sensory system. This last role is biologically vital insofar as human intestines have an internal surface area roughly 100 times the size of the skin and interface with vast ecologies containing roughly 100 trillion microorganisms from 40,000 species (Mayer, 2011). There is accordingly a great deal to handle and sometimes defend against.

This is more so since gut problems have body-wide ramifications with bacteria imbalances predicting conditions, such as anxiety, depression, autism, schizophrenia, Alzheimer's, and eating disorders (Burrus, 2012; Foster and McVey Neufeld, 2013; Severance et al., 2016; van de Wouw et al., 2017; Wong et al., 2017; Cusotto et al., 2018). Internal bacteria thus have obvious impacts on cognition, perception, and mood, and therefore dealings with the world.

Gibson (1966, p. 146) recognizes the centrality of gustation – and by extension, the gut – in animal life. He observes: “Predatory animals should come to be sensitive to the odor that specifies their prey... The cat smells the mouse. Reciprocally, the preyed-upon animal needs to be sensitive to the odor that specifies a predator.” He stresses that “this should develop early, since an error of discrimination is fatal and cannot be corrected. The mouse smells the cat,” and “the affordance of prey odor is different from that of predator odor, the one being positive the other negative.” Gibson (1979, p. 137) adds that “all these benefits and injuries, these safeties and dangers, these positive and negative affordances are properties of things taken with reference to an observer.” However, they are “not properties of the experiences of the observer. They are not subjective values; they are not feelings of pleasure or pain added to neutral perceptions.” Summing up, Gibson (1979, p. 233) writes: “The positive and negative affordances of things in the environment are what makes locomotion through the medium such a fundamental kind of behavior for animals.”

There are times, however, when internal ecologies push outward, inverting positive and negative affordances and values with frightening results, as in the case of *Toxoplasma gondii*. Infecting the brain of mice and rats after ingestion, this parasite cultivates an attraction or at least indifference to cat smells, especially urine (Berdoy et al., 2000; Vyas et al., 2007a, b; Lamberton et al., 2008; Kannan et al., 2010; Ingram et al., 2013). Reduced wayfinding capacity and a tendency to stay in the open are other symptoms (Hodková et al., 2007a; Webster, 2007). These changed manners of coordinating with the structure of the chemical and optic array increase vulnerability to predation, which serves the pathogen since it reproduces in cats to be redistributed to rodents through feces. In effect, *T. gondii* rebuilds the worlds of rodents in order to serve its biological imperatives. One might say, therefore, that infected animals become prey to *T. gondii* and, in Gibson's (1979, p. 97) terms, act according to its values or utilities. Though typically asymptomatic in humans, infected males find cat urine more pleasant (Flegr et al., 2011); they have elevated testosterone, higher aggression, and degraded motor-control, which has the side effect of increasing car accidents (e.g., Havlíček et al., 2001; Flegr et al., 2002, 2008, 2009; Hodková et al., 2007b; Kocazeybek et al., 2009; Coccaro et al., 2016). Testosterone links to mood and thus action – or in Heidegger's (1927/1962) phraseology, to altered being-in-the-world, which has also been characterized in terms of situation-defining habit deployments and practical handlings. In particular, it brings out a more dangerous world by motivating risky behavior, to some extent inverting what would normally be negative affordances. This may have served objective values of the pathogen in the

evolutionary past since it can reproduce in large felines such as lions (Ferreira et al., 2019).

Gut bacteria similarly modulate external dispositions with probiotic interventions highlighting some causal mechanisms by which this occurs. Treatments can increase the neurotransmitter GABA along with serotonin precursors (see Wallace and Milev, 2017). GABA suppresses immunological inflammations, and ingesting it decreases fatigue and improves cognitive performance, even though it probably does not reach the brain (Kanehira et al., 2011). Conversely, inflammation and diminished serotonin link to impaired cognition and depression (see Jenkins et al., 2016) with gut bacteria also regulating glucose and energy (Gérard and Vidal, 2019), all of this relevant to active stances. Earlier-cited experiments suggested that energy levels affect affordance availability, and there is some fairly direct evidence that gut bacteria do the same and for similar reasons. Studies find that *Bifidobacteria* species alter communication in GABA receptors and decreases blood cortisol (Cryan and Dinan, 2012). Energy consumption involves both GABA and cortisol (Nieuwenhuizen and Rutters, 2008; Xu and Tong, 2011). The latter associates with stress, hence mood, habitual dispositions, and perception. Cortisol enhances negative valence in visual perception (Brown et al., 2017). Registering negative valence in objects can in turn make them appear farther away (e.g., Beloff and Beloff, 1961; Balçetis, 2016), which means less approachable.

These outcomes are not just a result of chemical diffusion from the gastrointestinal tract. They also follow from direct communication between gut and brain as demonstrated by the fact that probiotic benefits attenuate in mice with severed vagus nerves, the primary neural pathway between brain and viscera (Cryan and Dinan, 2012). The solitary nucleus – a brainstem area – is a major junction in gut-brain pathways, intercommunicating with stomach, kidneys, heart, and more (Critchley and Harrison, 2013). Involved neurons project into other subcortical regions, such as the hypothalamus and amygdala bulbs, together contributing to “coordinated autonomic, hormonal, and even immune outputs” collectively oriented toward “functional goals” (Critchley and Harrison, 2013, p. 625). These structures in turn interact with other neural regions, including cortical ones, and the brain reciprocally with the rest of the body and indeed the world. This means that in addition to sensing the internal milieu and helping synchronize it, peripheral organs cultivate coordination with the external environment, in some sense also monitoring it. Gustation is dominant in this, entering sensorimotor loops with the gut and other visceral organs supplying information about fluid balance and energy levels, modulating environmental searching accordingly (Oliveira-Maia et al., 2011; Thornton and Norgren, 2016). In response to pathogen threats, peripheral organs not only respond to problems; they indicate them, perhaps increasing gastrointestinal dysrhythmia, pulse, blood pressure, perspiration, and otherwise supplying information about internal conditions (see Horn, 2008). In conjunction with the brain and environmental contact, this helps organisms regulate action, attention, cognition, emotion, homeostasis, reward, and memory (Humphries et al., 2007; Farr et al., 2016), and therewith external information foraging

(see Miller, 1983; Pirolli and Card, 1999). Shifts may be specific as when an aversion closes an illness-inducing food as a viable affordance, leaving alternatives more attractive. Conversely, studies find that thirst and nicotine deprivation make cups appear taller and cigarettes longer, and presumably more central in perception as their value increases (Brendl et al., 2003; Veltkamp et al., 2008; also see Gibson, 1979, pp. 131–134).

Gibson observes that “animals need to perceive the affordances of substances, their chemical values or utilities” (Gibson, 1979, p. 97). He further remarks that “food values of natural substances in the environment are extremely difficult to detect” (Gibson, 1966, p. 141), which is perhaps why so many systems in the body orient toward this task. Water and salt are other chemical values around which activity organizes, and the last serves as an illustration that recapitulates several central points. To begin with, brainstem regions and chorda tympani nerves, which relay taste bud information, fire proportionately to saltiness, all else equal (Thornton and Norgren, 2016). Yet, affairs are rarely equal and firing rates are lower in sodium-deprived animals (Garcia et al., 2008; Huang and Yan, 2008). This makes things taste less salty, thereby increasing sodium foraging and consumption with human subjects finding heavily salted foods less intense and more pleasant (Bertino et al., 1981). Saltiness is accordingly not a “sensory given” (Parrott and Schulkin, 1993), registered independently of homeostatic needs, in line with enactive claims. Hence, while salt is present or absent independently of an organism, the value afforded by salty foods and their resonance in perceptual systems depends on internal sodium balance. Moreover, following the logic of the earlier mentioned studies on perceived glass and cigarette size, one can speculate that salt resources increasingly stand out as they become more objectively required. This again suggests that affordances vary with need, but without making them merely subjective. It is also to propose along enactive lines that the internal milieu is part of the sensorimotor loop and involved in bringing forth environmental dimensions that are essential to cellular life.

One general lesson implied in all this is that the visceral-neural axis is environmentally situated. Something similar holds in cases of microbe-gut-brain interactions. Gut bacteria – weighing between 1 and 2 kg – are in effect an organ functioning to digest, nourish, and produce critical hormones and neurotransmitters; cephalic responses lead to the secretion of nutrients to feed bacteria, again as if they are organs in the system; bacteria in turn differentially regulate reward chemicals like dopamine, adjusting value attunement according to what and how much we ingest; bacteria further appear to influence when food is consumed, consequently shaping circadian rhythms and therewith energy levels (see Fetissov, 2017; van de Wouw et al., 2017), which has obvious implications for affordance theory and enactivism. This partly occurs through bacteria producing short chain fatty acids and hormones that regulate host appetite and metabolism (van de Wouw et al., 2017). Moreover, all this appears to occur through a dynamic looping effect with bacteria. That is, dietary choices affect gut bacteria, and gut bacteria affect dietary choices (Cusotto et al., 2018). Outcomes can be quite profound. For example, experiments with *Drosophila* – a fly species – show that altered gut microbiota

lead to significant shifts in chemosensory foraging, largely olfactory guided in this case (Wong et al., 2017). Researchers speculate something similar holds for humans (Norris et al., 2013; van de Wouw et al., 2017). In Gibsonian terms, gut bacteria appear to moderate the value that chemicals in the environment have for organisms; understood enactively, gut bacteria transform behaviors and thus the animal's world. These positions seem entirely compatible.

The upshot is that internal living ecologies interacting with their surroundings get animals to do the same through total body coordinations with the world. This means that the gut and bacteria in it – again considered as an organ – are part of sensorimotor loops. Thus, Merleau-Ponty (1945/1962, p. 272) – a biologically informed influencer of both Gibson and enactivists – was more right than he knew when he observed: the “body is not a collection of adjacent organs, but a synergic system, all the functions of which are exercised and linked together in the general action of being in the world.” Along lines of both enactivism and ecological psychology, this suggests that psychic life depends on global synchronization of capacities, only not all directed toward the external world. There is a great deal of internal regulation, albeit synchronized in large degree with the animal's world – synchronized because external coordination calibrates the internal milieu, whether through gustation or stressful events affecting the microbiome (Cusotto et al., 2018). Gut bacteria in turn moderate feeding behavior (Fetissov, 2017; van de Wouw et al., 2017), hence environments and values in them. Specific balances appear to further coordinate external activity by increasing or decreasing stress-like behavior and related hormones (Cusotto et al., 2018). This is consistent with the enactive and phenomenological thesis that actions bring forth worlds and certain valuative tones. Insofar as this occurs partly through altered habitual tendencies, it also implies shifts in environmental affordances.

CONCLUSION

I began this article by considering a widely discussed bone of contention between ecological psychology and enactivism: that the former adopts a realist position and the latter adopts a constructivist one. Antagonists from both sides frame this as a serious source of conflict. Relatedly, while both schools focus on embodied environmental life, enactivists lay comparatively more weight on agent-driven somatic structuring of perception and cognition. This is compared to ecological psychologists, who start with the environment, arguing that information from it is sufficient to structure perception. These different starting points lead enactivists to accuse ecological psychologists of neglecting individual contributions to psychic life and ecological psychologists to censure enactivists for promoting subjectivism and getting dangerously close to solipsism.

Drawing on Dewey's analysis and a range of supporting examples, I attempted to show that there are cases in which constructivism does not obviate realism or generate subjectivism. I reinforced the claim by examining the behavior of *P. polycephalum*. Specifically, I made the case that its

sensorimotor coordinations are enactments of affordances constructed in slime, adding that these outcomes are achieved without violating realist tenets. Later on, I repeated variations of this argument in an effort to show that values can be agent-enacted yet real. The last section of this article took a cue from Gibson, who emphasizes the importance of detecting the structure of chemical arrays inside the body. I expanded on the observation by sketching an ecology of the internal milieu and its relation to the external environment. The aim here was to bridge the agent-driven thrust of enactive constructivism and the environment-external orientation of ecological psychology.

The kinds of cases emphasized in this article are not at odds with ecological psychology and in fact cited in the literature, including the pioneering work of Eleanor and James Gibson. However, they get less attention in ecological quarters, which disproportionately focuses on visual perception, notwithstanding many exceptions. The object handling examples offered in this paper are ones that enactivists use to argue that we immediately “bring forth” qualities and experiences, even if one wants to object that the illustrations are unoriginal since they reoccur in pragmatism, phenomenology, and indeed ecological psychology. The chemical engagements of *P. polycephalum* and rodents infected with *T. gondii* demonstrate comparable points. Ecological psychologists, of course, talk at length about haptic and chemical perception, and they do not deny the obvious: that organisms change their environments. However, it may be that their emphasis on visual perception – which is a modality of distance (see Dewey, 1934, pp. 236–237; Gibson, 1979, p. 233) – leads them to understate the frequency and extent to which perception requires changing local surroundings. The latter suggests constructive dimensions, even while not undercutting realism.

Though I hope my case has been compelling, I would not want to argue for the universal status of conclusions I have drawn, and this is part of the point. It may turn out that some aspects of psychic life fit conventional constructive models that do not reconcile with realism and vice versa; it may even be that theoretical standpoints that both enactivism and ecological psychology vehemently reject – for example, cognition as discrete symbol manipulation – are needed to account for dimensions of psychic life. This suggests an additional lesson, and one emphatically advanced by pragmatists: that explanations likely need to be pluralistic (see James, 1880/1992). Scientists have not unified physics, and the challenges posed here are inestimably less than those raised by the enormously complicated phenomenon of psychic existence.

A simultaneous problem and strength of academic work is the fervor with which proponents commit to specified views and the fact that critics only tend to read a small subsection of the literature they are attacking (Baggs and Chemero, 2020). A troubling and related tendency is that founding documents are too often taken as canonical when they are more accurately works in progress, steps in the right direction. “The Ten Commandments of Ecological Psychology” has already been written. It is a little tongue-and-cheek, and its authors acknowledge that it may add to already existing impressions that Gibsonians are fanatical, as opposed to conservative yet open minded researchers. However, the authors also write that “just as observant Jews and Christians

ought not pick and choose which Commandments they follow, advocates of ecological psychology (or of genuinely embedded and embodied cognitive science) should see our commandments as a package deal” (Michaels and Palatinus, 2014, p. 19). While ecological psychology arguably is zealous, it is remarkable how much one can explain, for example, from the environment side without any recourse to the inner constitution of organisms. It is doubtful that ecological psychologists would have arrived at this productive point absent quasi-religious prohibitions against discussions of internal representations and other concepts that are part and parcel to mainstream cognitive science.

At the same time and at risk of offending both enactivists and ecological psychologists, it seems that unnecessary attempts to differentiate themselves from competitors and predecessors are at the root of some of today’s disputes. Gibson, (1979, pp. 138–140) for example, acknowledges debts to Gestalt theorists, while criticizing their distinction between the behavioral and geographical world as a pernicious subject-object dichotomy. This is in spite of the fact that it is close to the phenomenological distinction between the lived-world and second-order abstractions from it (see Crippen, 2015), which does not represent a subject-object divide.⁴ Varela et al. (1991), in their turn, do to Gibson what he did to Gestalt psychologists: they acknowledge a kinship, but then aggressively stress a radical departure, as opposed to simply framing their work as building on older models, and developing them in new directions.

⁴For similar argument, see Kiverstein et al. (2019).

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What I have tried to do in this article is to highlight some unnecessary distinctions that enactivists and ecological psychologists insert, treating them as insurmountable differences. I have thereby attempted to affirm mutually reinforcing aspects of both schools, suggesting future directions for how they may combine into more encompassing accounts of embodied existence.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Convergently Emergent: Ecological and Enactive Approaches to the Texture of Agency

Marek McGann*

Department of Psychology, Mary Immaculate College, University of Limerick, Limerick, Ireland

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*Correspondence:

Marek McGann
marek.mcgann@ul.ie

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Enactive and ecological approaches to cognitive science both claim a “mutuality” between agents and their environments – that they have a complementary nature and should be addressed as a single whole system. Despite this apparent agreement, each offers criticisms of the other on precisely this point – enactivists claiming that ecological psychologists over-emphasize the environment, while the complementary criticism, of agent-centered constructivism, is leveled by ecological psychologists at enactivists. In this paper I suggest that underlying the confusion between the two approaches is the complexity of agency, which comes in different forms, at different scales or levels of analysis. Cognitive science has not theorized the relationship between these different forms in a sufficiently disciplined manner, and a task therefore remains of finding a way to map the complex territory of agency.

Keywords: agency, enaction, ecological psychology, emergence, scales

MUTUAL MUTUALITY

Both ecological and enactive approaches to cognitive science begin with a recognition of a mutuality, or reciprocity, between an agent and its environment. The agent-environment system must be studied as a whole. The environment must be defined in terms of the agent, the world as it is engaged with and experienced by the agent; not an abstract and neutral domain about which the agent must reason. In a complementary manner, the agent must be understood not, for instance, as an abstract processor of information or logic engine, but an embodied being connected with and in continuous interaction with the world around it.

Despite these apparently shared foundations, the two research communities have had surprisingly little to say to one another. While they agree on some of the premises, both approaches have quite distinct perspectives and emphases, which seems to have led each to approach this mutuality between agent and environment from opposite directions. As would be predicted from either perspective, the particular orientation taken significantly affects the form of engagement between the research community and their subject matter. In this case, while both camps argue that a full circle of mutual influence and dependence must be drawn between the two aspects of a cognitive system (considered here as the agent-environment whole), just how you perceive that mutual relation will depend on where on the circumference you decide to first place the pen.

In what follows I argue that enactivists and ecological psychologists accuse each other of complementary violations of this shared principle of mutualism. Enactivists (Varela et al., 1991) claim that ecological psychologists are guilty of stipulating specific structure in the world prior to the agent and thus attempting to build an account of their relationship from just the environmental

aspects in question. Ecological psychologists, meanwhile, argue that enactivists are guilty of requiring that structure to be stipulated *post-hoc* by the agent (Fultot et al., 2016) thus attempting to get the agent to do all of the meaningful work. I argue that this complementarity of criticism is driven by the ways in which we have addressed the question of different forms of agency to date, particularly with regards to the interaction between those different forms at various scales. I argue that both approaches share an emergentist stance that can help move us forward on the issue, that this stance raises other important points of consideration regarding the kinds of agency that exist, and the relationships between them.

COMPLEMENTARY MUTUALITIES

Though parallels had been noted from the beginning, Chemero (2009) was perhaps the first to suggest a potential complementarity between ecological and enactive approaches to cognitive science. Both take what might be called a “radical embodied” perspective, one which denies the need of representational states underlying cognition. Their shared mutualist framing of the question means they both place an emphasis on the embodiment of the agent and the dynamics of its interaction with its environment. Chemero discussed the apparent complementarity of ecological psychologists’ examination of the environment and its structures that empower the engagement between it and the agent, while enactivists have explored the details of how the structure and dynamics of the agent affect that same relationship.

Ecological Psychologists Focusing on What You Are in, Rather Than What Is in You

Ecological psychologists have addressed themselves to the question of how the environment supports perception and action by embodied agents. Their work is some of the most robust, precise, and successful that has been conducted in psychological science. Researchers have identified a range of ways in which structure in ambient arrays of energy or chemistry can be coupled with by an animal (or other embodied agent) to engage in some form of goal-directed action.

While some approaches see the abundance of detail in the environment as a problem that must be overcome to avoid the agent being overwhelmed, for ecological psychologists it is in fact a blissful wealth of specificity that means we can get an awful lot of work done without needing complex inferential processes (Chemero, 2009; Fultot et al., 2016). Perception and action are two aspects of the same phenomenon (Turvey et al., 1981; Gibson, 1986) and perceptual skill is not about piecing sensory stimuli together to form a complex mental structure but more of a matter of making better and better discriminations regarding the fine-grained details of the environment within which we are acting (Gibson and Gibson, 1955).

The various aspects of the environment that afford such effective action have been examined in some detail by ecological researchers and this has from the outset included a recognition of

the importance of the body of the agent, or animal¹. If perception is relative to action, then actions of which my body is capable matter to what I will perceive.

But there has also long been some uncertainty about how that animal should be considered, and it is on this issue that apparent conflict between the otherwise consonant approaches of enactive and ecological cognitive science first arose. In their initial statement of the enactive approach Varela et al. (1991, p. 202–203) explicitly take issue with Gibson’s ecological work, arguing that it attempts to build an account of the relationship between the agent and the environment entirely from the side of the environment, and thus appears to violate the principle of mutuality. Though they note in a footnote (Varela et al., 1991, p. 274–275, 38n) that where the relationship is characterized as emergent within the animal-environment system (as is argued by Turvey et al., 1981 for instance) then some of this tension is dissolved. The heavy (though not exclusive) emphasis on the environmental rather than animal-environmental structures in the relationship remained a point of contention. While Varela et al.’s comments did not prompt an extensive dialog between ecological and enactive researchers, questions about the specification of the embodied agent in ecological psychology have also been raised by those working within the ecological approach.

Stoffregen and Bardy (2001) and Stoffregen et al. (2017) point out that Gibson, and almost all of those who have extended his work, have maintained a sharp distinction between structure in the environment (in particular in the arrays of ambient energy), and structure within the organism. They make this point with reference to perceptual modalities, arguing that Gibson (and subsequent ecological work) generally maintains unexamined traditional distinctions between systems – the visual, haptic, auditory, and so on, each coupled to structure in a particular array of ambient energy to which they are sensitive. Stoffregen and Bardy (2001) argue that these are inappropriate distinctions, made by scientists for the sake of organizing their work (and partly just following traditional categories descended from Aristotle’s) but not by perceiving agents under normal circumstances. Gibson himself noted that the visual system includes not just the eyes and brain but also, for instance, the trunk and legs of an animal playing a role in orienting the organism and coordinating its movements with the structures in ambient light. Therefore what is involved in visual perception involves the body of the organism, not just the structures of those rays of ambient light. In a sense this is part of Gibson’s recognition of the importance of embodiment, and is present in foundations of his ecological approach, but its implications remain insufficiently appreciated. Stoffregen and Bardy (2001) argue that the role of the body in coupling of action to structure in the ambient arrays means that it is not possible give an account of the coupling on the basis of the ambient arrays alone. There can be no case of “pure” vision in terms, for instance, of optics,

¹Ecological psychologists most frequently refer to the “animal” or “organism”, in keeping with their strong emphasis on the concrete and particular. Fultot et al. (2016) have noted, however, that the principles of the ecological approach are sufficiently general as to apply regardless of whether or not the agent in question is living in this paper I have the for most part kept with the more generic and ecumenical “agent”.

as the body, and at least kinaesthetic and vestibular systems are always also implicated. The structures of energy in question are thus never purely optical, but complex or “compound.”

Structure in ambient arrays is generally taken to reveal invariants in dynamics that can support coordination between an organism and its environment. The most frequently discussed is structure in the rays of ambient light, but Gibson explicitly notes the existence of compound (Gibson, 1986, p. 141) higher order invariants in complex arrays of multiple forms of energy. Stoffregen and Bardy (2001) simply point out that a moment's consideration will tell us that such compound invariants are the norm, rather than the exception. In the normal case, the world is perceived not as a set of combined modal components but a complex perceptual whole, though one which might, as necessary, be interrogated according to modal characteristics. There are not separable perceptual systems, sensitive to distinct ambient arrays, which are combined to create some complex percept, but rather a single complex perceptual system capable of coming into coordination with rich structure in a complex “global array” (Stoffregen and Bardy, 2001).

The surprising criticism leveled by Stoffregen and Bardy (2001) at Gibsonian ecological psychology is, therefore, that it does not take the embodiment of the point of observation seriously enough. A strange criticism to see made of the scientific community who can be argued to have been doing embodied, and even “radically embodied” (Chemero, 2009) cognitive science longer than anyone else (Fultot et al., 2016). But I find Stoffregen and Bardy (2001) and Stoffregen et al. (2017) arguments compelling (you could say I'm predisposed to, though McGann (2010) was written in shameful ignorance of their work). Perceptual systems are entangled in the body and isolating individual modalities in experience is more an achievement of disciplined phenomenology and scientific practice than the default state of affairs. The body does not work to put together separate sets of ecological information from distinct arrays, but creates structures of complex ecological information by being the point of entanglement and inter-relation between those distinct arrays. The global array comes into existence with the agent, and *only* with the agent, and to properly account for the invariants that support coordination between agent and environment requires that agent to be specified to an extent that Stoffregen and Bardy (2001) and Stoffregen et al. (2017) claim is rare in ecological research.

The mutuality tenet would also suggest that this limited account of the agent also underlies an ambiguity concerning Gibson's description of the environment discussed by Baggs and Chemero (2020). Gibson in *The Ecological Approach to Visual Perception*, distinguishes between the physical world (as studied, for instance, by physicists), which is not animal-relative, and the environment, which is. Baggs and Chemero argue that Gibson is ambiguous in his descriptions of this second sense. Sometimes Gibson is referring to a generic environment shared by all animals with similar embodiment (for instance, members of the same species), which Baggs and Chemero suggest calling the “habitat.” And sometimes he uses the phrase as unique to individual organisms with their particular learning histories, which Baggs and Chemero term “umwelt.” They suggest that the continuation

of this ambiguity in subsequent work by others helps understand a number of confusions or controversies that continue within the ecological literature to date.

Of course, from a mutualist perspective two separate considerations of the environment imply distinguishable conceptions of the complementary agent. Ambiguity in discussion of the environment implies a concomitant ambiguity in specification of the agent in question. Were differences and varieties of agent and agency more explicitly theorized, it would seem less likely that any ambiguity in discussion of the environment could have been maintained, particularly for so long without people being keenly aware of the issue.

And so we return to Chemero (2009) suggestion that an enactive approach offers a useful complement to the ecological flavor of radically embodied cognitive science, partly as he identified this need to address the individuality, rather than generality, of relationships between specific concrete agents and their environments. As ecological psychologists appear to have stumbled over a complexity of agency in the complex system of animals interacting with their environments, enactivists, who can be seen to have approached the complementarity from the other direction, have been struggling with it so much that they have barely got around to looking at the environment at all. This focus on agency by enactivists is to the point that Fultot et al. (2016) argue that enactivists have given too much account of the agent's role in the interaction that it looks like they are offering little more than a warmed over serving of mental representations, a mental constructivism by which the agent “brings forth a world” from a meaningless soup of ill-specified environment. Some approaches, it would seem, are more mutual than others.

Enactivists Focusing on What You Are

In contrast to ecological psychologists' heavy emphasis on questions of the environment, enactivists have spent 30 years trying to get to grips with the fine-grained details of agency – how it arises, how it operates, in what forms it can be found.

Enactivists put forward a naturalistic account of value, which in the abstract is a system of processes that, together, continue to produce that very system, essentially becoming an enabling condition for its own existence. This is done under conditions of precarity (Di Paolo, 2009) which is to say that without the self-supporting organization, the system would tend to run down or disintegrate. Though self-sustaining, it is considered more a continuation of a trajectory or dialectic than a maintenance of a fixed or rigid set of relations or variables (Di Paolo, 2018). Understanding agency means understanding both the values that animate it, and the constraints (bodily, worldly, and various things in between) that underpin it.

We should not be surprised that as ecological psychologists have found structures in the environment at various scales and degrees of complexity, so enactivists have identified agency as having a variety of forms and scales too. I will not attempt a systematic enumeration here, but it is worth noting two relatively separable strands within the enactive literature: one exploring issues of life, skill, and agency within the domain of sensorimotor activity (Maturana and Varela, 1987; Varela, 1997; Weber and Varela, 2002; Di Paolo, 2005; Thompson, 2005; Buhrmann

et al., 2013; Beaton, 2016; Di Paolo et al., 2017; Froese and González-Grandón, 2020) and a second exploring the perhaps more complicated and differentiated world of social and cultural dimensions of the same, in which agency inheres not necessarily within individual bodies, but also across them (De Jaegher and Di Paolo, 2007; De Jaegher and Froese, 2009; McGann and De Jaegher, 2009; Torrance and Froese, 2011; Kyselo, 2014; Cuffari et al., 2015; Cummins, 2018; Di Paolo et al., 2018). We should also note that there is a great deal of complexity being teased apart within each of these strands.

Identifying values that are not inherent in individual bodies, but which encompass more than one is both necessary (how else can we come to terms with basic multicellularity, for instance), but also subversive. Introduced first in terms of participatory sense-making by De Jaegher and Di Paolo (2007) it is a recognition that the values animating and organizing actions cannot be fully described or explained by the theorizing of the individual agent.

Several significant works in the field are perhaps best understood as attempts to braid or knit these two strands of enactive research together, finding ways in which the different forms of complex, particularly human, agency, can be understood as consistent and inter-related. Cummins (2018) for instance, explores in detail the ways in which different domains of human existence feed back on one another, highlighting that human beings are multiply animated, committed to and engaged with a complex of different processes which both motivate, enable, and constrain our activities in complex and often conflicting ways. Cummins begins with an examination of the universal, but little studied phenomenon of joint speech, when more than one person says the same thing at the same time. It is a striking feat of inter-personal coordination that is both achieved with apparent ease and deployed in circumstances of significant importance to identity and collective action. Seen across cultures in situations ranging from prayer to protest, education to sports fandom, Cummins examines a plethora of examples to tease out the implications regarding different forms of subjectivity and agency that encompass much more than individual organisms. He highlights how these different forms of agency arise not just from biological systems, but at confluences between biological, moral, civic, and other domains of activity, and must be understood in those terms – it is a sensorimotor skill that, in its naturally occurring enactment, inescapably highlights the need to understand it within moral and civic reference frames.

Though we are individuals, we are rarely *just* individuals, but rather simultaneously enacting a number of different forms of agency, and bringing them into greater or less degrees of coordination. Some of the values which animate human bodies are not inherent wholly within those bodies.

Di Paolo et al. (2018) *Linguistic Bodies* involves a slow, cautious examination of the ways in which bodies engage in sense-making, an adaptive process of skilful coping by the agent with the environment in which it finds itself. Enactivist work has examined ways in which the materiality and history of an agent affect the dynamics of its agency; the body, environment, and activity that combines both are in a constant process of pull and press that has emergent dynamics at multiple scales. The individual agent (with its particular body, history, and skills)

matters, and must be understood through the ways it is engaged in several different ways with the world around it. While we might identify a number of different domains of activity within which a particular agent is embedded – sensorimotor, discursive, social, cultural, others – all of these domains are entangled through the body of the agent and Di Paolo et al. (2018) make a first attempt at mapping those relationships and finding ways to describe and consider them systematically.

There is I think, a real but distant resonance here with the insight of Stoffregen and Bardy (2001) whatever domain of activity in which you as a scientist are interested is tangled up with everything else that the agent does, because the agent's embodiment is necessarily embedded in it all. What we as scientists perceive as distinct domains of activity might be addressable in that way for the purposes of conducting particular forms of research, but are also entangled and inter-related with one another by the (rather messy and complex) unity of the embodied agent. A mature cognitive science will include means by which such orientation can be done in a systematic manner, in perhaps a similar way that biologists are able to orient themselves within subfields of biochemistry, genomics, morphology, and ecology.

The strong agency-focus of enactive research has allowed a range of detailed aspects of agency and sense-making to be developed, but in that process relatively little has been said by enactivists about the environment with which these various forms of agency are mutual (McGann, 2014). Fultot et al. (2016) take enactivists to task over this imbalance, arguing that this failure to adequately address the environment, and too-heavy focus on the agent, has resulted in a violation of the principle of mutuality and an at least implicit requirement for a constructivist agent – one that constructs its environment rather than encountering it directly and meaningfully. There are several commentaries on the Fultot et al. paper, along with the authors' response, in the issue it appears, and I will not rehearse the debate here. Suffice it to say that several enactivists (myself among them) acknowledge the criticism, though reject the implied fatal conclusion for our shared principles. Di Paolo (2016, p. 329) points out that while an enactive account of the environment is work that has not been done, it is perhaps most appropriate to say that it is work that has not been done *yet*.

Though it may not be as problematic as some critics suggest, the form and structure of the environment is yet a rather fraught question for enactivists, particularly if the commitment to mutuality between agent and environment is to be maintained, which it must, being one of the principal tenets of the entire approach.

This is not to say that enactive theories of various forms have nothing to say about the environment, any more than ecological psychologists have had nothing to say about the structure or form of the agent. Rather, we might observe in the tendencies toward singular emphasis within each perspective a difficulty in addressing both aspects of the mutuality relation at the same time. Perhaps it is akin to trying to perceive both versions of a Necker cube simultaneously – examining one facet as figure seems to push the other into the background. How we should approach the issue of mutuality between environment and agent when there is

more than one form of agency to be understood is a question that will need to be approached with care, and in a manner cognisant of the careful balancing act involved.

GETTING ALONG

Coping With a Surfeit of Agency

I suggest, then, that the gap between ecological and enactive approaches is substantially a result of the complexity of agency – insufficiently addressed by one, addressed to the point of exclusivity by the other. The result is a remaining lack of clarity of how to conceptualize the more complex relationship between agent and environment that such a recognition entails. We are therefore faced with an interesting challenge; we must find a way to address this complexity that balances key tenets shared by both approaches.

First among these considerations is of course the agent-environment mutuality itself. Having identified it as a characteristic of such systems, we must find a means of describing the agent-environment system that does not impose or require a priority for either one. The agent is not simply caused by the environment, and the environment is not simply constructed by the agent.

Second, we should respect the autonomy of the systems in which we are interested at a given level of description. Both ecological psychology and enactivism hold to a non-reductive account of psychological phenomena – there is no “ground level,” the activity at which explains all else. The physical description of the world cannot adequately capture the existence of particular scales of phenomena which arise in relation to one another rather than in absolute terms. Observed or measured at the wrong grain of resolution and we will miss our phenomena of interest.

This does raise questions about how best to think about the complexity of agency, and bodies as engaged with (and engaged by) values of different levels of analysis. Mind-relevant phenomena occur at a wide variety of scales. From chemical and biochemical processes, to physiological, neural, and biomechanical, to behavioral, eco-behavioral, social, and cultural, there are a host of different perspectives we might take, and within any one of them identify events or processes that relate in meaningful ways to the phenomena of life and mind. This is a rather trite observation to some extent – it is clearly recognized in many ways, not least of which is the existence of several disciplines dedicated to different levels of study, from neuroscience, to psychology, to sociology, and anthropology. The entire field of cognitive science was founded in a recognition that more than one perspective will be necessary to develop a satisfying understanding of mental phenomena. Psychology cannot be a complete science of the mind.

For all of our vaunted inter-disciplinarity, however, cognitive science tends not to do collaborations across disciplines terribly well (Núñez et al., 2019) and collaborations across scales of description would seem to be rarer still (Boden, 2006; Bender et al., 2010; Ignatow, 2014). The question is what kind of framework could be put in place which will allow us to make sense of the relationships between these different scales –

recognizing their differences and systematically addressing their interactions. Enactivists have been involved in this effort, though as noted, primarily with regards to the question of agency, with the environment remaining something of a promissory note (Di Paolo, 2016).

If enactivists are correct about the ways in which agency arises (Barandiaran et al., 2009; Di Paolo, 2009; Di Paolo et al., 2018) then there is a consistency in the general form of the dynamics in all cases, being grounded in the dynamics of autonomous networks of processes – different values just aren’t consistently related to the body in the same way. Some of these values are inherent in the bodies of biological agents, but some of these values arise in dynamics that pass through those bodies (De Jaegher and Di Paolo, 2007; Kyselo, 2014; Cummins, 2018). There is therefore no one-size-fits-all account of embodied agency. And yet it remains true that these various forms of agency are all entangled in different ways in living bodies (Kyselo, 2014; Cuffari et al., 2015; Di Paolo et al., 2018) their attributes, powers, and skills. Di Paolo et al. (2018) work in particular examines how multiple forms of agency imply multiple forms of embodiment, though all of them ultimately entangled in the particular concrete form of given agents. Any one body will be animated by multiple such forms of agency, whose relationships we as cognitive scientists must be capable of mapping.

I am simultaneously white, cis-male, middle-class, a father, an academic, writing, and hungry, and my enactment of any and all of these domains of activity is accented by my engagement with the others (to greater and lesser extents). Within the kind of distributed approach to cognitive systems taken by ecological and enactive approaches the individual body is perhaps then to be defined by the particular, unique collection of domains of activity it tangles together. The body is perhaps more a matter of *skein* than *skin*. It should be possible to identify a particular tangle of values and agentive processes that is “me,” but that “me” cannot be exhaustively described within any narrow range of temporal or physical scales, and indeed, it remains to be understood what the specific dimensions of import are (time and space are not likely to be the only ones).

In a somewhat different context, the range of temporal scales of agency has been broached by van Dijk and Withagen (2016). They note the extended, enduring character of human agency, that individual actions are not just punctate events, but are largely manifestations of multiple engagements of many long-duration processes, which can be more or less stable over different timescales. A useful analogy might be the height of the sea – if we pay too much attention to the brief but salient crash of the waves, we can miss the rather important role of the tide. Actions taken, movements made, utterances spoken, are wavefronts borne by tides of mind extending over periods not apparent were we to limit our observations to salient bodily motions (however, skilful). Long timescale cognitive phenomena are occurring right now just as the short ones are. For van Dijk and Withagen (2016) the point was that a radical embodied cognitive science need not be constrained by the traditional distinction between “online” and “offline” cognition, but the implications, I think, are more general.

As we have already noted, this complexity of temporal and physical scales of agency implies a similarly complex complementary environment. Di Paolo et al. (2018) largely address this implicitly – with the environment considered in terms of other agents, and the particular (often messy) details of their specific embodiments. The materiality of those embodiments matters, but the emphasis in their discussion remains on agency, with much work still to do to unpack that implications of the mutuality they nevertheless endorse.

Di Paolo et al.'s work is not alone in recognizing the range of scales of agency. There is also a broader effort by a number of researchers to bridge the apparent gap between sensorimotor and social by drawing in an ecumenical and integrative fashion from both ecological and enactive approaches (Costall, 1995; Rietveld and Kiverstein, 2014; van Dijk and Rietveld, 2017; Bruineberg et al., 2019; van Dijk and Kiverstein, 2020). Clearly, I wholeheartedly agree that we need to find a way to deal coherently with activity in this variety of domains, and that ecological and enactive approaches are valuable resources that should see better integration (I attempted to make my own small contribution to this parsimonious rapprochement myself in the past, McGann, 2014). However, our limited understanding about the relationships between the different kinds of activity has meant that the default approach has been to search for a means of applying the same mode of analysis to all of them, one which emphasizes the autonomy and potency of the individual agent. I have come to suspect, however, that this is in a sense seeking to homogenize these varied environments in order to extend our account of the individual agent across the entire gamut of domains in which that agent is embedded. Such a unifying approach, while laudable in its emphasis on consistency and continuity across scales or levels of analysis, threatens to make us blind to discontinuities and heterogeneity; differences, conflicts, and tensions between the various kinds of value that animate agents' actions, and therefore the particular ways in which those tensions play a role in organizing and animating the behavior of our systems of interest. It suggests that all of the various scales or domains of activity are ultimately implemented within each individual agent, perhaps by nested systems of the body with dynamics at different temporal scales. This occludes the possibility that some of these forms of agency work across (rather than within) individual biological agents, for instance, meaning they can work sometimes in keeping with, and sometimes in conflict with, other values and forms of agency within which the animal is embedded.

A common mode of explanation in this unifying effort is to appeal to skills of various kinds. We learn to coordinate in all domains of life in which we work through the development of more skills. The problem with such an approach is that this takes the perspective of a given form of agent – the individual biological one – because a skill is by definition a means by which an individual agent comes into increasing coordination with its environment, and these are typically ascribed to individual biological bodies and their relations to the world. If it is the case that the animating values accenting or driving the behavior of a person at any given time may be part of a network of processes that move *through* the individual biological agent, but

not be wholly inherent within them, then properly theorizing the environment, and the agent-environment relationship across the different scales of that such processes operate is vital. This is not something I suspect would be controversial for any of the authors I have cited here, but I wonder if the implications for our understanding of agency and bodies have been fully worked through.

If this way of thinking is correct, then it will be important *not* to unify all agencies *within* the body, but to catalog the multiple ways in which the body can be animated, and (crucially) find ways to map the relationships between them. Some values that animate the agent are incorporated in the agent, some incorporate the agent, and we need a coherent and systematic way of moving between the various points of view that enable us to see these different kinds of relationship, without violating the principles of non-reductiveness and mutuality. It is quite likely that grappling with this question will involve a commitment to observing people “in the wild,” so to speak – actually just engaging in a natural history of human behavior to a great and more systematic extent than we have done thus far (Barker, 1968; McGann and Speelman, 2020). But it will also involve engaging in theorizing with the right kind of approach.

Emergent Media

It is apparently poor form to introduce a problem without also at least hinting at how we might go about solving it. Both camps do, as it happens, share a promising point of departure. The concept of emergence, which is usually deployed in reference to the self-organization of systems under various conditions, appears to fulfill our starting criteria. Both enactive and ecological researchers refer to their approach, or key aspects, as involving “emergence” or “emergent properties” at various times (Turvey et al., 1981; Stoffregen, 2003; Thompson, 2007; Di Paolo et al., 2010; Lobo et al., 2018) typically in order to affirm a non-reductiveness of their account. Emergent properties define their own scale, they are not to be explained away with reference to processes at a single different (usually smaller) scale of description, but must be acknowledged and addressed on their own terms.

An emergentist approach, understood as self-organization of the whole agent-environment system also fulfills the requirement for mutuality, avoiding any stark claims for priority of either facet. It does so, however, at a given level of description, which must be identified if we are to be able to recognize the patterns of interest that are self-organizing.

In looking for patterns not as agents acting in environments, but as cognitive relations without preemptively assigning agency to any particular subset of the system in question, we implicitly distinguish the agent-environment system from a background. That background itself has a set of dynamics associated with it. In essence through our investigations we as scientists create a new agent-environment system, with us coordinating with our target system on the one hand, and an environment within which we are working on the other (a meta-level issue raised for instance, as the topic of second-order cybernetics, Pask, 1996; Von Foerster, 2003). The background is tricky to theorize, but it is not impossible.

Of use to us here is a set of concepts that has already had a role to play in ecological psychology – the distinction between thing and medium, as introduced by Heider (1959, originally published in German in 1926). In this important paper, Heider distinguishes between things whose components have relatively fixed relationships and a rigid structure, and media, whose components have only contingent or “spurious” relationships, making the whole fluid, and therefore tending to become rearranged by the structure of things moving through it. What happens in a medium depends on what impinge upon it. What happens to an object depends more on the existing relationships within it (Heider, 1959). The sense of medium then is not as channel of information, but fluid substrate which can come to be affected or formed by things, their structures and motions, thus allowing things to move through it, but also the structure of those things to propagate and impinge in various ways on other things, at a distance.

Heft (2001) explores the significant impact that Heider’s work had on Gibson’s conceptualization of perception, bringing into focus as it did not just the things to be perceived, but the means by which that perception could take place. The medium for Gibson is distinct from both substances (essentially, things) and surfaces (the planes of interface between things and medium). For terrestrial animals the medium of perception and locomotion is air, which is transparent and fluid. It supports the formation of ecological information in arrays of ambient light and thus direct perception.

Heider goes on to point out, however, that all media are made of things. So long as there is flexibility in their inter-relationships any sufficiently large aggregate of things can act as a medium. Building on Heider’s work Schoggen (1989) notes that the more things, the more flexible the medium. A Lego brick, for instance, is a rather rigid thing. A collection of 50 Lego bricks can be a medium for a variety of structures, and a collection of 500 Lego bricks even more so. The difference between a thing and medium is not absolute. This gives rise to the possibility of a nested set of media, in which the dynamics of things at one level of description act as an emergent medium at another, with each level of description having a particular set of characteristic dynamics – possibilities and constraints emerging from how the phenomena at that level of description operate.

As an illustration of how this might work we can look at how Heider’s ideas influenced another kind of ecological psychology – that of Roger Barker and colleagues, and also discussed in some depth by Heft (2007). The ideas of Barker and the work of the “Midwest Psychological Field Station” developed over years of observation of human behavior in the wild (or as wild as a small Rockwellesque town in rural Kansas in the 1950s and 60s was likely to get). As regards their different uses of Heider’s ideas, Heft (2001 p. 281) suggests Gibson’s is a *within-level* theory, examining relationships within a single animal-environment system, with Barker’s a *between-level* theory, concerned with how higher order structures in the social world come to shape the behavior of individuals.

It is beyond the scope of this paper to properly introduce the rich theory of person-environment interaction developed by Barker (1968) and Schoggen (1989) for full presentations, and

Heft (2001) for an excellent introduction. Suffice it to note that for Barker et al., it is *people and their behavior* that are the medium, into which the standing patterns of organized social activity in appropriate places can impose their structure. These standing patterns of activity, with their accompanying physical milieu, are termed “behavior settings.”

Eventually situating his work somewhere between what we would normally call psychology, and sociology or anthropology, Barker adopted the term “eco-behavioral science” (Barker, 1978). He and his colleagues examined the ecosystem of human behavior at scales greater than individual actors or tasks. Barker warned that psychology as a discipline too frequently stepped outside of its competence (examination of the individual agent), and was too often asked to because there exists no theoretical framework for dealing with the factors that shape human behavior beyond the context of the immediate task, but beneath the broad domain of sociopolitical factors. The world is not randomly or probabilistically structured, and the transitions between one task and another do not occur in a stochastic manner for any given human being. In the vast majority of cases a person’s behavior coordinates very well with the setting in which they are working, and the sequences of settings that they experience from one end of the day to the other is neither accidental nor random. If we want to understand the structures of human behavior, he argued, we will need better theories of the structure of behavior settings, both as individual settings (usually involving multiple participants), and the relationships between settings, in buildings, neighborhoods, and cities. As Heft (2001, p. 258–259) points out, these structures are themselves made stable by sociopolitical forces and traditions. While Barker set his approach apart from sociological and anthropological concerns, it is vital to understand the ways in which power relations of gender, race, class, and other higher order dynamics play a role in the emergence of behavior settings. Heft (2001, p. 260) describes Barker as “offering a pluralistic perspective in the sense of requiring psychologists be sensitive to processes operating simultaneously at more than one level of analysis.” In this paper, I am simply amplifying or extending Barker’s approach. The possibility of multiple, nested, emergent levels of description, with “things” at one level of description having dynamics that allow them to operate as a medium for things at another level of description. This inter-level influence is not only one-way, however, as emergent systems also entrain, and therefore constrain, the dynamics of systems from which they emerge.

We must bear in mind that while a medium must have a significant malleability to allow itself to be shaped by things within it, no medium is perfect. As well as its own dynamics (some versions of tides or currents as we have already noted), any medium we identify will have certain structures that it can support, and others it cannot. These may be subtle, or they may not be (it is a version of this insight that led McLuhan, 1994 to utter his famous dictum that “the medium is the message”). In recent work, for instance, van Dijk and Kiverstein (2020) have explored the idea of a sociocultural practice as a medium of perception and action. Their analysis is broadly consistent with the approach I am advocating here, and they note the manner in which a medium can both enable and constrain the dynamics

that emerge within it. Though they primarily deploy the concept of medium in a manner consistent with Gibson (a “within-level” analysis as Heft would have it), their work illustrates the way in which different levels of analysis interact, and in which things and media are not entirely independent.

Additionally, there is also no escaping our place as observers of these various emergent systems and their backgrounds. Fluidity at one temporal scale will look like rigid fixedness at another. We must be cautious, therefore, not to be too exclusionary in our descriptions of media and things at levels of description beyond those in which we ourselves most comfortably perceive and act, at least initially, and bear in mind our own perspective as scientists as playing a substantial role (Pask, 1996; Von Foerster, 2003).

I do not suggest that cognitive scientists somehow bear all levels of analysis in mind at any given time (I don’t consider it possible, though never say never, I suppose). What is more, I would not be confident that there is a single map of all of the various levels of analysis possible and proper to cognitive science is achievable, given the dynamism of the territory. It is quite likely that there are several sufficiently stable relationships between different forms of agency for us to explore which will give us some insight into what dimensions matter.

Barker’s approach explicitly acknowledges inter-level influence – tides and turbulence, as it were, for behavior. Analysis of complex systems offers us some tools for conceptualizing and systematically analyzing mutual influence and elasticity of relationships between levels of description, dynamics that may be invariant across scales where things become medium and enable the existence of new things. At any given level of analysis we can seek to identify and characterize the medium in question, and look for those aspects of it that can be ordered by the level of interest (what allows it to act as a medium), and those that impose themselves on the level of interest (what its limits as a medium are). This analysis can be done without taking the particular perspective of agent or environment in the approach, and may in time come to support the systematic conceptualisation of various flows of value independently of any perspective of a given biological agent embedded within the various processes of its environment.

CONCLUSION: CARTOGRAPHERS NEEDED

Cognitive science has largely worked within a complex field built on methodologies and disciplinary traditions rather than an over-arching theoretical framework of how different forms of agency arise and interact at varied levels of analysis. There is certainly value to a pluralistic approach to understanding the mind, and some are quite fatalistic about such an over-arching framework (Gentner, 2019). I have suggested in this paper, though, that a substantial part of the apparent gap or miscoordination between ecological and enactive approaches has

been a failure to recognize, and fully theorize this range of scales or levels of analysis, and how to systematically account for real differences between them. Though I don’t imagine the task will be simple, or perhaps ever completed, I think there remains value in an attempt to catalog what kinds of scale or dimensions matter, and to build a map with which we can situate any one program of research within the broader, complex territory in a principled manner. There will always be ambiguities and tensions between different domains of a science – the boundaries between biochemistry, genomics, morphology, and ecology, for instance, are occasionally contested, as are the relationships between them. But biology is the better for being able to orient research questions within these and other subfields in a way that, if not wholly coherent, is at least stable enough to support clear communication. The same is not currently possible within the cognitive sciences.

I have suggested that the complementary criticisms that have been leveled by enactivists and ecological psychologists against one another suggest that a new mode of description is warranted, one that can potentially avoid fracturing agent-environment descriptions from one another, while supporting a description of emergent dynamics. Such an ecumenical mode of description may support us adjudicating between such disputes, or diagnose them as like arguments over pronunciation by two groups of speakers with different accents. We are some ways away from an over-arching theoretical framework that integrates the two approaches within a fuller understanding of mind and world. If we can maintain an appreciation of their mutual dependence at all levels of description of the phenomena in question, we might be optimistic the some such framework is at least possible.

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The author confirms being the sole contributor of this work and has approved it for publication.

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Picturing Organisms and Their Environments: Interaction, Transaction, and Constitution Loops

Ezequiel A. Di Paolo^{1,2,3*}

¹ Ikerbasque, Basque Foundation for Science, Bilbao, Spain, ² Centre for Computational Neuroscience and Robotics, University of Sussex, Brighton, United Kingdom, ³ IAS-Research, University of the Basque Country, San Sebastián, Spain

Changing conceptions of the relation between organisms and their environments make up a crucial chapter in the history of psychology. This may be approached by a comparative study of how schematic diagrams portray this relation. Diagrams drive the communication and the teaching of ideas, the sedimentation of epistemic norms and methods of analysis, and in some cases the articulation of novel concepts through pictographic variants. Through a sampling of schematic representations, I offer a concise comparison of how different authors, with different interests and motivations, have portrayed important aspects of the organism–environment relation. I compare example diagrams according to the features they underscore (or omit) and group them into classes that emphasize interaction, transaction, and constitution loops.

Keywords: organism–environment relation, diagrams, schematic representation, interaction, transaction, constitution, enaction, ecological psychology

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*Correspondence:

Ezequiel A. Di Paolo
ezequiel.dipaolo@ehu.es

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INTRODUCTION

There are important convergences between ecological psychology and enaction but also differences. Some differences are due to historical accidents, as in the use of technical terms such as *information*. Enactivists are cautious about information–talk because they build their theory in opposition to notions of information traffic between agent and environment (although they do not reject the use of information-theoretic methods, e.g., Aguilera and Di Paolo, 2019; see also Beer and Williams, 2015). Ecological psychologists, in contrast, rely on a different concept of ecological information as regularities in the ambient array that help specify affordances and guide behavior (e.g., Reed, 1996). There are also differences in focus, with ecological psychology dealing traditionally with explanations of perception and perceptual development, and enaction typically more concerned with explanations of agency that do justice to human experience. Other differences are conceptual. Some of these revolve around ways of conceiving the relation between organisms and environments, conceptions that are rooted historically and not always spelled out.

In this article I look at a sampling of diagrams that express how different authors have conceived of the relation between organism and environment through the history of psychology. The exercise is limited but still helps to present a possible perspective according to which diagrams may be grouped according to the type of relation they underscore: interaction, transaction, and constitution loops.

Why look at diagrams instead of performing a well-documented textual analysis of the literature? Both are needed. But diagrams are powerful in driving the communication and the teaching of ideas. They help sediment perspectives and are one of the first tools used to approach new problems. Diagrams simplify; they select and they omit. What they leave out or distort is part of the narratives they help sustain (Tufte, 1997).

I am mostly concerned with schematic rather than realistic diagrams; pictorial simplifications that serve as conceptual anchors, what Rudolf Arnheim (1969) describes as “thinking with pure shapes.” They consist of simple elements: arrows conveying influence, lines and surfaces conveying boundaries, enclosed spaces conveying entities or processes, simple figures standing for objects, and short labels.

Diagrammatic thinking can lead to pictographic formalisms, as in the case of Feynman diagrams (Kaiser, 2005), Peirce’s existential graphs (Roberts, 1973), and bond graphs in engineering (Thoma, 1975). Most often, however, schematic diagrams occupy some point in between the normative sedimentation of ideas and the advance of novel thinking. Their productivity need not take the shape of a full-blown formalism and depends as much on the intellectual context as on the expressiveness of its conventions. Kurt Lewin’s topological diagrams in psychology¹ (e.g., Lewin, 1936, 1938) show this, and so do Neurath 1936’s Isotype, and Moore (2016) extensions to the basic diagram of autopoiesis.

Some diagrams function as icons, others serve complex narratives and try to leave few aspects unaccounted. Many fulfill more than one function. Single depictions can afford close examination as in, for example, Evan Thompson’s analysis of Ernst Mach’s portrayal of his personal visual field (Thompson, 2007, pp. 280–82). Or a variety of illustrative diagrams can be put together to explore full theoretical frameworks, as in Turvey and Carello’s (1986) pictorial essay on ecological psychology. Here, I want to focus on single diagrams in relation with each other in order to uncover broad patterns and the ideas they convey.

The scope of this perspective is limited² and the choice of examples and groupings follows my interest in highlighting three kinds of organism-environment relations: interaction, transaction, and constitution loops. These terms are described below. They are not meant as a novel categorization but as a way of looking at differences in emphasis. And of course, a diagram indicating relations of one of these types does not imply that its author is unconcerned by relations of the other types. The idea is to cautiously explore what diagrams suggest. The same material may be interpreted through alternative lenses, e.g., the kind and complexity of the pictographic conventions, the aesthetic dimension, or whether the emphasis is on structures or on processes, to mention a few possibilities.

INTERACTION LOOPS

In almost every diagram that depicts organisms and their environments, we find arrows going from one to the other. Arrows convey influence and connection, and in most cases

they form closed circuits to indicate that the relation between organism and environment is one of reciprocal influence. Closed loops are not a recent reaction to the classical “sandwich” model of the mind (Hurley, 1998). Analogous criticisms have been raised against simple stimulus-response thinking since the end of the 19th century (e.g., Dewey, 1896). We see loops depicted explicitly or implied in all of the diagrams in **Figures 1, 2**. Having said that, it is important to remind ourselves that open-loop explanations still abound in cognitive psychology and cognitive neuroscience.

Formally, an *interaction* is a mutual coupling between two dynamical systems. A system is coupled to another when its parameters and constraints depend on the state of the other system. The coupling is mutual if the same situation obtains in both directions. The *environment* of any given system is defined in dynamical terms as the set of all external variables to which the system is coupled and the sets of all external parameters it influences. Crucially, while the states of coupled systems change during interaction, the sets of variables, parameters, and formal relations do not change.

An important antecedent for both enaction and ecological psychology that describes this situation is Jakob von Uexküll’s depiction of the functional circle of an organism (**Figure 1A**; Von Uexküll and Kriszat, 1934, p. 7). The diagram shows a circuit going from an organism’s receptor organs to its effectors and closed by an external object. The character of the perceived environment is organism-dependent and constitutive of its inner world (*Innenwelt*). It depends, in particular on what actions the organism is capable of performing and what it is sensitive to, respectively, its *Wirkungswelt* and *Merkwelt*, as well as on the possibilities afforded by the object (*Mekrmlträger* and *Wirkungsträger*). The diagram presents on a same plane objective and subjective aspects of action/perception and serves to buttress von Uexküll’s concept of the *Umwelt*, the surrounding world of an organism.

A different attempt to establish the relation between the objective and subjective aspects of behavior was introduced by Koffka (1935, p. 40; **Figure 1B**). The diagram lacks von Uexküll’s elegant simplicity. The geographical (objective) environment (*G*) affects the real organism (*RO*), within which a relation is established between real behavior (*RB*, feeding back to *G*), phenomenal behavior (*PHB*), and the behavioral environment (*BE*). Koffka intends to illustrate the structure of the life space but the diagram is imperfect. Kurt Lewin (1936, 77) criticized its confusing conventions, such as the relation between real behavior (shown as an area), which takes place within the behavioral environment (shown as a line), yet is depicted as separate from it. Koffka’s points may be valid, e.g., the fact that not all action and perception processes are phenomenally conscious. But condensing such complex ideas in a line drawing is difficult. Simpler diagrams, like von Uexküll’s, travel further at the risk of blurring nuances.

Simplicity here is meant conceptually. **Figure 1C** shows a well-known illustration from Descartes’ *Treatise on Man* (Descartes, 1998, 154). Despite the artistic portrayal of a human body, it counts as a simple diagram. One source of bodily movement is the stimulation of the sense organs, which in turn

¹Lewin’s use of abstract diagrams is fundamental in the development of his dynamical approach to psychology and deserves more extensive treatment than we can provide here.

²Due to space and format constraints, only a small sample of 12 representative diagrams is shown here. Other diagrams are mentioned briefly in the text. All diagrams with the exception of **Figure 1C** have been (re)drawn by the author with permission and following as closely as possible the original sources (including placement of elements and types). **Figures 1A,C,E** are taken from the public domain.

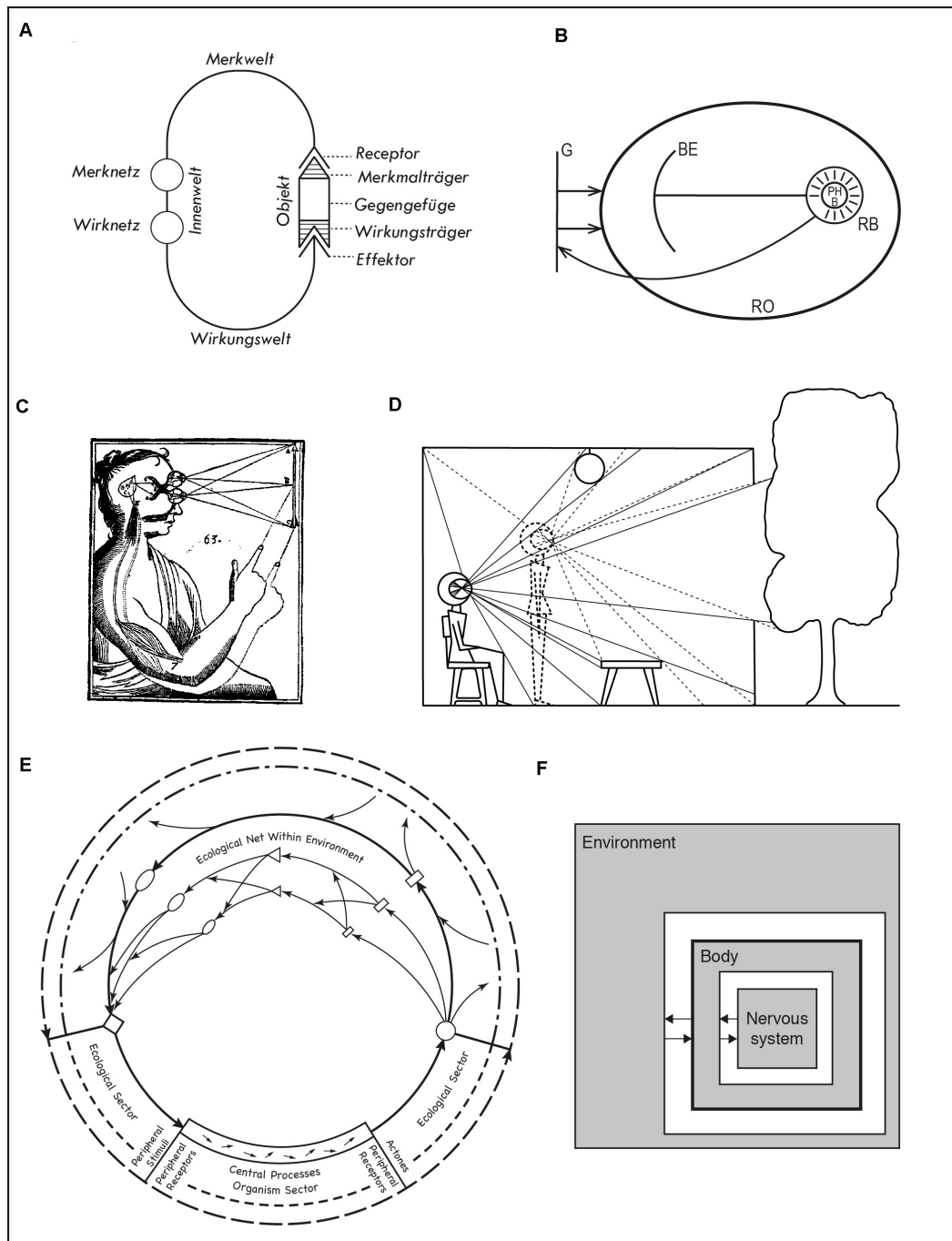


FIGURE 1 | (A) von Uexküll's functional circle. **(B)** Koffka's depiction of the behavioral and geographical environment. **(C)** Descartes' representation of a stimulation-action cycle. **(D)** Gibson's depiction of lawful changes in the ambient array as a result of moving the observer. **(E)** Barker's eco-behavioral circuits. **(F)** Beer's iconic diagram of brain, body, and environment as coupled dynamical systems. See text for references.

induces activity in the pineal gland; from there a flow of spirits to the muscles activate a motor reaction. This is illustrated by the two positions of the arm, by the lawful relation between object and retinal stimulation, and by the internal circuit from eyes to brain to muscles. Formally, the diagram is a less abstract version of von Uexküll's functional circle (**Figure 1A**), yet the intended

meaning is quite different: one supports a mechanistic view where the body, like an automaton, is activated through stimulation (and other sources of activity in the pineal gland); the other conveys an inescapable subjective dimension of perception.

Descartes diagram is visually similar to a famous picture that Gibson (1986, p. 72; see also Gibson, 1963) used to make

yet another different point (**Figure 1D**). Gibson was interested in moving beyond the special case of the static perceiver. Motion of the observation point reveals structural properties in the ambient array that are absent in the static case, such as variations in solid angles, changes in occlusions, and so on. As the array changes, some features and relations remain invariant. We see two stages in the motion of the whole body, from sitting to standing. This and similar diagrams have been used extensively in ecological psychology, e.g., to highlight the enabling effects of developmental changes (e.g., Adolph and Hoch, 2019, p. 144). Unlike **Figure 1C**, the internal arc of the sensorimotor loop remains implicit, while complex visual relations within the environment are shown explicitly. Pictorially, the requirements of depicting a body situated in an everyday environment and the lawful effects of motion on sensation are jointly met by replacing the whole head by the cross-section of a disproportionately large eye where light rays are inverted (as in Descartes' diagram).

Figures 1E,F lie at opposite ends of representational complexity. **Figure 1F** is a well-known, iconic diagram produced by Randall Beer (e.g., Beer and Chiel, 2008; **Figure 1**) describing the reciprocal coupling between organism and environment. As in other cases (e.g., Warren, 2006, p. 367), its purpose is to support the formulation of mathematical expressions functionally connecting variables in the agent and the environment. The environment is depicted as surrounding the whole agent. Unlike other versions of the same diagram, a thicker line has been drawn around the square indicating the body. This highlights a certain unity of the agent within which two interactive systems have been indicated, the nervous system and the (rest of the) body. Context here is important. Beer has been using diagrams like this since the early 1990s (e.g., Beer, 1992) to accentuate the dynamic nature of each of the shaded areas and the notion that in principle none of them determines what goes on in the others. This contrasts with mainstream notions of staged processing prevalent in cognitivist and connectionist approaches. It also contrasts with the view that the brain controls the body as a puppeteer does. Moreover, the diagram conveys a subtler point: the whole organism, not its nervous system, interacts with the environment. The nervous system is not directly coupled with the environment, but indirectly and always through the body. This makes all the difference if we conceive the body as a dynamical system and not merely as a signal transducer.

Another interaction loop is shown in Roger Barker's diagram (**Figure 1E**). It comes from his theory of behavior settings (Barker, 1968, p. 139) and depicts an organism engaged in various eco-behavioral circuits. The organism appears at the bottom of the large circles and is divided into peripheral receptors and effectors and central processes, in a way reminiscent of von Uexküll's *Merknetz* and *Wirknetz*. Unlike von Uexküll's single object, Barker shows various complex processes in the environment: relations between agent and objects (small circles, diamonds, and rectangles) both at the proximal level (e.g., a behavior such as catching a ball in a ball game) and ecological level (e.g., the playing field, other players). This diagram is animated by a richness of interactions between objects and even the dynamic character of the organism is underlined by a series of small arrows. In terms of the proportion of the loop occupied

by the agent, Barker's and von Uexküll's diagrams are almost opposites. For Barker, the organism occupies a short segment in much larger loops that include many environmental processes. This is a suitable representation of his contention that when accounting for what groups of people do in everyday life, the behavior setting is usually the strongest determinant.

All of these examples show interaction loops in the sense that they do not explicitly depict any permanent change in the organization or structure of the systems involved. Such possibilities are not disallowed, but they are not emphasized either.

TRANSACTION LOOPS

Interaction loops are well-defined if the systems are well-defined. We are often, however, interested in how systems change. Once we allow organisms and environments to change structurally as a result of their engagement, the notion of interactive coupling becomes fuzzy as systems undergo a history of transformations. Variables and parameters may appear or disappear, functional relations may change. Such a history is better described by the concept of *transaction* (e.g., Dewey and Bentley, 1949), a situation where labels are only provisional as relations and processes undergo transformation. In developmental psychology, transactional models stress "the plastic character of the environment and of the organism as an active participant in its own growth" (Sameroff, 2009, 8). If systems may change, how do they sustain their identity? Maturana and Varela (1987) propose a distinction between organization (a set of formal relations) and structure (an actual instantiation of those relations) and suggest that the criterion of sameness is the conservation of organization even when structure changes, a process they define as *structural coupling*. We can then define transaction loops as processes of structural coupling whereby an agent's organization is maintained but structures in the agent and the environment undergo a history of mutually enabled changes.

Figure 2A is a depiction of an ultrastable system, a concept developed by Ashby (1960, p. 83). The environment (*Envt*) is in a two-way coupling with the behavior generating sub-system (*R*) of the organism. Two other elements are shown that also belong to the organism: a set of parameters (*S*) that modulate the dynamics of *R* and a "gauge" indicating the state of organism's essential variables, i.e., variables that must be kept within viability bounds for the organism to survive. A secondary feedback circuit connects all the elements in the diagram. An arrow from the environment to the gauge shows the effect of environmental states on the essential variables. An arrow from the essential variables to *S* indicates the triggering conditions that lead to changing the behavior control parameters. If changes in *S* affect *R* in such a way that essential variables at the viability boundary return to a safe zone, the system will have adapted to a new situation. Through this double feedback the organism undergoes a history of adaptive changes, i.e., a series of transactions. While the secondary, transactional, feedback is not operating, the first feedback instantiates a simple interaction loop.

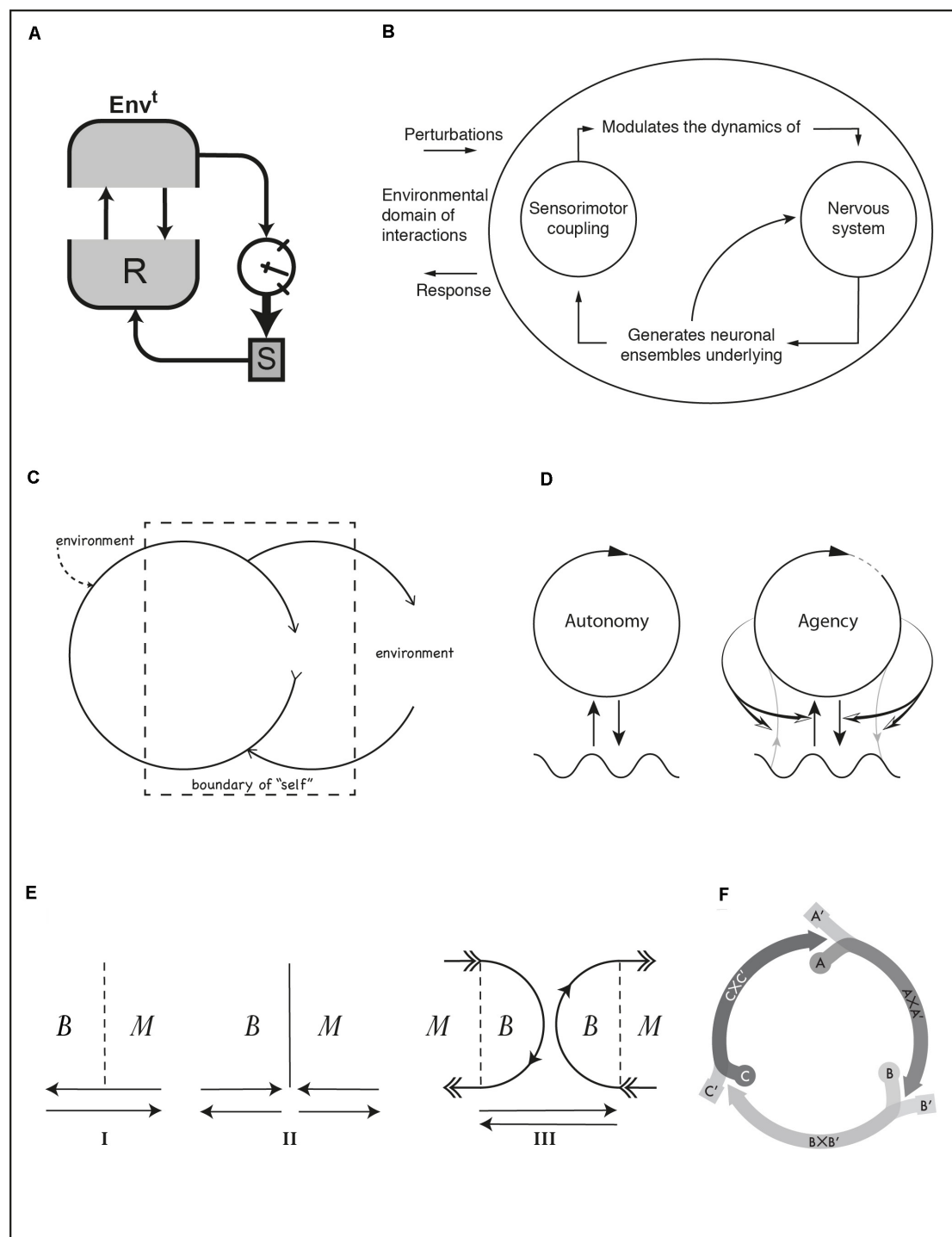


FIGURE 2 | (A) Ashby's ultrastable system. **(B)** Thompson's depiction of internal processes in organisms with a nervous system. **(C)** Bateson's conception of a self-constitution loop. **(D)** Iconic representation of a self-constituting autopoietic system (left) and enactive agent (right). **(E)** Plessner's distinction between nominal (I), reified (II), and processual (III) boundary between body and medium. **(F)** A sensorimotor scheme composed of three agent-environment coordination patterns. See text for references.

Transactional relations are sometimes conveyed by describing the classes of processes at play. A typical diagram used in the enactive literature is **Figure 2B** (Thompson, 2007, p. 47).

Similar diagrams appear in ecological psychology (e.g., Gibson, 1963, p. 12). A rather absent environment may be regarded as this diagram's fault (contrast with **Figure 1E** or with an

extended version in Chemero, 2009, p. 153). This diagram expresses the circular relations between processes within an agent with a nervous system, something deemed applicable to any environmental situation. The environment is the blank background from which arrows emerge carrying perturbations to the agent and sink carrying its responses. Other versions of this diagram (e.g., Varela, 1984, p. 319) add some symmetry and show the environment as an additional circle on the left. But **Figure 2B** is interesting in a perhaps unintended way. Read critically, diagrams like this may demonstrate a lack of attention toward environmental processes (cf. Barker's diagram). Read more charitably, we should notice a broken convention in the use of arrows. Shortcutting semiotic levels, they point toward the diagram's own background and not to another graphic element on the same plane. We may take this to signify a sense of inescapable environmental immersion. That diagrams may be assessed critically for their omissions or charitably for their subtlety underscores their semantic openness. Interpretation can reveal meanings intended implicitly, but also unintended meanings from which we can nevertheless draw interesting implications.

Looked at closely, even a sensorimotor scheme can count as a transaction loop although it involves only a behavioral scale typically conceived as interactive. Each segment in **Figure 2F** (Di Paolo et al., 2017, p. 85) stands for a joint coordination between organism and environment. Each coordination leads to a bodily and environmental situation that gives rise to the next coordination in the cycle. Coordination patterns are labeled, following Piaget, as AxA' , BxB' , CxC' , where A, B, and C are the bodily supporting processes (e.g., breathing, suckling, and swallowing when a baby is drinking from a milk bottle) and A' , B' , and C' the supporting environmental processes (e.g., air, bottle, milk). Each coordination induces a transformation of the organism-environment relation such that at its end, the next coordination starts as a result. Each coordination thus fulfills functional and structural roles, and this fulfillment results from a history of past and ongoing equilibration. Unlike other diagrams, we see pure relations between organism and environment (bands that converge into an arrow segment), without explicitly schematizing either.

CONSTITUTION LOOPS

We may sometimes be concerned not just with the historical transformation of organism and environment but with their very production, the coemergence of an individual together with its associated milieu (Simondon, 2005). If this is an ongoing process, as enactivists sustain, the continued existence of the organism as an entity must be the result of relations of *constitution*, i.e., relations by which organisms and environments co-emerge. These loops will often have a transactional character, but not all transactions entail relations of constitution which include organizational and as well as structural changes.

The meaning of arrows and closed shapes in most diagrams is usually straightforward. Arrows go from an "entity" (a closed shape) toward another "entity" or toward a relation

(another arrow) in the case of modulatory couplings. The autopoiesis diagram (**Figure 2D**, left; Maturana and Varela, 1987, 74) re-signifies this convention: an arrow closes on itself forming a closed shape to indicate an entity constituted by circular relations between processes. This dialectical synthesis of conventions for entities and relations (circles and arrows) describes a constitution loop. The diagram has been adapted and extended many times, e.g., to illustrate ideas of minimal, sensorimotor, and linguistic agency, and social interaction³ (Di Paolo et al., 2018, pp. 54, 68, 197; see also Moore, 2016). For the enactive concept of agency (**Figure 2D**, right; Di Paolo et al., 2018, p. 54) modulatory arrows have been added that go from the self-constituting organism toward the environmental *coupling*, not toward the environment. This secondary loop may be seen as a generalization of Ashby's ultrastable system. Gray lines indicate material exchanges that constitute the organism. They can also undergo regulation by the agent. The circle is not fully closed to signal that the agent is constantly in the process of making itself also through its actions.

The convention of the self-encircling arrow to indicate a constitution loop has been used before by Gregory Bateson (**Figure 2C**; Ruesch and Bateson, 1951, pp. 187, 189). Formally, if we ignore the dashed lines, this diagram and the autopoiesis diagram are identical, the only differences being the horizontal orientation, the fact that the circle describing the organism ("an entity with a self-correcting causal circuit," p. 186) does not fully close on itself, and the missing wavy line, replaced by the label "environment" on the right. What distinguishes Bateson's diagram is a dashed rectangle conveying the idea that the personal sense of "self" often combines both organismic and environmental processes and that parts of the body may sometimes be felt as belonging outside ourselves (thus also labeled "environment," although this may cause confusion) and parts of our "self" include processes in the body's environment (e.g., wearing glasses).

The idea of a self-producing entity that is itself constituted by the way it relates to its medium, though perfectly conceivable in scientific terms, is difficult to picture. In **Figure 2E**, Helmuth Plessner presents a comparison between views of the relation between body and medium (Plessner, 2019, p. 183; originally published in 1928). Inset I indicates a nominal boundary between body and medium (dashed line); interaction arrows freely transverse it in both directions. Inset II illustrates the boundary as a reified barrier, suggesting a domain of constitution on the left and a domain of interactions on the right, an idea similar to the doctrine of non-intersecting domains in the theory of autopoiesis. Inset III illustrates two coupled process arcs of construction and disintegration out of which both body and medium reciprocally constitute and distinguish themselves. The organism as a whole is "only half of its life" and demands environmental "supplementation without which it would perish" (Plessner, 2019, p. 180), a fundamental tension

³To clarify, *social* interactions, according to their operational definition in enactive terms (De Jaegher and Di Paolo, 2007), can and usually do comprise interaction, transaction, and constitution loops. They are not only interactive in the restricted sense used here even if, for reasons of continuity with social psychology and social science, they are labeled as social *interactions*.

between openness and separation. The dialectical situation is reminiscent of Simondon's (2005) philosophy of individuation and the enactive conception of life (Di Paolo, 2018).

DISCUSSION

This brief excursion does not exhaust the lessons we could draw from a more detailed comparison of schematic diagrams in psychology. More points can be made; more diagrams can be discussed. But it does produce some insights.

Pictorial or formal resemblance does not ensure that diagrams are used to make similar points, as we have seen in comparing Descartes' diagram with von Uexküll's and Gibson's. It seems legitimate to ask whether similarity of representation might not sometimes suggest tacit convergences that are neither avowed nor rejected. Perhaps Descartes would not have entirely dismissed the dynamic interpretations in von Uexküll's diagram, perhaps it makes some sense to link Gibson's depiction of the observer in motion with von Uexküll functional cycle more explicitly (see Baggs and Chemero, 2018). Comparing diagrams can suggest novel interpretations and bring implicit ideas into the open.

There is a conceptual and practical distinction between interaction, transaction, and constitution loops even if some diagrams may ambiguously belong in more than one category. Establishing the timescale of interest may help in determining whether a situation is best treated as interactional (e.g., behavior) or transactional (e.g., learning and development). But this is not the only difference. Transactions do not only occur at longer timescales, and even when they do, their effects can still make a difference in the here and now of action and perception (like jumps in skill). Constitution loops are meant to describe how organisms are themselves

always individuated through processes that constantly create the distinction between organism and environment. Their diagrammatic representation in self-encircling arrows graphically transcends the entity/relation distinction.

We may tentatively suggest that one difference between ecological psychology and enaction is that the former focuses more intensively on interaction and transaction loops, and the latter on transaction and constitution loops. This is only approximate and there are bound to be counterexamples (as in Randall Beer's case, who has worked on models of interaction as well as models to clarify ideas of transaction and constitution in autopoiesis and enaction, e.g., Beer, 2020). Nor is there any implication that the situation must stay like this. But the suggestion may act as common ground in discussing the differences between the two approaches as well as pointing to transaction loops as a fertile zone for collaborative work.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Extended Skill Learning

Edward Baggs^{1*}, Vicente Raja¹ and Michael L. Anderson^{1,2,3}

¹Rotman Institute of Philosophy, University of Western Ontario, London, ON, Canada, ²Department of Philosophy, University of Western Ontario, London, ON, Canada, ³Brain and Mind Institute, University of Western Ontario, London, ON, Canada

Within the ecological and enactive approaches in cognitive science, a tension exists in how the process of skill learning is understood. Skill learning can be understood in a narrow sense, as a process of bodily change over time, or in an extended sense, as a change in the structure of the animal–environment system. We propose to resolve this tension by rejecting the first understanding in favor of the second. We thus defend an extended approach to skill learning. An extended understanding of skill learning views bodily changes as being embedded in a larger process of interaction between the organism and specific structures in the environment. Such an extended approach is committed to the claims that (1) the appropriate unit of analysis for understanding skill learning is not the body but the activity and (2) learning consists in the establishment and adaptive organization of enabling constraints on that activity. We focus on two example cases: maintaining upright posture and walking. In both cases, environmental structures play a constitutive role in the activity throughout learning, but the specific environmental structures that are involved in the activity change over time. At an early stage, the child makes use of an environmental “support”—for example, holding onto furniture to maintain upright posture. Later, once further constraints have been established, the child is able to let go of the furniture and remain upright. We argue that adopting an extended understanding of skill learning offers a promising strategy for unifying ecological and enactive approaches and can also potentially ground a radically embodied approach to higher cognition.

Keywords: skill learning, embodied cognition, ecological psychology, enactivism, animal–environment system, psychological explanation

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*Correspondence:

Edward Baggs
ed.baggs@gmail.com

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INTRODUCTION: TWO SENSES OF SKILL

One promising potential area of convergence between the ecological and enactive approaches in cognitive science is in the development of a general theory of skill learning. Theoretical work within both approaches has come increasingly, in recent years, to appeal to the notion of skill as an explanatory factor in the understanding of behavior (e.g., Chemero, 2009; Rietveld and Kiverstein, 2014; Di Paolo et al., 2017; Baggs and Chemero, 2020). This is particularly true in the case of attempts to explain specifically human forms of behavior, namely those involving language. To be a competent well-adjusted adult human, so the story goes, is to exercise a set of skills in an appropriate way in a variety of contexts.

Within current theoretical writing within these approaches, however, a tension seems to exist in how the notion of “skill” is used. On the one hand, the word is used as if it denotes some property of the animal’s body. The body is said to “possess” a set of skills or to be constituted as a network of such skills. On the other hand, the word is used to denote

the performance of some activity. When “skill” is invoked in this second sense, it seems that the concept can no longer be understood as referring narrowly to some property of the body, but must be understood as an extended phenomenon spanning the animal–environment system.

Two examples will suffice to illustrate this tension. First, Rietveld and Kiverstein (2014, p. 325, emphasis added), in their work that seeks to expand the theoretical scope of ecological psychology, tell us that “the affordances an environment offers to an animal are dependent on the skills the animal *possesses*”. On the face of it, this is an instance of treating skills as a property of the body (a possession). But it is clear that these authors do not want to view a skill as simply a property of the organism. Elsewhere in the paper, the authors endorse the claim of Gibson (1979) that learning involves the “education of attention.” They write (Rietveld and Kiverstein, 2014, p. 331): “In acquiring a skill, we learn in which places in the environment to find the affordances relevant to our concerns and what aspects of [the] environment to attend to.” This seems to imply, in contrast, that the learning and exercising of a skill *inherently* involves the environment: skillful acting simply is directing one’s attention to something *in* the environment. In that case, it is misleading to say that the skill is something that can straightforwardly be considered a property of the organism’s body alone.

Second, Di Paolo et al. (2017, p. 196), in developing their enactivist account, propose that “a cognitive agent” (an animal) can be conceived “as essentially an integrated ecology of sensorimotor skills.” Building on Piaget, these authors take skill learning to involve the construction and progressive elaboration of a network of sensorimotor schemes. The suggestion is that we somehow “incorporate” these schemes into our bodies. This appears, once again, to be an instance of skill-as-bodily-property thinking. Yet elsewhere, these authors insist that skills are in fact something other than simply properties that the organism’s body possesses. Skill learning is said to be “world-involving.” Skill learning leads to mastery, which “is a world-involving concept since it relies on dynamic engagements with the world, enacted or potential” (Di Paolo et al., 2017, p. 107). Again, it seems that skill-as-bodily-property thinking is too restrictive to capture the theory of skill learning that these authors are actually trying to develop. The tension that we have identified seems to run through both of these contributions.

How might we resolve this tension? A standard formulation proposes that learning should be understood not in terms of the accumulation of bodily properties but in terms of change. Instead of viewing the learner as gathering more and more “knowledge” of its environment, we should view the learner as changing so as to become increasingly adapted to the structure of that environment (e.g., Gibson and Gibson, 1955; Pacheco et al., 2019). Similarly, Araújo and Davids (2011) suggest that it is a mistake to use the phrase “skill acquisition” to refer to this process. To frame the investigation in terms of “acquisition” is already to seek an explanation of learning in terms of an accumulation of bodily properties. Araújo and Davids (2011) suggest that we should abandon

talk of “skill acquisition” in favor of terms such as “skill adaptation” or “skill attunement.” We agree with this. It is important to note, however, that what Araújo and Davids are in fact advocating for here is not merely a change of wording, but a change in the scale of analysis at which we understand what skills are in the first place.

The key to resolving the tension, then, is to appreciate that the two senses of skill—skills as bodily properties vs. as properties of the extended organism–environment system—are simply two ways of describing the outcome of a single process. Specifically, the two senses of “skill” are describing the same process of learning at two different scales of analysis—namely, the bodily scale and the ecological scale. In practice, it only really makes sense to talk of skills at the scale of the activity, not at the scale of the body. Of course, the body does change over the course of learning, and this change includes changes in the nervous system. But, crucially, those changes do not arise autonomously within the body alone (and thus it is odd to say that the body “possesses” the skill). Rather, skills arise always *through situated engagement with an environment*. Bodily change should, therefore, be understood as bodily-change-relative-to-an-environment or, even better, as a change in the extended structure of the animal–environment system. In short, skill learning is an inherently extended phenomenon.

In what follows, we will be drawing on work from the empirical literature on motor control in infancy and in later learning. We highlight this work in order to illustrate the claim that skill learning, in practice, can only ever be understood as an extended phenomenon that constitutively involves structure not just in the animal’s body but also in the animal’s environment.

Toward the end of the paper, we will turn to the question of how adopting this extended view of skill learning might help to unify the ecological and enactive approaches. Generally speaking, we envision a future ecological–enactive account of skills, which recognizes that (i) the appropriate unit of analysis for understanding skill learning is not the body itself, but the activity that spans organism and environment and (ii) learning consists in the establishment and the adaptive organization of *enabling constraints* on that activity (Anderson, 2015; Raja and Anderson, 2020). This view allows for a flexible and general account of skill learning, one that is equally appropriate for describing learning in motor tasks such as learning to walk, and learning in social situations, which should be understood in terms of action relative to an environment that is populated with other actors. First, we consider some examples from infant motor control.

TWO EXAMPLES OF SKILL LEARNING

Upright Posture

Learning to maintain an upright posture is an important developmental milestone in typically developing children. Children generally learn to stand unaided sometime around their first birthday, though it takes years of learning for an individual to be able to maintain the upright posture in a wide variety of different contexts and situations (Adolph, 2008).

Some of the factors necessary for upright posture are seemingly straightforwardly features of the body. The first requirement is that the infant develops sufficient bodily strength for overcoming gravity (McGraw, 1932; notice that already here we are referring to gravity, i.e., a feature of the animal–environment system). Other requirements include anatomical and biomechanical changes, such as in the spine and the pelvis (Lovejoy, 2005a), the hip and thigh (Lovejoy, 2005b), or the knee (Lovejoy, 2007).

Maintaining the upright posture is also a perceptual task. In simple terms, it calls for continuous compensatory movements to control the position and momentum of the center of gravity of the body in order to hold it within the limits of its base of support—that is, the area of contact between the body and the supporting surface in the environment (Riley et al., 1995; Krebs et al., 2002).

An illustrative example of the role of visual perception in maintaining the upright posture is the moving room experiment (Lee and Aronson, 1974; Lee and Lishman, 1975). In this experiment, participants stand within a room that looks completely normal. In fact, however, the walls of the room are mounted on rails (or else the room is suspended on ropes from above) so experimenters can “move the room” relative to the participant. A participant may therefore be standing still looking at a wall and nevertheless she may see the wall approaching or receding away from her. The movement of the walls generates different patterns of optic flow (i.e., changes in the visual field of the participant) that directly affect the participant’s capacity to maintain upright posture. The flow generated by an approaching wall, also known as optic push, often causes the participant to lose her balance. The effect is especially dramatic when the participant is a toddler. The approaching wall can easily cause the child to lose control of the upright posture and fall to the floor (Lee and Aronson, 1974). The same optic push does not affect adults to quite the same extent. As long as the adult participant is standing on a wide enough base of support, for example, she is standing on a regular floor, the participant will not typically stumble or fall over. But if the base of support is thinner or less stable than usual, for example, if the participant is asked to stand on a narrow wooden beam, the adult participant will typically have more difficulty staying upright and may be forced to make strong corrective movements or to step off the beam (Lee and Lishman, 1975; see also the differences in standing on the land or on a ship at sea in Stoffregen et al., 2011).

For present purposes, we are interested in the question of how it is that children learn to stand upright in the first place. It is noteworthy that at its earliest stages, the task involves environmental support in a very immediate way. Infants, before they learn to stand unaided, typically first pull themselves up on furniture and other object, maintaining upright posture by leaning on the object with their hands or torso. It is commonly said that this behavior allows the infant to “augment” her balance (e.g., Berger et al., 2013). This is surely true. But another way to describe this pulling-to-stand activity is to say that the furniture item is in fact itself part of the learning

process that is necessary in order to reach a mature task solution. That is, postural control extends from the body of the learner to incorporate the solid structures she encounters in her environment.

By holding onto the furniture, the child has achieved temporary postural stability. The child’s postural degrees of freedom have been frozen, in a sense. But notice that this is not achieved simply by freezing the degrees of freedom internal to the child’s musculoskeletal system. In effect, the furniture item has been incorporated into the postural control system, and it is this that provides temporary stability (we will discuss the degrees of freedom problem in more detail in the next section).

Holding onto the furniture, the child is now free to explore her motor space in a new way. She is free to explore the kinds of perceptual information that are generated when she arranges her lower limbs into the arrangement necessary for standing. Crucially, this kind of information (visual information about the room, haptic information about the angles of the joints, the weight of the body on the limbs, etc.) can *only* be explored by actually adopting an upright standing position. As long as the child holds onto the furniture, the solution space is constrained and some of the degrees of freedom of the system have been fixed (e.g., having pulled herself up on the furniture, the child cannot move from *here*, except by lowering herself again). Later, once the child has sufficiently explored this new motor solution space, she learns to control her posture relative to some structure in this new information field. Eventually, the child is able to let go of the furniture. At this point, the postural task has become different in nature, but note that it remains equally extended into the environment. Now, instead of relying on a single item of furniture to stay where it is, the child relies on the global layout of the whole environment to stay roughly where it is—we might say that the motor constraint offered by the furniture is replaced by a set of perceptual constraints enabled by the optic flow, the gravitational vector, and so on.

Walking

As we have just seen, maintaining an upright posture involves swaying so as to *cancel out* optic flow relative to the environment (assuming the environment is stable and you are not standing in a moving room). Walking and locomotion in general is different. Walking involves *generating* optic flow in a more or less continuous manner, in order to control movement in a desired direction. Optic flow, in the case of locomotion, is the information that specifies whether or not the actor is successfully moving from “here” to “over there.”

But again, optic flow alone is not enough. A number of other enabling factors are required in order for walking to occur. These include postural stability, sufficiently strong muscles and bones, a motivation to move in a particular direction, and an appropriate surface of support (Thelen and Smith 1994, p. 20; see also Adolph et al., 2012).

A classic illustration of one of the relevant constraints at play is provided by Thelen’s work on the spontaneous “stepping” motion in infants (Thelen, 1984; Thelen and Smith, 1994).

Newborn infants, when held upright, will often spontaneously exhibit a pattern of leg movement that looks like stepping—that is, the infant will exhibit alternate rhythmic movements of the left and right legs (McGraw, 1932). This behavior, however, “disappears” at around 2 months. Typically, the stepping pattern does not “reappear” until the child begins to walk by herself toward the end of the first year. This “U-shaped” developmental pattern had long been a puzzle in infant movement research. When Thelen and her colleagues investigated this, they discovered that the stepping behavior could be re-induced by various methods. For instance, a 3-month-old infant might show the stepping pattern if held in water, rather than over the ground. Or a 7-month-old infant might show a natural-looking stepping gait when held over a treadmill, rather than a stationary substrate (Thelen and Smith, 1994). So what is going on here? On the face of it, it seems as though the child does not actually lose the *ability* to produce the rhythmic pattern, but simply stops doing it, for some reason. Thelen and her colleagues were able to offer a persuasive explanation. The reason for the “disappearance” of the stepping pattern in the first months, they argued, is that infants quite rapidly gain body weight in this early period and the weight gain occurs faster than the gain in leg muscle. For 2-month-old infants, the problem is simply that their legs have gotten too fat for it to be worth assembling the stepping pattern (this explanation is supported by a wealth of evidence; for details, see Thelen and Smith, 1994, chapter 4).

Notice that on Thelen’s interpretation, it is not the case that stepping is a “skill” that the infant can be straightforwardly said to alternately possess, and then not possess, and then possess once more. It would make little sense to say that newborn infants “possess a stepping skill,” which they then “lose,” only to “reacquire” the same skill later in the year. Thelen herself understood this developmental phenomenon as a demonstration that causal explanations of infant development cannot appeal only to a single cause, such as the presence of some structure in the central nervous system, but must appeal instead to the whole situation supporting the activity. Causation is spread across body and environment: “There is ... *no essence* of locomotion either in the motor cortex or in the spinal cord. Indeed, it would be equally credible to assign the essence of walking to the treadmill than to the neural structure, because it is the action of the treadmill that elicits the most locomotor-like behavior” (Thelen and Smith, 1994, p. 17, emphasis in original). Notice that Thelen and Smith are here already offering what we are calling an *extended* account of learning to walk.

We noted above that, at its earliest stages, maintaining upright posture constitutively involves the environment: infants pull themselves up to stand against furniture. The same is true of learning to walk. Characteristically, early walking is supported in some way by structure external to the infant’s body—either by furniture items, which the infant holds onto while shuffling, “cruising,” along (e.g., Haehl et al., 2000; Berger et al., 2013), by an adult holding onto the infant’s torso or hands as the infant is allowed to move her feet (McGraw, 1932), or by some specially constructed device such as a baby walker with wheels.

Again, these external “supports” can be thought of in a particular way: not merely as background conditions but as constitutive or necessary constraints on the infant’s activity and on the process of skill learning. Just as it is not possible to learn to stand except by adopting the standing posture (by, say, holding onto furniture to gain better control over the degrees of freedom relevant for the task), so it is not possible to learn to walk except by alternately planting your feet on the ground and moving forward, thus generating the relevant information about bodily posture—joint angles, momentum, vestibular flow, and so on. The infant’s activity, at this early “supported” stage of walking, is constrained in the sense that her body is temporarily coupled to another object or person. She cannot move around in this way except by, say, holding on to the fingers of a parent. As soon as she lets go of the fingers she slumps to the floor. In other words, the presence of the constraint (holding onto the parent) is a necessary condition for assembling the relevant motor solution. The learning of the skill is therefore an extended animal-environment event. Later on, after extensive practice in this “supported” manner of walking, the infant will let go of the fingers and begin to take her first steps “unaided.” When this occurs, the infant is demonstrating that she has gained some mastery over her internal postural control during walking and she no longer needs the postural constraint provided from outside her body. She has freed herself from one concrete externally-provided constraint and is now free to explore the motor space of this new walking posture relative to a moving pattern of optic flow (which, once again, is still an environmental constraint). She is free to explore her surroundings.

SKILL LEARNING AS THE ESTABLISHING OF ENABLING CONSTRAINTS

We have discussed two simple examples of skill learning. These examples are sufficient to show that skill-as-bodily-property thinking is inadequate for capturing the process by which a skill is learned. As soon as we begin to look at the details of the learning process in a given case, it becomes apparent that we need to understand learning not merely in terms of bodily change, but also in terms of the environmental resources that are involved in the performance of the task. It is more useful, in fact, to think of learning as a process whereby a set of enabling constraints are established that allow the learner to carry out the task.

The concept of enabling constraint is a general concept that we have previously introduced in order to distinguish certain system-scale explanations from more reductionistic component-based explanations (Anderson 2015; Raja and Anderson, 2020). Roughly, an enabling constraint is something that limits the degrees of freedom of a system and thereby allows the system to perform some activity that would otherwise not be possible for the system. More formally, a constraint is a relationship between some system *S* and some set of entities or processes *{X}* such that *{X}* biases the probability of

a set of possible outcomes/states for S. An *enabling* constraint is one that biases the set in favor of *positive, functional* outcomes for S (defined relative to S; Raja and Anderson, 2020). The concept is useful, for instance, for making sense of the activity of starburst amacrine cells in the mammalian retina: it is difficult to understand the direction-specific motion-detection function of the cell's dendrites except by considering the cell as part of a larger system that constrains the activity of the cell to render it functional (Anderson, 2015). At a more macro scale, the concept of enabling constraint can also be applied to the behavior of the organism itself: the relatively slow movements of the organism, for instance, can be understood as constraining the relatively fast activity of the organism's nervous system (Raja and Anderson, 2019; Raja, 2020; see also Van Orden et al., 2012).

We now suggest that the concept of enabling constraint can usefully be applied to understanding how skills are learned. Indeed, the concept of enabling constraint captures the way that skill learning is already understood by researchers working in several broadly embodied traditions who study the process of skill learning empirically. The notion of enabling constraint is consistent with at least the following three strands of current thinking in skill learning research.

First, consider Newell's constraint-based theory of coordination (Newell, 1986; Pacheco et al., 2019). Newell (1986) distinguishes between three sources of constraint: organismic constraints, environmental constraints, and task constraints. Organismic constraints are such things as the strength of the infant's limbs, mentioned above in relation to walking. Environmental constraints include such things as gravity, air temperature, lighting conditions, and also the medium in which the activity is carried out (for example, the infant's stepping pattern can "re-emerge" when the infant is held in water; see Thelen, 1983). Task constraints include the task goal, the rules for carrying out the task correctly (for example, in race walking there is a task constraint that at least one of the participant's feet must be in contact with the ground at all times), and the equipment used (a large soccer ball presents more difficulty to a small child than a smaller ball more appropriately scaled to the child's body). The general notion of constraint is in fact ubiquitous in the literature on ecological and dynamic systems approaches to skill learning (see, e.g., Runeson, 1988; Vicente and Wang, 1998; Jacobs and Michaels, 2007; Davids et al., 2008). The way that constraints are invoked in this literature, including in Newell's theory, can be understood in terms of enabling constraints at the scale of the task, that is, at the scale of the extended animal-environment interaction. On this constraints-based way of understanding things, it is inappropriate to say that a skill resides in the animal's body alone (Araújo and Davids, 2011).

Second, it is often proposed that learning involves the freezing, followed by the freeing, of degrees of freedom in the motor system (Newell and van Emmerik, 1989; Vereijken et al., 1992; Guimarães et al., 2020). This process was originally proposed by Bernstein (1967), as a solution to a problem that he identified and that has come to be known as Bernstein's problem: how does the motor system control a musculoskeletal

system that seems to offer an arbitrarily large number of degrees of freedom? The proposal is that the motor system freezes some of the degrees of freedom in order to enable the assembling of a task solution. The process is characterized as involving three stages. In the first stage, the relevant degrees of freedom of the motor system for a given task are frozen out, meaning that they are kept rigid or fixed with respect to each other. In the second stage, individual degrees of freedom are de-frozen, allowing them to vary with respect to the other ones and progressively being integrated into functional units usually named *coordinative structures* (Kugler et al., 1980) or *synergies* (Kelso, 1995). Finally, the control strategy becomes more economical by exploiting passive forces (e.g., gravity or inertia) in the last stage of learning. In the case of the upright posture, one aspect of the learning process could for instance go from the freezing out of the joints in the legs to their combined control as a functional unit in which ankles, knees, and hips compensate each other and ending up in a better economy of balance by exploiting the inertial properties of the whole body (see Schneider et al., 1989, for an example of a similar process in the arms). Notice that coordinative structures or synergies are precisely instances of explanation in terms of enabling constraint.

This notion of freezing and freeing of degrees of freedom can be pushed further. Adopting an extended view of skill learning, we would say that in addition to recognizing the freezing of internal degrees of freedom *within the motor system*, we can also consider structures in the environment as providing constraints that enable the emergence of the activity. When the infant pulls to stand against a piece of furniture, she is freezing the degrees of freedom of her postural system relative to the furniture. By leaning on the furniture, the child is freezing the relevant degrees of freedom for the task in at least in two ways: in terms of the body, by making impossible some kinds of variations (e.g., rotating the forearm in the elbow-wrist axis) and in terms of the animal-environment system, also by making impossible some kinds of variation (e.g., moving too far away from the furniture such that her arm can no longer reach). In this sense, the environmental elements and the relation of the infant with them become an integral part of the learning of the skill: they are the way the process of mastering the control of degrees of freedom is extended beyond the body.

Third, the process of learning is often understood, within ecological and dynamical approaches, in terms of a search strategy (Pacheco et al., 2019). For instance, one of the main ecological theories of perceptual learning, *direct learning* (Jacobs and Michaels, 2007), understands learning as a change in the attunement to perceptual information, from not-so-good information to better information, to accomplish some task. Specifically, the learning process is understood as a search through the information space leading to a maximally optimal solution to the task. Learning to walk can be understood as a solution to the problem of locomoting through the environment (Adolph et al., 2012). The search for a solution is enabled by the infant's establishing constraints on her own movements (holding on to furniture, etc.).

The search of the information space leads the child to discover new enabling constraints. She discovers that it is possible for her to remain upright while keeping the rate of optic flow within some appropriately bounded region. She can let go of the furniture because new enabling constraints have been established that render the previous furniture-holding constraint no longer necessary.

The above considerations lead us to reject the concept of skill-as-bodily-property. It makes little sense to say that the child *acquires* a skill, or *possesses* it (again, we agree here with Araújo and Davids, 2011). Instead, it is more useful to understand skill learning as a re-organization of the entire extended system constituted by the actor, its environment, and the relational structure connecting the two. Skill learning is the establishing of enabling constraints at the scale of the task.

SKILLFUL ACTING IN A POPULATED ENVIRONMENT

The two main examples of skill learning that we have discussed so far are limited in various ways. Both are problems of motor control. In each case, movement is controlled relative to optic flow. And a similar set of constraints is involved in both cases (gravity, a suitable surface of support, muscle strength, etc.). More broadly, both are problems whose explanation can be conceived in terms of an *individual* actor encountering its own particular environmental surroundings. The examples are drawn from the literature on dynamical systems and motor development. Dynamic systems explanations have historically hewed to a version of methodological individualism (quite reasonably so, given the problem domains these approaches have been applied to). Explanation, in this approach, targets the system constituted by a single, individual actor and the relevant surroundings of that one actor. This is made explicit in certain places, such as in the following from Thelen and Smith (1994, p. 97): “A crucial assumption in a dynamic strategy is that *the individual and his or her behavioral changes over time are the fundamental unit of study*” (emphasis in original).

More recently, proponents of ecological and enactive approaches have sought to push explanation in cognitive science beyond the limitations imposed by methodological individualism (e.g., De Jaegher and Di Paolo, 2007; Schilbach et al., 2013; Chemero, 2016; Baggs et al., 2019). We think this rejection of methodological individualism is worth pursuing and we further suggest that the ideas outlined above are already general enough to be extended to social phenomena. An extended, relational account of skill learning offers a more powerful explanatory toolkit than has been suggested so far. Here, we will briefly consider two areas in which the extended view of skill learning may potentially be illuminating for social phenomena: in explaining the emergence of higher cognition and in explaining group activity.

Ultimately, theorists of radical embodiment seek to move beyond explanations of sensorimotor skills of the walking/standing upright type. We also want to be able to explain skills of the “higher”/symbolic type, such as language or counterfactual

reasoning (see, e.g., Baggs, 2015; Sanches de Oliveira et al., 2019). The most promising framework for getting to the latter type of explanation remains that outlined by Vygotsky in the 1930s (Vygotsky, 1978). Vygotsky’s framework can be summarized quite succinctly. The basic story is the following. All actions start off as overt behavior. Counting to 10, for instance, initially consists precisely of speaking “out loud” the sequence of sounds “one, two, three...” This occurs, of course, in a social setting. A caregiver encourages the child to repeat the sequence and provides additional structure, for example, drawing the child’s attention to objects that are being “counted.” Over time, the child learns to coordinate the sequence of individual number words with attention to the sequence of individual objects. Eventually, the child is able to reliably produce the sequence of numbers in the appropriate order and to reliably coordinate the uttering of the individual number words along with the “counting” of individual objects. What was once a meaningless sequence of sounds has become a meaningful series of numbers and the child can now be said to have mastered, in some sense, the skill of counting. She can now engage in “higher” forms of social interaction that were previously impossible.

Note that the later forms of activity are not simply a more complicated version of the earlier form. At the earliest stage, the child is simply reproducing a sequence of sounds. Somehow, the child needs to discover that the individual numbers correspond to individual “countings” of objects. She needs to discover the relation, or the constraint, that connects the two structures. This discovery is facilitated by the actions of the caregiver. The caregiver “scaffolds” the discovery of the relation, to invoke the common metaphor (Wood et al., 1976). It should be noted that the child is always an active participant in this process. The caregiver acts so as to *constrain* the child’s utterances and to channel the child’s attention toward the objects. The outcome is that the initial task, reproducing a sound sequence, is transformed to a new activity, counting. But this new activity is still a world-directed activity. It is questionable whether it makes sense to say that anything has been “internalized” here. It is more accurate to say that the nature of the activity has changed and a new skill has emerged. A radical embodied account of language must begin with this kind of situated, embodied, attention-directing activity in early childhood (Reed, 1996; Baggs, 2015; Di Paolo et al., 2018; Van den Herik, 2018).

A constraint-based account of skill learning can also provide a valuable way to think about group activity. The world that we encounter in early childhood is a world that is *populated with other actors*. We live in a populated environment. A consequence of this is that other people (and animals) can constitute constraints on any given individual actor’s activity. We here wish to make explicit a claim that is latent in the discussion above. We have so far been appealing to the notion of enabling constraints as though such constraints only arise as an emergent consequence of the individual’s own behavior. But this is not the case. A baby walker, for instance, is an inanimate object that is encountered by the individual. But it is also a social object. It is designed specifically to assist learning, and it is provided to a child by a caregiver for that specific purpose.

A more radical claim could also be made here. We have proposed that skills should be understood as emergent properties of systems spanning animals and their environment. There is no reason in principle why we should not extend this and talk about skills at the scale of groups. In any team activity where there is a high degree of interdependence between the activities of the actors, such as in a soccer team, or between the staff on a hospital ward, the ability of any individual to achieve some desired outcome will be dependent on the skillful functioning of the system as a whole (Hutchins, 1995). In other words, structural properties of the team can influence, in a top-down fashion, the possibilities that are available to the individual members of the team. And, as discussed just above with reference to Vygotsky, such interdependent activity is characteristic of infant-caregiver interactions from early in life (Trevarthen and Aitken, 2001). So perhaps we should reject methodological individualism after all. Such a move—recognizing the primary role of interaction in skill learning—can potentially allow us to avoid the knotty set of issues that is encountered by theorists of social cognition who begin by assuming that social encounters must start with the attempt to recognize the intentions of the other actor (Baggs, 2020; Gallagher, 2020).

EXTENDED SKILL LEARNING AND ECOLOGICAL-ENACTIVE COGNITIVE SCIENCE

We began this paper by noting a tension that exists in how the notion of *skill* is understood in current theoretical work in ecological and enactive approaches in cognitive science. Skill is understood ambiguously as either a property of the animal's body or as property of the extended animal-environment system. Our aim has been to resolve this tension by rejecting the first understanding in favor of the second. We have drawn on work from the empirical literature that shows how skill learning is an inherently extended phenomenon. We suggest that adopting such a view of skill learning offers the most promising strategy for bringing the two theoretical approaches—ecological and enactive—together into an empirically productive synthesis. In this last section, we will briefly sketch some reasons for pursuing such a synthesis.

Historically, the fundamental difference between the two approaches has been in where they locate meaning (Baggs and Chemero, 2018). Ecological psychologists, following Gibson (1966, 1979), generally hold that meaning is external to the observer. The concept of affordances, in Gibson's formulation, locates meaning in the environment (though note that this does not entail that meaning is independent of the features or the activities of the organism; see Segundo-Ortin et al., 2019). This theoretical move led to a productive empirical program. Rather than worrying about what is going on inside the organism, ecological psychologists are free to investigate the animal-environment relation by identifying repeatable structures and activities that occur in everyday life and seeking to understand the dynamics at play within those activities. The essence of the ecological empirical strategy is to study a

highly constrained *task*, i.e., a repeated pattern of behavior that can be characterized in precise mathematical terms—things like steering a vehicle around an obstacle or bouncing a ball on a bat (see Warren, 2006). Ecological explanation, in short, is *task-oriented*.

Enactivists, meanwhile, are suspicious of task-oriented explanations. More precisely, enactivists feel that task-oriented explanations only capture behavior in an incomplete manner. Their concern is that such explanations seem to deny the agency of the actor. Enactivists prefer to think of meaning as an achievement of the actor (Varela et al., 1991, Thompson, 2007, Thompson and Stapleton, 2009). Enactivists seek an explanation of why a particular goal-directed activity comes about in the first place. As Di Paolo et al. (2017, p. 27) put it, enactivism “is concerned with explaining precisely [the] critical transitions between particular conditions that sometimes afford different functional descriptions and those ‘in-between’ dynamics that (re)constitute these or novel conditions” (for a more detailed discussion of this difference in explanatory strategy, see Baggs, 2018).

The approach to skill learning that we have been outlining in this paper is undeniably in the task-oriented tradition, in the sense just identified. We have suggested that skills should be understood in terms of enabling constraints, but enabling constraints can be understood as constraints only relative to a goal. By invoking enabling constraints, we are already presupposing that the actor is engaging in some goal-directed activity, for example, that the actor is already *trying* to stand upright or to get around her environment. We are not explaining, as the enactivists wish to explain, *why* it is that this particular actor is even trying to stand upright right now, in this particular context—i.e., why did this goal arise in the first place?

Researchers within the ecological and enactive approaches, it seems, are pursuing two quite different projects. Is this a fatal problem for the prospect of an enactive-ecological rapprochement? Possibly. But we would like to suggest that it need not be. The key here is that the task-oriented mode of explanation in ecological psychology can be interpreted as a methodological strategy rather than as an ontological framework. To talk of tasks and constraints is not necessarily to reify those tasks and constraints (that is, it need not be the case that the actor herself sees the world in terms of tasks). Rather, a task-oriented approach can be seen as merely a useful methodological tool for empirically getting to grips with at least some subset of the behaviors that actors engage in (specifically, it allows us to empirically investigate just those activities that are susceptible to a characterization in terms of optimization relative to some perceptual variable. Activities that cannot be so characterized fall outside the scope of present-day ecological explanation).

Enactivists have long emphasized the need to understand the animal system in terms of its developmental history. A central notion in enactivism is that of *structural coupling*, which was defined by Maturana and Varela (1987, p. 75) as follows: “We speak of structural coupling whenever there is a history of recurrent interactions leading to the structural congruence between two (or more) systems.” An example of such a history

of interaction is the co-evolution of automobiles and cities: for example, the more people rely on cars to get around, the more the city develops on the model of urban sprawl (Maturana and Varela 1987, p. 99). In terms of the learning organism, change over time is understood as a “structural drift” (bodily change) that occurs as the organism continually maintains the conditions for its own viability (Maturana and Varela 1987, p. 170).

This understanding of learning has been substantially developed by Di Paolo et al. (2017, p. 152), who (as mentioned earlier) propose that learning should be understood as the construction and maintenance of a network of sensorimotor schemes. These schemes should be understood, they note, not as something that is confined to the body of the individual actor (like a set of motor algorithms), but as spanning the animal–environment system: “it is important to stress that sensorimotor schemes, and networks of these, constitutively involve both the organic body and its environment.” But, again, the maintenance of the network is understood in terms of the organism’s maintaining the conditions for its own viability. Specifically, Di Paolo and colleagues propose to adopt a version of Piaget’s theory of equilibration, which conceives the learner as repeatedly attaining new stable forms of organization by repeatedly engaging with the environment (Di Paolo et al., 2017, p. 85).

One way to contrast the way that learning is understood in the ecological and enactive approaches is to say that for enactivists, learning is understood as a process of construction and self-maintenance, while for ecological psychologists learning is a process of attunement. On the enactivist perspective, the things the animal learns to do are constructed by the animal. In Maturana and Varela’s early work, this construction process has no inherent direction, but is understood simply a process of “structural drift.” In the formulation of Di Paolo et al. (2017) there is a direction to the process and the direction arises from a dialectical confrontation between newly encountered worldly structures and the organism’s existing structure: equilibration is what happens when the organism successfully re-organizes itself so as to incorporate an appropriate response to the newly encountered structure. For ecological psychologists, by contrast, learning cannot be understood as a process of construction at all. Learning must be understood instead as being directed toward specific structures that already exist in the environment. This is most clear in Jacobs and Michaels (2007) proposal that there exists “information for learning,” i.e., information that is available in ambient energy which the learner is in principle able to detect. By detecting this information, the learner discovers in which direction to adjust its activity in order to optimize its performance relative to some task goal (see also Raja, 2019, p. 337). On this account, then, the “end point” of learning already exists at the beginning of the process, in a sense.

On the face of it, it would appear that a comprehensive embodied theory of learning will need to synthesize both of these perspectives. To appeal only to a process of individual equilibration or sense-making seems insufficient: if learning is all just about incorporating novel structures into our body schema, then why is it then we end up behaving in such

remarkably similar ways to one another? Why, for instance, do we end up speaking basically the same language as those around us? Or consider the question of why infants bother to transition from crawling to walking (Adolph et al., 2012). Why do not some of us simply carry on crawling? The direction that exists within learning seems to come, in at least some sense, from the learner’s seeking out of more effective ways of doing things that already exist as possibilities in the environment: walking would seem to already exist as a possibility that the toddler can strive toward, and not merely as a perturbation that has to be incorporated into the existing system. On the other hand, if we can only learn to perform actions that already exist as possibilities in the structure of the environment in some sense, then how do we ever come to do anything inventive, like coming up with new cooking recipes or telling jokes?

Once we understand skill learning as an extended phenomenon, as we have advocated above, it becomes possible to see how an ecological–enactive synthesis might be pursued. What is needed is an account that recognizes *both* the autonomously generated exploratory behavior of the organism *and* the pre-existing structure of the environment toward which that exploratory behavior is directed.

A view of the learner’s exploratory behavior as being directed at a structured environment is already central to Eleanor J. Gibson’s ecological approach to learning and development (Gibson, 1988; Adolph, 2019). This is well expressed in a paragraph from a recent paper (Adolph, 2019):

“Eleanor Gibson ... said that watching children on a playground is a revelation of attention to affordances. Children swoosh down, climb up, and hide under the chute of the slide. They swing on the monkey bars, hang by their knees, and balance upright on the rungs. Any small object presents a compelling opportunity for infant exploration with hands, eyes, and mouth. Infants carry objects to share with their caregivers, to place in different locations, and for no discernible reason except their apparent delight in carrying things that afford carrying... Even in a seemingly empty room, infants find things to do. They poke their fingers into indents in the floor, pick up tiny crumbs from the carpet, and use any small protuberance to try to climb the walls.”

An extended account of skill learning must begin with an understanding of exploratory behavior and play as situated in an environment that already has structure.

Ultimately, the reason that it is important to clarify what we mean by skills is that the notion of skill is central to an ecological–enactive theory of learning. If we are going to give skills a central position in our theorizing, then we ought to develop an explicit theory of learning too. The notion of enabling constraints can potentially provide a valuable tool in this project. For historical reasons, learning has been marginalized in embodied theory. It is time to put learning back into the heart of things. Giving learning a central position in radical embodied cognitive science is, we contend, the most promising

strategy for unifying the ecological and enactive approaches. The payoff of this theoretical effort is potentially a much more powerful approach to embodied cognitive science in general.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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Defining the Environment in Organism–Environment Systems

Amanda Corris*

Department of Philosophy, University of Cincinnati, Cincinnati, OH, United States

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Peter J. Marshall,
Temple University, United States

*Correspondence:

Amanda Corris
corrisab@mail.uc.edu

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Enactivism and ecological psychology converge on the relevance of the environment in understanding perception and action. On both views, perceiving organisms are not merely passive receivers of environmental stimuli, but rather form a dynamic relationship with their environments in such a way that shapes how they interact with the world. In this paper, I suggest that while enactivism and ecological psychology enjoy a shared specification of the environment as the cognitive domain, on both accounts, the structure of the environment, itself, is unspecified beyond that of contingent relations with the species-typical sensorimotor capacities of perceiving organisms. This lack of specification creates a considerable gap in theory regarding the organization of organisms as coupled with their environments. I argue that this gap can be filled by drawing from resources in developmental systems theory, namely, specifying the environmental state-space as a developmental niche that shapes and is shaped by individual organisms over developmental and, on a population scale, evolutionary time. Defining the environment as an organism's developmental niche makes it clearer how and why certain contingencies have arisen, in turn, strengthening a joint appeal to both enactivism and ecological psychology as theories asserting complementarity between organisms and their environments.

Keywords: enactivism, ecological psychology, developmental systems theory, developmental niche, naturalization of perception

INTRODUCTION

Enactivism and ecological psychology converge on the relevance of the environment in understanding perception and action. On both views, perceiving organisms are not merely passive receivers of environmental stimuli, but rather form a dynamic relationship with their environments in such a way that shapes how they interact with the world. Much of the attention in the shared literature between enactivism and ecological psychology has focused on the cognitive capacities of a perceiving organism in relation to its environment; less attention has been given to the environmental setting as a state-space, which is context-sensitive and organism-specific. As the environment plays a defining role in the sort of interactions that are possible for perceivers, specifying the structure of the environment for a species, or even a particular organism, can shed light on the nature of perception. The aim of this paper is to draw out similarities between enactivism and ecological psychology by specifying the structure of an organism's particular environmental setting in such a way that illustrates how that structure partly organizes the organism–environment system and thus what features are perceptually relevant. A detailed account of the environment on an enactivism–ecological psychology framework can, in turn, provide

guidance for a naturalized theory of perception. I suggest that viewing a perceiver's environment as a developmental niche specifies the environment in an organism–environment system at the scale of the individual, thus providing a way of talking about how individual variation in perceptual abilities and traits can have an impact across developmental, behavioral, and evolutionary timescales.

In 'Enacting a World' I detail the ways in which the environment is discussed within the enactive literature. 'Perceiving Environmental Information' provides an overview of the concepts used within ecological psychology to describe the environment as guiding perception and action. In 'Specifying the Cognitive Domain' I suggest that specifying an organism's cognitive domain as its developmental niche, as an integral part of a larger developmental system, can serve as a way of understanding organism–environment interaction as it is discussed in both the enactive and the ecological psychology literature. This conception of the environment, which draws on resources from the developmental systems theory (DST) can be built into a shared enactive-ecological psychology framework for an appropriately naturalized account of perception.

ENACTING A WORLD

Enactive approaches to cognition share a commitment to a principle of dynamic coupling between organisms and their environments, with action being fundamentally guided by perception. Though emergent varieties of enactivism may differ in their philosophical aims (Ward et al., 2017), they each view the organism–environment relation as central to understanding the phenomenon of cognition. Additionally, they share a general commitment to rejecting computationalist, representationalist conceptions of cognition that posit it as a form of processing via symbol manipulation. For enactivists, a suitable explanation of cognition requires viewing it as a global process occurring as a result of dynamic interaction across multiple scales of organismal organization (with emphasis on the bodily scale, see also Chemero, 2009 for similar views) and the environmental state-space, rather than locally, as a matter of neural mechanisms.

On the conception of the enactive approach detailed in *The Embodied Mind* (Varela et al., 1991, see also Thompson, 2004), cognition emerges as a result of coupled interactions between organisms as autonomous systems and their environmental milieu. This relation is actualized through interactions between the organism via its sensorimotor capacities and the environmental features to which it is sensitive. Notably, not all environmental features play a constitutive role in an organism's environmental milieu. The sensorimotor structure of the organism constrains which features are perceivable and thus actionable. Therefore, an organism's embodiment plays a central role in constituting cognition, as "cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities" (Varela et al., 1991, 173). Humans lack the capacity to perceive ultraviolet light, and so ultraviolet light cannot modulate action for human perceivers. Honeybees, which enjoy the

capacity to perceive ultraviolet light, regularly treat it as an action-guiding visual cue.

While humans and honeybees both share the same physical world, their perceived worlds drastically differ due to their variation in sensorimotor capacities. Thus, an organism *enacts* a perceived world depending on its sensorimotor capacities. As Varela et al. (1991) stress, "perception is not simply embedded within and constrained by the surrounding world; it also contributes to the enactment of this surrounding world" (174). Drawing on similar claims by Merleau-Ponty, they describe the organism as both initiating and shaping its environment, with both systems being "bound together in reciprocal specification and selection" (174). While an organism's sensorimotor structure determines which environmental features are salient in its perceived world, the actual enactment of such a world is possible through the distinctive organization of organisms as living systems.

The Organization of Living Systems

Early enactive work (Varela et al., 1974; Maturana and Varela, 1987) provided the foundation for understanding the organization of living beings. On this view, a defining feature of living beings is that they are continually self-producing—they are structured such that they are able to maintain themselves as a unit over time. This feature is referred to as *autopoiesis* (from Greek *auto-*, self, and *poiesis*, production). Autopoietic systems are specified as networks of processes with certain enabling relations. If these relations fail to hold, the system will necessarily disintegrate (Varela et al., 1974). The canonical example in this body of work is the cell. A cell can be conceived of as autopoietic system due to the way in which its internal processes enable the system to persist:

It is a network of chemical reactions which produce molecules such that (i) through their interactions generate and participate recursively in the same network of reactions which produced them, and (ii) realize the cell as a material entity. Thus the cell as a physical unity, topographically and operationally separable from the background, remains as such only insofar as this organization is continuously realized under permanent turnover of matter, regardless of its changes in form and specificity of its constitutive chemical reactions (Varela et al., 1974, 188).

Here, the environment is specified as merely the background in which the physical unity that is the cell is contrasted. The cell, as an autopoietic system, is "operationally separable" in that it undergoes a particular set of reactions that effectively forms an operationally closed network. Additionally, the cell's membrane constitutes a boundary that distinguishes it as an entity from its environmental setting. In this context, autopoiesis captures metabolic self-production—it specifies the type of chemical reactions necessary for a living entity to maintain itself over time. For Maturana and Varela (1987), metabolic processes are central to a conceptualization of life, as they constitute the "dynamic transformations" that enable a living system to persist (Maturana and Varela, 1987, 46) and, as a result, form a membrane that serves as a spatial boundary for an individual cell.

The same organizational pattern can generally be found at the scale of larger organisms such as animals. Although these organisms may vary in structural form, they are organized in the same self-producing manner, in that they are “internally self-constructive in such a way as to regulate actively their interactions with their environments” (Thompson and Stapleton, 2009, 24). In other words, organisms are endowed with the ability to maintain their internal dynamics through self-regulation. An artifact of this organizational property is that it specifies an environmental state-space as well, described as the features that are operationally external to the organism’s self-regulatory capacities such that they are not necessary for the operational closure of the organism as a living system, though they may be necessary for its persisting over time.

Thus, a distinction can be drawn between two co-acting, yet organizationally distinguishable, systems. This property of the organism is referred to as its *autonomy* because it specifies the organism as a system that is “composed of processes that generate and sustain that system as a unity” (24). Because the internal, self-regulatory dynamics of the autonomous system are necessary for its persisting as a unity, it can be said to be operationally closed in the same manner that cells are. Importantly, as Thompson and Stapleton point out, “operational closure does not imply that conditions not belonging to the system cannot also be necessary” (24). Living systems are thermodynamically open, such that they undergo processes to regulate the flow of energy both between them (from the environment into the system) and within them (as regulatory processes internal to the system).

The properties of autonomy and operational closure can, in certain contexts, define a spatial boundary to a system as well. It is important to note that autonomous systems are not necessarily autopoietic systems because autonomous systems do not need to be spatially bound for their self-regulation. Thompson and Stapleton offer the example of a human or non-human animal social group as an autonomous system that is not spatially bound and therefore not autopoietic. As Froese et al. (2007) note:

It is generally claimed that autonomy in living systems is a feature of self-production or autopoiesis. However, this restriction of autonomy to living systems is unsatisfactory because we also want to refer to some systems as autonomous even though they are not characterized by metabolic self-production, for example artificial and social systems (Froese et al., 2007, 5; Luisi, 2003).

Further enactive work thus aims at a taxonomy of systems where autopoietic systems are members of a broader class of autonomous systems (Froese et al., 2007). Given Maturana and Varela’s (1987) specification of metabolic processes as those responsible for the dynamic transformation of components within the cell as a living system, drawing a distinction between types of structural arrangements that result in the same type of network can be helpful, namely, in the case of understanding social cognition as arising from interactions between two or more distinct systems.

Specifying an Environment

According to the enactive approach to cognition, living systems are autonomous systems that are structured by their

own internal, operationally closed regulatory dynamics as well as their thermodynamically open regulatory dynamics with the environment. Organisms engage in energy transfer from environment, but they do not do so entirely passively. Environmental features have a degree of valence for individual organisms. For a honeybee, the ultraviolet color pattern found in the center of a flower indicates a potential pollen location; for humans, the redness of a tomato indicates it is ready to be harvested and eaten. Organisms do not engage in passive reception of sensory stimuli but in positively or negatively valenced interactions with the environment. On an enactive view, this process is referred to as sense-making; it is “behavior or conduct in relation to environmental significance or valence, which the organism itself enacts or brings forth on the basis of its autonomy” (Thompson and Stapleton, 2009, 25; see also Thompson, 2007, Chapter 6; De Jaegher and Di Paolo, 2007). Sense-making, then, is a way of relating to the world and responding to environmental stimuli for the sake of enabling further actions and viability.

The enactive notion of structural coupling captures how organisms relate to their environments. Specifically, coupled systems, such as the honeybee and the flowering plants in its ecological niche, structurally codetermine one another as a result of their reciprocal interactions over time. Varela’s “Bittorio” model was originally conceived to illustrate how such structures co-emerge, though Barandiaran (2017) notes some theoretical difficulties with the model and offers a set of models illustrating the sensorimotor constitution of neurodynamic patterns as a more robust example of how autonomous systems are structurally coupled. On Barandiaran’s account, Bittorio is problematic as an example of structural coupling due to the fact that environmental features are both random and held static. Barandiaran suggests that this is an insufficient characterization of the environment on an enactive framework. An organism’s environmental state-space is not merely a random setting but is constituted by features corresponding to its sensorimotor capacities, and crucially to the enactive approach, organisms are not passive receivers of environmental stimuli but are coupled with the environment in such a way that impacts the structure of the environment. The conceptualization of the environmental state-space in the Bittorio model seems to conflict with one of the key tenets of the enactive approach, namely, that dynamic interactions with the environment shapes which features will affect the system; the environment cannot merely be conceived of as an independent producer of stimuli.

Using Varela’s example of bacteria swimming up a sucrose gradient (Varela, 1991, 1997), Di Paolo (2005) suggests that merely describing the system as autopoietic is not enough to explain the dynamic coupling between the bacteria and the sucrose environment and the interactions between the two systems. More is needed that explains “graded notions such as lacks and breakdowns and articulates in detail how signification is generated” (Di Paolo, 2005, 437). It is not merely the case that the bacteria constitute autopoietic systems, while the sucrose gradient constitutes the environmental state-space. The sucrose has a degree of valence for the bacteria, as suggested by the concept of sense-making. It invites further activity as specifically

an action that is dependent upon on the internal state of the bacteria at that particular time. Therefore, there is some further aspect to the coupled system that generates a particular action on behalf of the bacteria:

As defined, structural coupling is a conservative, not an improving process; it admits no possible gradation. If the concentration is enough to keep bacteria viable the latter should be equally – not more – viable in a range of higher concentrations. Even if the current rate of nutrient intake is lower than the rate of consumption (leading to certain loss of autopoiesis in the near future), bacteria will not seek higher concentrations just because they are autopoietic since improving the conditions of self-production is not part of the definition of autopoiesis. Only if they are able to monitor and regulate their internal processes so that they can generate the necessary responses anticipating internal tendencies will they also be able to appreciate graded differences between otherwise equally viable states (Di Paolo, 2005, 437).

Di Paolo introduces the concept of *adaptivity* in order to specify how autopoietic systems maintain homeostasis in the face of environmental perturbations and despite existing far from thermodynamic equilibrium. This aspect of autopoietic systems necessitates that they act in accordance with graded norms of vitality and viability—bacteria generate appropriate responses to the presence of a sugar gradient depending upon the state of their internal processes. This necessitates that environmental features have a particular valence depending upon the internal state of the organism and assuming that the organism has some capacity to engage with the world in such a way that deals with negatively valenced conditions such as lacks and breakdowns (see also Weber and Varela, 2002).

Thus, the environment is specified as a source of both perturbations and assistances according to graded norms, to which the organism can respond provided it both has the sensorimotor capacities to do so and those features have a particular valence that corresponds to an organism's processes of internal regulation. The enactive concepts of sense-making and adaptivity help to flesh out how organisms, as autopoietic systems, respond to particular features of the environment in the ways that they do.

While this approach helps to specify the environment as a state-space populated by elements that correspond to graded norms relative to particular organisms, there remains the question of what processes are responsible for the coupling of these coupled systems. It is clear that the environmental “information” indicating pollen is in some way coupled with the honeybee's capacity for sensing that information. However, this suggests something of a synchronic view of dynamically coupled systems—it tells us why an organism may be acting in a certain manner at a certain time. The environment is here specified as an organism's cognitive domain, but the structure of the environment, itself, is unspecified beyond that of contingent relations with the sensorimotor capacities of individual organisms. Cognition is undoubtedly more complex of a phenomenon than individual instances of perception and action, and so in order to serve as a rich theory of cognition, enactivism, I want to suggest, requires a further fleshing out of the processes relevant to the generation of coupling between systems.

In other words, I hold that it is worth investigating the features of the structure of organisms as cognizing systems and the system that makes up their environmental state-space. This task requires looking at the diachronic relations between organisms and their dynamic niches, which will be the focus of the Specifying the Cognitive Domain section.

It is worth noting that early works in the enactive approach, namely, *The Tree of Knowledge* (Maturana and Varela, 1987), did, indeed, give treatment to these biological questions, suggesting that a history of interactions between systems can result in structural selection acting upon those systems, which, in turn, gives way to a particular determination of structure for each system. This evolutionary-scale claim appears in *The Embodied Mind* in the form of “evolutionary path-making,” and is again addressed in *Mind in Life*, under the concept of “enactive evolution.” These arguments are undoubtedly valuable in that they weave additional biological considerations into an enactive account of cognition, thus resulting in a naturalized approach to cognition. However, more recent work in enactivist thinking has, for the most part, put aside these biological considerations, despite the fact that recent developments in evolutionary and developmental biology (Griffiths and Gray, 2001; Stotz, 2014) have potentially useful resources to contribute to the discussion. Therefore, drawing attention to this dimension of enactivist thinking and expanding upon that work can be a fruitful task to take on.

An enactive view of cognition treats it as a phenomenon spanning a range of timescales, from those as short as only a few milliseconds (the domain of neurophysiology) all the way up to an evolutionary timescale (Varela, 1999; Gallagher, 2017). At each scale, the emphasis on dynamic coupling between processes within the larger organism–environment system remains crucial; the enactive treatment of cells, nervous systems, and organisms as each constituting an autonomous system both situated in, and specified by, a particular environmental context illustrates how the approach is applied at various spatiotemporal scales. What remains constant is the dual-system organization; the autonomous system is always specified in the context of an environmental setting. The environment, therefore, can refer to any state-space in which an autonomous system persists. A parasite's environmental setting is its host; a cell's environmental setting is a molecular background. At the scale of the individual organism, namely, for medium-sized animals typically under investigation in the study of perception and cognition, the environmental setting is specified as its ecological niche. The environment is the appropriate cognitive domain for an organism, a feature of the enactive approach that ecological psychology shares.

PERCEIVING ENVIRONMENTAL INFORMATION

In contrast to commonplace views of perception that describe it as a process of inferring information from environmental stimuli, ecological views of perception treat it as a means of directly picking up information from the environment.

James Gibson's work, which serves as a canonical approach to ecological psychology, emphasized the direct perception of environmental information. On Gibson's view, there is no intermediary task for the brain to accomplish in perceiving environmental information, and so there is no need to cognitively represent that information in order to make sense of it. Gibsonian ecological psychology is thus a non-representational account of perception, as is the case with the enactive approach.

Affordances as Revealed Information in the Environment

On Gibson's approach, percepts are not representations of objects in the world, but instead are features of the environment itself. These environment percepts are directly sensed by organisms, depending upon their sensorimotor capacities. They inform organisms as to what actions are possible—in other words, what actions are afforded to the organism. Thus, Gibson termed these environmental percepts as *affordances*. Affordances make direct reference to what is physiologically possible for an organism. For the honeybee, the pollen-rich flower affords landing on, the pollen affords collecting, and so on—whatever is afforded to an organism is something that it perceives and can act upon accordingly. Affordances can therefore be thought of as action-guiding cues from the environment (Stoffregen, 2003).

This conceptualization of the environment should sound relatively similar to that put forth by the enactive approach. There is a key distinction to be made. However, Gibsonian ecological psychology suggests that organisms directly perceive information from the environment, making it the case that such information is built into the structure of the environment itself. In *The Embodied Mind*, Varela et al. (1991) assert that the enactive view does not share this conceptualization of the environment, in that they do not hold that perceptual information is “out there” as a static feature of the environment. Rather, on the enactive view, perceptual information is constructed via the structural coupling between organisms and their environments. Thus, there is an important ontological distinction between the two views. For Gibson, affordances exist independently from perceivers who may (or may not) act on them, whereas for enactivists, perceptual information in the environment is effectively “enacted” via sensorimotor engagement with the world. Varela et al. (1991) clarify that “[w]hereas Gibson claims that perception is direct detection, we claim that it is sensorimotor enactment” (Varela et al., 1991, 204). While Gibson did state that affordances are neither objective properties of the environment nor subjective properties of the perceiver but rather somewhere in between (Gibson, 1979), his is not a constructivist view, as affordances are not in essence created in the interaction between perceiver and environmental stimuli but rather are specified as features acted upon in a relevant manner.

According to Gibson, it is possible for perceiving organisms to “pick up” affordances as visual information due to the way in which the pattern of light reaches a perceiver's eyes. A setting is visually accessible when ambient light creates a particular structure depending on the position of the perceiver. For example, if you are sitting on a garden bench surrounded by trees and a garden table, the angles at which the light from

the sun hits these objects will illuminate the setting allowing you to visually perceive your surroundings. Gibson describes this particular kind of visual arrangement as the *ambient optic array*. The geometric structure of this setting is dependent upon the position of the perceiver—the angles at which the light hits the perceiver's retina will change as the perceiver moves around in the environmental setting. Through movement, an important feature of the optic array is revealed—some features change, such as the particular angles relative to the light source and the perceiver's location, but some features are invariant. Thus, invariant structure is revealed through movement, in addition to variant structure:

In the optic array, presumably, there is an underlying invariant structure to specify the edges and corners of the layout and the colors of the surfaces, and at the same time there is a changing structure to specify the temporary direction of the prevailing illumination. Some components of the array never exchange places – that is, they are never permuted – whereas other components of the array do. The former specify a solid surface; the latter specify insubstantial shadows only (Gibson, 1979, 89).

The invariant structure of the garden table, for example, is revealed through movement relative to the ambient optic array, and it is this information that can then be acted upon by the perceiver. The ambient array provides structure to the environmental setting in such a way that, in turn, provides visual access to features of that environment.

Naturalizing Perception and the Problem of Specifying Variables

Gibson's account of perception appears, at least at first glance, firmly naturalistic, relying upon optics as the means by which we establish perceptual contact with the world, rather than an inferential process dependent upon the construction of a conceptually imprecise notion of representation. Indeed, as Withagen and Chemero (2009) note, Gibson's approach was an important contribution to the naturalization of perception. Conceiving of perception as a biological function invited discussion of how organisms endowed with a perceptual apparatus made use of the information available to them via that apparatus as well as how they came to be endowed with such—in other words, how and why they evolved the capacity for visual perception. Yet while Gibson's ecological approach provided a way of talking about perception in a naturalized manner, Withagen and Chemero (2009) suggest that further developments by neo-Gibsonians introduced new problems.

Neo-Gibsonians (Shaw and Kinsella-Shaw, 1988; Turvey, 1990) elaborated on Gibson's claim that perceptual information in an environment is specified by the structure of that environment. Their work details a specificity relation between the perceptual information and the environmental feature, and a further specificity relation between the organism's perceptual experience and the perceptual information, making perception “specific to information that is specific to a particular environmental property” (Withagen and Chemero, 2009, 368). On the neo-Gibsonian view, then, there is a one-to-one-to-one mapping between the environment, the perceptual information in the environment, and the perceptual activity. The environment

provides the structure for perceptual information to be accessible, and the perceiver is then able to pick up this information through their locomotive behavior in the environmental setting.

While Withagen and Chemero (2009) note that the lawlike generality described by this mapping relation is appealing, especially for a naturalistic framework, empirical concerns arise. They stress that “the one-to-one-to-one theory assumes an absence of variation in what information is exploited both between animals and within animals over time . . . In other words, all members of a species use the same information in their perception of a particular environmental property” (369). They question whether such a theory is plausible on a naturalistic approach to perception—that is, on one that treats perception as a biological phenomenon that is subject to evolutionary pressures over time. Given evolutionary considerations, they hold that the one-to-one-to-one theory is implausible: the two specificity relations fail to hold empirically under biological scrutiny.

The specificity relation between perception and environmental information suggests that members of the same species, perceptually endowed in the same manner, make use of the same environmental information in their perceptual activity. On this perspective, all honeybees treat UV light as an action-guiding visual cue, while all humans do not. However, Withagen and Chemero (2009) note that this claim is inconsistent with the biological concept of variation. Variation is necessary for evolution to occur, so in any species subject to evolutionary change, variation must be present in order for it to then be acted upon by selection. Suggesting that perceptual information is specified in an exact manner relative to a perceiving population leaves no room for variation, thus making the theory biologically untenable. Individual differences in various traits, including perceptual abilities, must be possible, making it the case that a specificity relation between a specific variable as environmental information and a perceiver is too strict.

Indeed, differences in perceptual abilities only mark one way in which individual variation may influence relations between environmental information and perception of that information. Other psychological and physiological qualities can have a relevant impact on perception-action dynamics as well. Salient examples can be found in Dennis Proffitt's work on embodied perception: Proffitt (2006) found that distances to targets appeared greater to participants when they were tasked with carrying a heavy backpack. Thus, as Proffitt explains, physiological potential can have a profound impact on perception. This quality not only varies between individuals but there can also be significant within-individual variation.

Differences that arise as a result of perceptual learning help to illustrate the tension in the neo-Gibsonian view. Withagen and Chemero (2009) cite numerous studies that show how perceivers can learn to exploit new perceptual information, and additional research found significant between-subject variation in perceptual learning ability (Withagen and van Wermeskerken, 2009). They assert that this work shows how human perceivers.

Vary in how well and quickly they can learn a perceptual task, implying variation in what information is exploited at any moment in time. Hence, the ubiquitous variation among the

members of a species that proponents of Darwin's population thinking emphasize . . . is also present in the perceptual realm. This means that population thinking needs to be taken seriously in the study of perception. In other words, the suggested specificity relation between information and perception and the allied search for the information that members of a species exploit in a particular perceptual task are biologically unsound (Withagen and Chemero, 2009, 374).

A one-to-one mapping between environmental information as a specific variable and the perception of that information is therefore problematic on a biological basis. Individuals learn how to differentiate between variables in the environment, making it the case that through learning they can act on information that they previously did not make perceptual contact with. In addition, individuals vary in their perceptual abilities (color vision deficiencies are a simple and common example), so mapping species-typical perceptual abilities onto specific environmental variables may result in biological inconsistencies. For a naturalized theory of perception, biological inconsistencies are severely problematic.

With regard to non-human perceivers, similar results have been found. The perceptual learning capacities of insects are commonly studied, namely, in terms of color vision. In many of these studies, insects are found to possess the ability to make visual discriminations after undergoing learning tasks, illustrating the effect of individual experience and learning on visually guided action. Honeybees, for example, are trichromatic, with the capacity for visual discrimination in color space. Avarguès-Weber et al. (2010) found that free-flying honeybees were able to make more fine-grained color distinctions after aversion training, showing how individual differences and learning experiences can change what perceptual information they interact with. The one-to-one mapping between specified values in a color space and perceptual activity suggested by the neo-Gibsonian approach fails to hold in these cases, as perceptual learning opens up the possibility for interacting with new perceptual information in a non-species-typical manner. These individual differences are important on an evolutionary account in terms of looking at possible mechanisms for, in this instance, the evolution of color vision as movement through color space via novel perceptual abilities.

While Gibsonian ecological psychology provides a naturalized approach to perception that is suitable for understanding perception as an evolved capacity, I am in agreement with Withagen and Chemero (2009) that “a naturalistic theory of perception must explain the individual differences in what information is exploited in terms of the interplay of multiple organismal and environmental factors” (379). For this reason, a neo-Gibsonian reading may prove inadequate, and there is a task for researchers working in the Gibsonian tradition to address these biological concerns if the theory is to prevail as a naturalistic approach. Describing environmental, perceptual information as specified variables fails to account for individual differences in perceptual ability, especially due to learning and experience.

Looking beyond the scale of species-typical perceptual ability and instead considering the individual perceiver's relation to its environmental setting requires, in turn, looking at

individual-specific environmental settings. Often an individual organism is represented as an idealized member of its species, and given research constraints, necessarily so. However, such limitations should not stop researchers from looking more closely, and more carefully, at what constitutes an individual's environmental milieu for the sake of understanding how an idealized individual might relate to that setting. Indeed, as stressed in this section, looking at potential ways in which individual differences may bring about evolutionary change is necessary for understanding biological diversity, and in thinking about perception as a biological phenomenon.

In the next section, I suggest a way forward for how to specify an individual's cognitive domain for the sake of understanding how environmental information co-varies with perceptual abilities. This approach respects the goal of naturalization of perception as found in Gibsonian ecological psychology, while at the same clarifying the notion of an "enacted" world central to the enactive approach to perception and cognition (see also McGann, 2014 for a complementary approach). In particular, I suggest that it is helpful to think of an individual organism's cognitive domain as mapping onto its developmental niche, which is the environment in which it undergoes its life cycle. This specification, I argue, provides a way of thinking about the environment in organism-environment systems that is complementary to both enactivism and ecological psychology, while at the same time addressing some of the ambiguities that arise in both fields' use of the environmental setting as a key part of understanding cognition, action, and perception.

SPECIFYING THE COGNITIVE DOMAIN

I am not using the term "cognitive domain" in any specific technical sense; it is simply meant to refer to an organism-specific environmental state-space in which cognitive activity takes place. We can think of a bee's cognitive domain, for example, as the environmental state-space containing whatever is potentially perceivable and actionable by the bee. Whatever those elements are will depend upon the bee's sensorimotor capacities. On an enactive reading, the bee's enacted world is its cognitive domain, in virtue of its autopoietic, adaptive configuration. According to ecological psychology, the bee's cognitive domain is populated by affordances, with certain affordances acted upon according to the bee's perceptual activity¹.

Determining what elements populate an organism's cognitive domain requires careful investigation of its sensorimotor capacities and its coupled history with its environment (the details of which matter will be addressed in the Developmental Niche section). For example, eyes are ubiquitous throughout the natural world. Yet even in locations where vision is seemingly

no longer worth investing resources in, such as in subterranean habitats, eye structures, though reduced, persist (Nevo, 1979; Nikitina et al., 2004). Normal development for the naked mole rat (*Heterocephalus glaber*), for example, results in a reduced eye structure, but an ocular phenotype nevertheless. Researchers have asked why this trait still develops despite at least 25 million years of subterranean evolutionary pressures (Bennett and Faulkes, 2000; Nikitina et al., 2004). Just like any organ, eyes have metabolic costs, and so individuals who direct those resources elsewhere may be better off. Nikitina et al. (2004) suggest, however, that a closer inspection of the environmental stimuli and the mole rats' regular activities can provide clues as to why the phenotype has not been completely selected against:

... Retaining the capacity for light-dark discrimination is important for the survival of these animals. The soil-removal activity of the naked mole rats results in their direct exposure to sunlight, as the animals kick soil out of an open mound. The open mound poses a further threat of exposure to aboveground predators (Sherman et al., 1991). An ability to detect light and dark and sudden transitions associated with the arrival of a predator at a well-lit burrow entrance may confer a survival advantage and hence be maintained by natural selection (Nikitina et al., 2004, 331).

While the species-typical habitat of the naked mole rat is categorized as being distinctly subterranean, brief instances of direct exposure to sunlight is enough to serve as an environmental pressure necessitating the retaining of an eye structure. The payoff of these reduced eye structures is a discounted metabolic cost along with a sufficient capacity for light-dark discrimination. These findings support an account of perception that stresses how perception is actually used—while there are no scientific findings that suggest that the mole rats use visual information in the way animals with fully developed eyes typically do, their eyes still pick up environmental information—specifically, transitions in brightness. They may not be able to "establish perceptual contact" with objects in the world (including conspecifics, which they identify through olfactory and tactile cues) (Nikitina et al., 2004, 331), but in a sense, light still affords them seeing, albeit an unconventional mode of seeing.

This example is meant to show how careful investigation of the specifics of the relationship between perceiving organisms and their environments matters to how we think about perception and action. The mole rats' habitat is not merely a subterranean one, and the particular way they interact with that environment, even if in brief moments, can end up impacting their evolutionary trajectory. As we saw, occasional surfacing in the activity of burrow building has generated enough selective pressure to retain minimal eye structures. It may not be a conventional way of using eyes, but it works for the mole rats.

Persisting both at the developmental and at the evolutionary scale is often a matter of getting by on what works rather than maximizing potential. Indeed, Varela et al. (1991) note this biological fact in their reference to evolution as natural drift, stating a call for recasting selective pressures as "broad constraints to be satisfied" (Varela et al., 1991, 198). They refer to this satisficing principle in describing the enactive notion

¹I am aware that there may be a tension here, as affordances are typically understood as existing independently from a perceiver, and on this account, it seems as though only organism-specific affordances populate its cognitive domain. One way to ease this tension might be to suggest that the specification of a cognitive domain is meant to serve as a heuristic tool. In other words, specifying an organism's cognitive domain can be helpful in determining what might be cognitively relevant to it, but it does not have to entail that the organism is limited to perceiving only those elements.

of mutual specification, or the Lewontin-inspired notion of codetermination (Lewontin, 1983):

The key point, then, is that the species brings forth and specifies its own domain of problems to be solved by satisfying; this domain does not exist “out there” in an environment that acts as a landing pad for organisms that somehow drop or parachute into the world. Instead, living beings and their environments stand in relation to each other through *mutual specification* or *codetermination*. Thus what we describe as environmental regularities are not external features that have been internalized, as representationism and adaptationism both assume. Environmental regularities are the result of a conjoint history, a congruence that unfolds from a long history of codetermination. In Lewontin’s words, the organism is both the subject and the object of evolution (198–199, original italics).

This coupled history matters, particularly in instances where interacting features are both organisms. Pollinators and angiosperms are typically thought to have a mutualistic relationship, with one organism relying upon the other for its survival and reproductive needs. However, an established coupled history between these organisms matters for their viability. Aizen et al. (2014) note that seemingly mutualistic relationships between a native organism and an invasive organism may result in detrimental effects to the native organism. There is a lack of a coupled, shared history between the two species, resulting in an imbalance in costs and benefits to each. An established relationship matters for how environmental features modify organisms over developmental, behavioral, and evolutionary timescales—features may be exploited (or not) with a variety of effects over these timescales. In addition, importantly, organisms, in turn, modify these features, which results in the generation of new developmental and evolutionary effects, as discussed in the literature on niche construction (e.g., Odling-Smee et al., 2003). So the details of interaction matter, especially for a naturalized account of perception. If we want to understand perception as a biological phenomenon, we need to look at how it is actually used, down to the individual differences and peculiarities such as those seen in the naked mole rat. One approach to investigating the details of interaction is to consider the environment at the scale of the individual; this requires specifying the environment in a more fine-grained manner.

Multiple Senses of Environment

Brandon and Antonovics (1996) suggest that, in the field of population biology, there are three ways to distinguish between conceptions of the environment for the sake of understanding organism–environment coevolutionary dynamics. These conceptions differ based on what sets of environmental factors are taken to be relevant in the generation of selective pressures. The first sense of environment is purely external—the environment is constituted by a set of factors independent of an organism of interest and are measured independently from an organism of interest. Brandon and Antonovics (1996) suggest that a fundamental problem with conceptualizing the environment in this manner, however, is that because these factors are measured entirely independently from the organism, they may turn out to be irrelevant to an organism’s fitness, and

thus do no work toward an understanding of how and why populations evolve. So a conception of the environment that merely identifies the set of physical factors external to organisms is insufficient.

The second conception of the environment is the ecological environment, which utilizes organisms as “measuring instruments” (Brandon and Antonovics, 1996, 164) to determine the external factors as they affect population growth. This conception effectively picks out features of the environment that are relevant to a particular lineage such that identifying them sheds light on that lineage’s evolutionary trajectory (Griffiths and Gray, 2001). Brandon and Antonovics (1996) note that a further step is needed in order to compare fitnesses of different genotypes. A third conception of the environment as selective allows for comparison between genotypes in relation to pressures from the environment. As the goal with this approach is to be able to measure organism–environment coevolution by way of assessing organism–relative factors, specifying an environment as a narrower set of features can aid in understanding why some genotypes fare better than others. The selective environment, then, is the appropriate sense of the environment to consider when comparing individual genotypes, and thus individual differences that may over time be selected either for or against.

One way to further parse out these differing senses of environment is in a developmental context, albeit one with relevant evolutionary implications. Each sense of environment can be said to be constituted by a set of resources organisms can make use of, and some of which are necessary for the transgenerational stability of form (Griffiths and Gray, 1994). Identifying the structure of resources available to organisms is a central goal of developmental systems theory (Oyama, 1985). By specifying individual domains with unique sets of resources, it is possible to identify developmental resources, which may arise during the interaction of organisms as developmental processes and the environments in which they are situated. For example, persistent resources may be those specified by the notion of an external environment, such as temperature, gravity, and light. These resources play a role in the developmental process and may potentially be relevant to organismal fitness, but they are not identified with reference to a particular organism and exist independently and regardless of any organismal interaction. The sets of resources specified in more fine-grained scales are all organism-dependent and are thus factors in the ecological sense of environment. Resources specified at an even finer-grained scale can arguably fit into the sense of a selective environment. The availability of these resources highlights interactions that take into consideration individual differences in behavior.

Organisms, as developmental processes themselves, make use of resources across each domain depending on a shared history of interaction and with regard to individual needs. What is relevant for the sake of providing an evolutionary explanation is identifying recurrent interactions between resources and organisms with the capacity to utilize those resources. Variation arises when resources are utilized in a new manner, when new resources are introduced, or existent resources are removed, the relationship with resources is altered, and so on. In this

way, the developmental system is comprised of not solely an individual organism interacting with an environment over the course of its life cycle, but rather it extends over both the organism as a developmental process and the developmental resources with which it is coupled such that interactions with those resources constitute a species-typical life cycle. This picture places greater emphasis on the environment, itself, in understanding the life activity of the organism than traditional accounts of ontogeny do, as developmental resources (potential or actual) are integral to the specification of the system as a developmental system. Without reference to these features, the resources available for explaining the transgenerational stability of organismal form are impoverished. Specifying the environment and building that specification into an understanding of organisms as developmental processes embedded within a larger developmental system results in a richer account of ontogeny, with greater explanatory power across a developmental timescale, but also a behavioral and, on a population scale, an evolutionary one.

In ecological psychology, similar attempts have been made to parse out different senses of the environment. Baggs and Chemero (2019) distinguish between the physical world, a species habitat, and an individual organism's *umwelt*. Here, I think it is helpful to map this distinction onto the three-way distinction between senses of the environment described by Brandon and Antonovics (1996). The physical world approximately corresponds to the notion of an external environment—it is not specified in relation to any particular organism. The sense of the environment as a habitat is species specific and contains affordances as resources typical for that species. The third sense of environment, the *umwelt*, references Jakob von Uexküll's concept of a particular organism's lived environment (von Uexküll, 2010); it is a behavior setting that is "shaped by the places where that individual dwells, and by the history of interactions that the individual participates in" (Baggs and Chemero, 2019, 16). An individual organism's *umwelt*, then, references its unique abilities and experiences to determine which features of the world are especially salient to it given these properties.

The goal in introducing this three-way distinction between the physical world, a habitat, and an *umwelt* is to resolve tensions in Gibson's original distinction between a perceiver-independent physical world and an affordance-containing yet ambiguous surrounding environment, which roughly corresponds to the notion of a habitat on Baggs and Chemero's three-way distinction. What the sense of an *umwelt* is meant to do, in this context, is specify exactly how individual differences result in different affordance spaces. A species-specific habitat contains environment features that are utilized in a species-typical fashion, thus referencing an idealized member of that species. The bee orchid (*Ophrys apifera*) that successfully tricks male bees into thinking they are encountering female bees presumably tricks all male bees, but the one male bee that does not fall for this trick does not act on the affordance in a species-typical manner. The world, to this clever bee, appears differently—there is no female bee to encounter, only an equally clever orchid plant. Thus, an *umwelt*, as an individual-specific, third sense of environment, allows for individual variation, which as Withagen and Chemero

(2009) note, is essential for an understanding of evolution on a naturalized account of perception.

The Developmental Niche

The sense of the environment as an individual-specific environment, I want to suggest, can be built upon by further specifying how structural features of the individual-specific environmental milieu both shape and are shaped by coupled features of the individual organism. This task requires looking at the environment, understood as an organism's cognitive domain, as an ontogenetic or developmental niche². Individual variation in perceptual activity can be investigated in relation to the developmental niche in which individual organisms live. I want to suggest that specifying the cognitive domain in which organisms are situated as their own developmental niches provides a framework for understanding the environment in such a way that builds on both enactive and ecological cognitive science.

West and King (1987) [see also Stotz (2014)] suggest that the concept of an ontogenetic niche can aid in identifying the set of developmental resources that an individual inherits in addition to genes. The social, cultural, and ecological circumstances that an organism is born into play a prominent role in its developmental trajectory. For example, West and King (1988) [see also Smith et al. (2000)] found that the presence and response of female cowbirds had a significant effect on male song development. Identifying this social influence as a parameter in the male cowbird's ontogenetic niche guides the understanding of what factors are relevant in the species-typical development of singing behavior. This influence on song learning and development can have transgenerational effects, making it the case that the multimodal (both visual and auditory) sensory feedback from social interactions can serve as an inherited resource.

Griffiths and Stotz (2018) describe a developmental niche as the "set of parameters that must be within certain bounds for an evolved life to occur (or, in more traditional terms, for the organism to develop normally)" (Griffiths and Stotz, 2018, 237). Importantly, they distinguish between a developmental niche and the selective niche described by niche construction theory, which they define as "the set of parameters that determine the relative fitness of competing types in the population" (ibid.; see also Stotz, 2017). While the selective niche picks out elements that generate selective pressure on an organism, the developmental niche picks out elements that are relevant for the species-typical development of an organism.

The developmental niche is part of the larger developmental system; it identifies the environmental setting or context in which a developmental system constructs a life cycle. It is the set of parameters that "play a role in the modification and reproduction of the life cycle" (Stotz, 2017, 2). The relevant parameters may be not just physical resources but also "social, ecological and epistemic" (ibid.) resources that aid in the reliable reconstruction

²While West and King use the term "ontogenetic niche," Griffiths and Stotz note that they use "developmental niche" as a synonym in their work (Griffiths and Stotz, 2018; see also Stotz, 2008, 2010; Griffiths and Stotz, 2013). I will use "developmental niche" here to make it clear that I am drawing mainly from DST.

of a life cycle (in other words, an individual organism³). These resources are inherited in the reconstructing of a life cycle. The claim that extragenetic resources are inherited within the context of a developmental system is a key aspect to DST and differentiates it from traditional accounts of ontogeny.

One example in this regard is Gottlieb's (1985, 2002) experimental work on duckling vocalization behavior (Gottlieb, 1985, 2002; see also Gottlieb, 2001). While this behavioral trait is typically considered to be instantiated by innate mechanisms, Gottlieb found that particular external factors, such as a duckling's experience hearing its own vocalizations as well as vocalizations of its siblings while still at the embryonic stage of development, played a significant role in the species-typical development of that behavior (Gottlieb, 2002). This example shows that even something as precise as individual experience, at a very specific stage in development, can affect an organism's developmental and behavioral (and potentially evolutionary) trajectory:

The intricacy of the developmental causal network revealed in these experiments proved to be striking. Not only must the duckling experience the vocalizations as an embryo (the experience is ineffective after hatching), the embryo must experience *embryonic* vocalizations. That is, the embryonic vocalizations change after hatching and no longer contain the proper ingredients to tune the embryo to the maternal cell (Gottlieb, 2002, 170).

In this sense, an individual organism's developmental niche is its own unique environmental setting, morphed by its interaction with resources within the niche just as those resources impact it. Whether or not species-typical phenotypes are exhibited is dependent upon specific kinds of interaction between an organism and the resources within its developmental niche. Changes in interaction potentially have a generative effect over time. Shifts in developmental niche are possible through variation in behavior.

In Oyama's, *The Ontogeny of Information*, organisms are conceived of as integral parts of a larger developmental system, which contains environmental resources that act on and are acted upon by the organism in that system. The developmental system is comprised of a complex web of interactions that impact how the organism develops and changes over its lifetime. In this context, an organism's developmental niche can be thought of as the specific environmental setting that is comprised of inherited developmental resources part of a larger developmental system. Thinking of the environment as an individual organism's developmental niche makes it clearer how organisms form certain relationships with certain environmental

elements (including conspecifics) and how those relationships can change (and new ones created) over developmental, behavioral, and evolutionary time. This conceptualization leaves room for the creation of new coupling processes via individual innovation, potentially leading to new features of both the organism and its environment.

As Gottlieb stresses, developmental systems are dynamic and in constant flux, with new iterations (i.e., new generations) impacted by prior individual variations acted upon by selection over time. This view of the environment thus avoids potential issues with circularity that may arise if the improper environmental scale is considered. The concern here is that on a generalized account of the environment, which as stressed in the previous section leaves no room for variation, a perceiver-environment system is markedly circular—perceivers pick up relevant environmental stimuli, and environmental stimuli is present as a resource for perceivers. This picture does not tell us why the coupling has arisen or why it persists. Bees perceive UV light, and UV light is perceivable by bees. However, this was not always the case; bees did not pop into existence ready to utilize UV light as an action-guiding visual cue. In a similar vein, one hypothesis for the evolution of trichromatic color vision in some primates was the ability to pick out colored fruit (Allen, 1879). A generalization of this coupling does not tell us how organisms move, evolutionarily, through color space. It properly identifies a coupled system, but provides only a synchronic account of that phenomenon. If we are convinced that a dynamic approach to understanding perceptual activity is a fruitful way forward, we must look at the environmental setting in which perception occurs across multiple timescales—developmentally, behaviorally, and evolutionarily. I have attempted to illustrate that the biological resources for looking at the individual organism across these scales (both spatial and temporal) are plentiful, and thus, a robust naturalized account of perception ought to make good use of them.

In accordance with DST's concept of a developmental niche and Baggs and Chemero's sense of the environment as an individual-specific *umwelt*, I suggest that one fruitful way of specifying the cognitive domain is to characterize it as an individual-specific developmental niche. On this view, conceptual tools from enactivism and ecological psychology can be put to use alongside conceptual tools from DST to result in a cohesive framework for understanding the cognitive domain for perceiving organisms.

Enactivists speak of the "enacted world" of a perceiver as emerging from perceptual interactions contingent upon sensorimotor capacities. The enacted world is populated by environmental features with potential valence to an organism depending on the internal needs of the organism at a specific time (Thompson, 2007; Di Paolo et al., 2017). The enactive approach is thus a naturalistic one, as it draws on the biological factors involved in cognition for explanatory purposes. However, exactly what features populate an organism's enacted world is dependent upon not only a history of coupled interactions between its species and the ecological environment but also between an individual and its developmental niche. Importantly, these interactions are dynamic, with some couplings strongly

³One route to pursue as an application of this framework is the task of identifying what qualifies as an organism in organism-environment systems. I do not have the space to give this task adequate treatment here, but I do think there are resources available for addressing it. For example, we might think of the organism in the organism-environment (or developmental) system as the process of an individual life cycle (see Griffiths and Gray, 1994, 2001; Griffiths and Stotz, 2018). Recent discussions on process ontology in biology (see Nicholson and Dupré, 2018) are also resourceful. A process view of the organism would fit fairly naturally with the enactive approach, I think, though I am less sure of how well it would connect with ecological psychology. I thank an anonymous reviewer for drawing attention to this important question.

conserved over time (such as eye structures and light stress) (Nilsson, 2009; Oakley and Speiser, 2015) and others in flux during an individual's life cycle (such as differentiation in abilities enabled by learning). Thus, the cognitive domain of a perceiving organism shapes and is shaped by that organism's influences on various timescales, making the enacted world a dynamic one emerging out of a complex web of interactions as a result of both individual experience and innovation⁴ as well as species-typical behavior.

From ecological psychology, resources across each environmental domain, from persistent resources to self-generated resources (Griffiths and Gray, 1994), can be thought of as affordances in that they invite certain interactions that have the potential to alter both the developmental trajectory of an organism and its species' evolutionary trajectory. In this way, affordances are conceived of as non-specifying features, in that they vary as a result of cycles of interactions within the developmental system. The problem neo-Gibsonians face due to their commitment to the specification of features, then, is avoided. This leaves room for the evolution of affordances as resources themselves, as well, as repeated interactions with a resource may result in evolutionary change within that resource, as is seen in relationships of coevolution between two species. Variations in interactions, therefore, lends to the possibility of new resources being utilized in the reconstruction of the developmental process, resulting in changes to organismal form over time—in other words, to evolutionary change. Enough repeated iterations of an interaction between a developmental resource and the organism as a developmental process can result in the emergence of new features to make better use of that resource.

Conceiving of the organism-specific environment as a developmental niche can potentially aid in alleviating some ontological tensions between enactivism and ecological psychology. On an enactive reading, the niche is partially constructed by the organism that occupies it and is continuously shaped by the organism's behavior. According to ecological psychology, the niche is populated by affordances, which exist as physical features of the environment but afford certain actions in relation to the organism's capacities. Affordance spaces might be constructed by individuals in a literal sense, but they are still features of the environment that can, in turn, have an effect on other systems that occupy that space. For example, a beaver dam is constructed by individual beavers, yet the structure itself can change the flow of the river, can provide a living place for other organisms, and so on. The constructing of an affordance space does not merely change the actions afforded to individual beavers, but has a global ecological effect as well. Therefore, thinking of an affordance space as relational only to the perceivers that are foremost responsible for its construction

might result in overlooking some important ecological aspects of that affordance space as an ecological niche.

Importantly, the developmental niche need not be thought of as being populated solely by biological or ecological factors⁵. Social and cultural affordances play a large role in guiding action for humans (Rietveld et al., 2013) and arguably for non-human animals as well (Avital and Jablonka, 2000). The resources an organism inherits in a niche include both physical resources such as food and shelter but also the potential for social interaction with conspecifics and behavioral traditions such as those seen in West and King's cowbirds. Individuals inherit a species-typical affordance space, but continue to shape it over time via their own behaviors and in regard to their own interests. Although beyond the scope of this paper, the close investigation of the social and cultural affordances in an individual's developmental niche may reveal valuable insights about individual variation and change.

By specifying the cognitive domain as an individual's developmental niche comprised of developmental resources, and as an integral part of the larger developmental system, it is possible to gain a better understanding of why perceiving organisms perceive the sort of features that they do, and how they are able to act on perceptual information in the way that they do. Importantly, this account provides us with a way of looking at how novelty, such as the move from dichromacy to trichromacy, may have been generated as a result of complex interactions between organisms and features within their environment. However, it also suggests the need for a complementary psychological view that emphasizes the dynamic relationship between organisms and their environments, across multiple spatial and temporal scales, and it is here that I think enactivism and ecological psychology equally have resources to contribute.

CONCLUDING REMARKS

In their 2019 paper, "Von Uexküll Revisited: Addressing Human Biases in the Study of Animal Perception," Caves et al., 2019 suggest that human perceptual biases have skewed experimental methodologies in sensory ecology, resulting in inaccurate portrayals of the visual world of differing species. A way forward for sensory ecology, they suggest, is to consider the specific context relevant to the perceptual phenomenon under investigation—that is, to look at which features of the visual environment are salient to an individual of that species, their physiological makeup, their behavioral traits, and so on. An account of perception that looks more carefully at the relationship between organisms and their environments can aid in avoiding such a bias, as it would involve taking seriously how the organism's body plays a role in its perceptual activity, how certain environmental features are perceptually salient depending on sensorimotor capacities, how organisms directly pick up information in the environment without the need for neurological machinery to translate that information from internal representations, and so on. Such an account would not

⁴One example of (often individual) innovation having a downstream effect is the notion of "cumulative culture," or the "ever-increasing, additive complexity or efficiency of cultural performance over time" (Schofield et al., 2018). The sweet potato washing behavioral repertoire of Japanese macaques began with a single innovator, with the behavior quickly spreading to others in the group. It is noted that the washing has the effect of reducing parasitic infections, thus suggesting an adaptive aspect to the behavior as well.

⁵Many thanks to an anonymous reviewer for highlighting the relevance of social affordances in this context.

take for granted how perception is utilized in the natural world. Both enactivism and ecological psychology have the conceptual tools to contribute to this view of perception; both stress the active exploration of the environment as central to understanding perception. However, we must look more carefully at that active exploration, over developmental, behavioral, and evolutionary time, and in turn, we must look at precisely what is being explored in order to understand perception as a biological phenomenon.

In this paper, I have argued that specifying the cognitive domain as an individual-specific developmental niche serves as a way to define the sort of environment that is referred to in the concept of organism-environment systems. This concept of the environment picks out the unique and dynamic relationships between perceiving organisms and their environments that might otherwise go unnoticed on either a physical environment reading or potentially even an ecological environment reading, which focuses on idealized members of a species. Sharpening the explanatory picture in this way allows us to account for individual

variation, in line with concerns raised in Withagen and Chemero (2009), and provides a better sense of what generates novel traits by looking at why an individual might either respond differently to existing environmental stimuli or cope with new environmental perturbations by generating novel adaptive responses. As shown in the previous section, these insights can shed light on broader questions about perception, and in such a way that shows the advantages to an account of perception that investigates the organism as a whole in the context of its surroundings. Both enactivism and ecological psychology share that commitment, and thus, the hope is to bolster both theories simultaneously by appealing to such a framework.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Bringing Forth Within: Enhabiting at the Intersection Between Enaction and Ecological Psychology

Mark M. James*

School of Computer Science, University College Dublin, Dublin, Ireland

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Edited by:

Manuel Heras-Escribano,
University of the Basque Country,
Spain

Reviewed by:

Toma Strle,
University of Ljubljana, Slovenia
Gunnar Declerck,
University of Technology Compiègne,
France

*Correspondence:

Mark M. James
markmichaeljames@gmail.com

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Baggs and Chemero (2018) propose that certain tensions between enaction and ecological psychology arise due different interpretations about what is meant by the “environment.” In the enactive approach the emphasis is on the *umwelt*, which describes the environment as the “meaningful, lived surroundings of a given individual.” The ecological approach, on the other hand, emphasises what they refer to as the *habitat* “the environment as a set of resources for a typical, or ideal, member of a species.” By making this distinction, these authors claim they are able to retain the best of both the ecological and the enactive approaches. Herein I propose an account of the individuation of habits that straddles this distinction, what I call a *compatabilist* account. This is done in two parts. The first part teases out a host of compatibilities that exist between the enactive account as developed by Di Paolo et al. (2017) and the skilled intentionality framework as developed by Bruineberg and Rietveld (2014) and Rietveld and Kiverstein (2014). In part two these compatibilities are brought together with the that these compatibilities can be brought together with the philosophy of Gilbert Simondon to develop the notion of *enhabiting*. *Enhabiting* describes a set of ongoing processes by which an *umwelt* emerges from and is reproduced within the relationship between an embodied subject and their *habitat*. Thus, *enhabiting* points toward a point of intersection between enaction and ecological psychology. To *enhabit* is bring forth (to enact), within (to inhabit).

Keywords: enaction, ecological psychology, sense-making, *umwelt*, *enhabiting*, Simondon, individuation

EPIGRAPH

Still, what happens if a breakdown is so severe that the agent is not, so to speak, “caught” within any particular activity or genre? There is likely at this stage a hiatus of deep disorientation, of simultaneous partial abandonment and retention of the old frame of significance. We may find ourselves still involved in some of the previous schemes, only that they do not seem to make much sense now. In fact, until the situation is resolved and a new microworld emerges, we are world-less.

(Di Paolo et al., 2017, p. 167)

INTRODUCTION

Convergences between enaction and ecological psychology are “many and strong” according to Di Paolo (2016a, p. 327). Both reject explanatory strategies understanding cognition as consisting in the manipulation of content-involving representations. Both emphasize contextuality over reductionism, foreground particularity and process, and stress the constitutive role of body–environment relationships in the development of cognition (Szokolszky et al., 2019). Given such

convergences, some suggest that they are ripe for integration (e.g., Kiverstein and Rietveld, 2018). An integrated perspective might offer “a systematized and consistent post-cognitivist approach to cognition” (Heras-Escribano, 2019, p. 1). Elsewhere, there is less certainty unification possible, and, as Di Paolo (2016a) also puts it, enactivists and ecological psychologists “stare at each other across an uncanny valley” (p. 327).

Segundo-Ortin et al. (2019) contend that when offering an anti-representationalist alternative, ecological psychology can get along well without enaction. Chemero (2012) contends that the theory of autopoiesis informing many enactive perspectives is “a troublingly idealistic theory” (p. 54). And Fultot et al. (2016) argue that enaction retains an implicit representationalism, lacks principled grounding, embeds an animal–environment dualism, and is purely constructivist position despite protestations otherwise.

Enactivism, although often relying on ecological psychology for empirical support, tends to be skeptical of the realism entailed by traditional approaches and implications about a “pre-given” environment, and dissatisfied by the apparent inability to provide any substantive account of value or the individuality of action. Reflecting these concerns in a comparison between approaches, Varela et al. (1991, p. 204) write, “Gibsonians treat perception in largely optical (albeit ecological) terms and so attempt to build up the theory of perception almost entirely from the environment. Our approach, however, proceeds by specifying the sensorimotor patterns that enable action to be perceptually guided, and so we build up the theory of perception from the structural coupling of the animal.”

This paper will not attempt to synthesize the approaches into a “systematized and consistent” whole. Building upon some recent work by Baggs and Chemero (2018, 2019), a *compatibilist* approach is advocated, i.e., a plurality of complementary frameworks¹. The compatibilist approach centers on intelligibility rather than systematicity and consistency. It can address phenomena that concern embodied cognitive scientists more completely and more sensitively to the “externalities” of theoretical application². Traditionally, the various approaches have different emphases and often provide consistent accounts of the phenomena they interrogate. There are, however, some phenomena that demand contributions from both approaches. The emergence of habits is one explored here.

Baggs and Chemero (2018, 2019) argue that the confusion between approaches can be circumvented by acknowledging their

different explanatory strategies. Each has a different starting point. The ecological approach has an ontological strategy, focused on characterizing the “environmental” structure that affords adaptive possibilities. The enactive approach has an epistemological strategy, focused on how a history of acting structures one’s “environment” so it calls forth existing skills (Baggs and Chemero, 2018). Such differences are revealed in how they employ the notion of affordance. There are three primary camps.

The first, the more traditional ecological perspective, is the *affordances as dispositions* camp (e.g., Turvey et al., 1981; Turvey, 1992; Wilson, 2018a). Here, affordances are lawlike and enduring environmental “dispositions.” They are enduring even in the absence of any who would make use of them and thus capable of applying selection pressures. As Wilson (2016) writes, affordances have “to be ‘out there’ and made of things that light can bounce off.” Given the lawful relationship between the structure in light and the structure in that which it reflects off, it can carry directly meaningful “information about” the available affordances. As the organism moves about its environment, it “picks up” this information and can thus act on the available affordances. Such affordances, as dispositions of the environment, are paired with dispositions in the organism, so-called *effectivities*, and whenever the two meet, a certain course of action follows (Turvey et al., 1981).

This dispositional account has its critics. Because any individual in a species can, in theory, occupy the same point of observation relative to the surfaces around him or her, he or she is thought to have access to the same “information about.” This supposition allows Gibson (1966, p. 321) to claim that, “The basis for agreement among men exists in the available stimulus information.” However, by focusing on the environmental structure there to be *found*, it de-emphasizes learning in shaping what any particular individual actually finds. In Baggs and Chemero’s (2018, p. 6) language, it “fails to account for the fact that a newspaper that is written in a particular language affords reading only for a certain subset of the world’s population, namely the set of people that are literate in that language.” A corollary of this is that if information is directly meaningful and available in the structure of the light (sound etc.), then there is nothing to be learned (Adolph and Kretch, 2015). And finally, this account struggles to make sense of within-individual variability. It “leaves obscure,” as Baggs and Chemero (2018, p. 8) put it, “the conditions under which a given affordance is actualised.” If affordances are dispositional properties of environments acted upon in the presence of a related “effectivity,” any time affordance and effectivity are present to one another, the affordance should be acted upon (Chemero, 2009). But this is quite obviously not the case.

The second position is the enactively informed *affordances as relations* camp (e.g., Chemero, 2003, 2009; Stoffregen, 2003). Here, affordances are relational entities that arise only under certain organism–environment configurations. This perspective was originally posed by Chemero (2003, 2009) to integrate insights concerning the role of environmental information with insights from enaction concerning the sources of value and the particularities of individual perception. There are prominent

¹Baggs and Chemero do speak, at different points, of the “complementarity” of these approaches and their “unification.” Thus, it is not clear whether the compatibilist account developed here is perfectly aligned with their ambitions or not. Nevertheless, their account does provide a stable mooring from which a compatibilist account might venture.

²The language of “externalities” comes from economic theory and pertains to the cost of an action on a third party who did not choose to incur it. Pollution is the customary example. It is used metaphorically here as a means to speak about what is “left out” or negatively affected by adoption of one particular framework or another. For instance, in the context of “mental” healthcare, the externalities of a reductive framework might be a failure to address underlying social conditions of disorder (see Alexander, 2010). The perpetrator is typically in denial of such costs and would most likely prefer that they were not incurred. It is simply presumed here that any theoretical framework will have some externalities, and thus they demand sensitive application.

critiques here also. Wilson (2016) highlights the most troubling of them: it is not clear how one perceives a relation of which they are part, and any capacity for affordances to apply selection pressures is negated, for they arise with the ability but do not precede it. Consequently, learning novel relational affordances is impossible. In the relational account, “organisms co-create affordances by their causal interactions with the environment. This means that I can only create affordances using abilities I already have; so how do I learn new affordances? It can’t be by being in the presence of those new affordances, because I cannot create them yet . . .” (Wilson, 2018b). In other words, within the account of affordances more agreeable to a typically enactive perspective, it is difficult to account for the emergence of novel relational affordances.

A third position is the *affordances as practices* camp of the skilled intentionality framework (hereafter SIF) (e.g., Bruineberg and Rietveld, 2014; Rietveld and Kiverstein, 2014). They develop a relational account too, but expanded from the purely “material” to the “sociomaterial” (van Dijk and Rietveld, 2017, p. 6). Here, affordances are defined as “relations between aspects of the sociomaterial environment in flux and abilities available in a form of life” (van Dijk and Rietveld, 2017, p. 10). A “form of life” relates to the practices common within a given species, their “relatively stable and regular ways of doing things” (Rietveld and Kiverstein, 2014, p. 328). We are not just sensitive to the material affordances of the hammer, but its role within its larger context. Such insights were inspired most recently by Dreyfus and Hubert (1992) responding to the so-called “frame-problem.” However, they can be originally traced to Heidegger (1927/1962). Heidegger (1927/1962), for instance, spoke about comprehending the tool against a background or network of other tools and uses that gave the tool its meaning, what he called a “totality of equipment” (p. 97)³. van Dijk and Rietveld (2017) use the example of climbing stairs to highlight the sociomaterial nature of affordances, describing how one’s steps might reflect an awareness that people are sleeping nearby. The stairs afford not just *climbing* but, you might say, *climbing quietly so as not to wake the others in the house who are up early in the morning for work*.

The SIF makes important contributions by recognizing affordances as being contextualized by larger *fields* and *landscapes* of affordances, i.e., the sociomaterial contexts that shape action at multiple timescales. By allowing attention to be oriented by more experienced individuals, through observation or training, learners can attune to the available affordances within a form of life. This account makes room for individual variation while not defining affordances in terms of individual abilities (van Dijk and Rietveld, 2018), allowing for affordances to drive selection and accommodate learning within a form of life. However, it is not clear how without an account of affordances also tied to individual abilities radically novel practices can emerge, or how an individual within a given practice might innovate beyond the boundaries of its present configuration.

All of these accounts make important contributions to questions of learning, but also harbor limitations⁴. The dispositional account argues for the kinds of structures necessary in the environment to guide learning but underdetermines the historicity of learning and the particularities of a given organism–environment relation. The relational account, although highlighting how a history of learning determines the affordances one is likely to make use of, is closed to the emergence of novel affordances at an individual level. And the practice account, although allowing for a relational account in which affordances still apply selection pressures, seems to come up short in its ability to account for the emergence of radically novel practices or innovations. One suggestion about the nature of these shortcomings is the idea that these accounts are focused on the *what* rather than the *how* of learning. As Cariani (2016, p. 324) puts it, “Both constructivist and ecological psychology theories need to explicitly incorporate concrete processes of learning alongside what is or can be learned.” But there *are* frameworks right across the valley that speak about the *how* of learning.

On the ecological side, the *perceptual learning* of Eleanor Gibson (1969, 1994), which focused on processes of selection and differentiation of a sufficiently rich stimulus. Or the contemporary progeny of such accounts, such as the *direct perceptual learning* theory of Jacobs and Michaels (2007), which is centrally concerned with how the acting agent comes to “identify useful, complex information–environment specificities at the level of ambient energy arrays, under universal constraints captured by natural laws and local constraints given by a specific task situation” (Szokolszky et al., 2019). Here, learning is an information-guided process in which attention becomes progressively more attuned to optimally useful information (see Szokolszky et al., 2019, for discussion).

On the relational side, the most comprehensive account of learning is the *equilibration* account put forth by Di Paolo et al. (2017). Here, the focus is on how stable sensorimotor correlations evolve through the resolution of tensions in the relationship between existing structures and structures in the environment (Di Paolo et al., 2017, p. 88). Their account provides insights into the developmental dynamics that support learning and the logic for why any act of perception reflects an individual history. Consequently, they provide an answer to the question of why the agent is attuned to “some particular subset” of environmental information “that has meaning to it at this moment” (Di Paolo, 2016a, p. 327).

The “issue” with these perspectives is not the internal details of the accounts themselves, but that they maintain the limitations highlighted in the various accounts of affordances. Thus, what is introduced here is not an amendment to any of the accounts in particular, though both may be informed by it. Rather, it is intended as a framing within which conversations between these various approaches might be couched given their shared interests in making intelligible the dynamics of situated action.

³See Kiverstein and Wheeler (2012) for an edited collection on the influence of Heidegger on contemporary cognitive science. Or Kaufer and Chemero (2015) for a more concise account, alongside the account of phenomenology more generally.

⁴One might refer to such limitations as “theoretical externalities.” See footnote 2 above.

Following Baggs and Chemero (2018), this starts with the recognition that the apparent incompatibilities with the above approaches result from attributing *some* reality, just different types, to each notion of affordance. The enactive approach emphasizes the structure of experience and how the world emerges in the relationship between organism and “environment.” In other words, here emphasis is placed on the *umwelt*, which describes the environment as the “meaningful, lived surroundings of a given individual” (Baggs and Chemero, 2018, p. 6). One primary value of the enactive perspective is the epistemic limits it sets, reminding us that the knower is always implicated in the known. Nevertheless, enactivists tend to conceive of their project not in the idealist terms attributed to them earlier, but as a kind of middle way, and are even committed to a basic ontological “realism” of sorts, i.e., there are some sort of mind-independent structures that we can come to know, even if coming to know “them,” we render them mind-dependent. Enactivists thus speak about the “structural coupling” of organism and environment (Varela et al., 1991). But accounts of the structure that make up the environmental side of the coupling are admittedly underwhelming.

More classically ecological approaches, given their ontological focus and their desire for an account of how structures in the environment can be a source of selection pressures, emphasize what Baggs and Chemero (2018) refer to as the *habitat*: “the environment as a set of resources for a typical, or ideal, member of a species” (p. 6). Importantly, the “habitat” does not designate physical reality writ large, but rather, the set of material relations that exist prior to and independently of any individual member of a species that could in theory impact them. “The habitat,” writes Baggs and Chemero (2018, p. 7), “is the physical world described relative to a potential actor, or set of actors.” This account speaks of a dispositional account of affordances, and its recognition is valuable for it provides the basis for an empirically grounded anti-representationalist approach to understanding perception and action, one that helps acknowledge the basic intuition that we occupy a shared world despite our individual histories.

Holding this distinction, Baggs and Chemero claim, we can retain the best of both approaches.

The affordance concept serves a different purpose depending on whether we invoke it in the habitat or in the *umwelt*. In the former case, affordances are dispositional properties, or persisting resources that exist across generations and exert evolutionary selection pressure. In the latter case, they are relational properties that exist for only so long as a given animal continues to live, and that change as that animal develops new skills and abilities, or loses them.

(2018, p. 8)

In the compatibilist account, the ecological perspective clarifies what might be said about the environmental side of the structural coupling, thus supporting the commitments throughout the valley to the possibilities of an account of perception and action grounded in the language of science. The enactive perspective, on the other hand, reminds us that even such a language is but a frame onto the world⁵.

⁵See Cummins, 2020 for an extended discussion of these particular relations.

The following article comes in two primary parts. Part I teases out existing tensions between certain enactive and ecological accounts, suggesting that if we maintain the distinction that Baggs and Chemero (2018) introduce, they can be understood as reflecting underlying compatibilities. There are, nowadays, enactivisms (e.g., Hutto and Myin, 2013; Villalobos and Ward, 2015; Cummins and De Jesus, 2016; Di Paolo et al., 2017) and ecological psychologies (e.g., Gibson, 1979; Chemero, 2009; Rietveld and Kiverstein, 2014; Wilson, 2018a). The focus here is on teasing out compatibilities between the sometimes called “autopoietic enactivism” associated with Di Paolo et al. (2017) (hereafter enactivism) and the skilled intentionality framework associated with Bruineberg and Rietveld (2014) and Rietveld and Kiverstein (2014), primarily within ecological psychology. The primary reason for focusing on these accounts is that both already acknowledge the importance of insights from ecological and enactive perspectives, and both have some central role for the notion of autonomy and thus compatibilities are already present that can be further refined. Importantly, the SIF is something of a marginal view within the ecology of ecological psychology. The developments herein do aim to be informative within that ecology. However, given available space, discussion is limited to comparisons between the perspectives mentioned. That said, future developments will benefit from engagements with more classically articulated ecological perspectives.

Starting from a shared concern with the idea of self-maintenance, a path is woven through a host of related notions, highlighting compatibilities along the way. Firstly, the central notions of *sense-making* and *tending toward optimal grip*. From there, through related concepts concerning the abilities of agents, the timescales that organize action, the role of the “environment,” and questions around identity and normativity. Concluding this first part, it is suggested that the compatibilities highlighted can be brought into a more enduring relationship through the necessity of their mutual deployment in accounting for the individuation of novel habit structures. Within this account, this process is termed *enhabiting*. Developing the notion of *enhabiting* is the focus of part II. Inspired by the philosophy of Gilbert Simondon, it offers an account it offers an account of the ongoing constitution of habitual organizations at multiple timescales, through establishing interdependencies between bodily structures and structures in the habitat.

PART I: FINDING COMPATIBILITIES

A starting point for thinking about compatibilities between these two approaches is simply pointing out that both accounts are centrally concerned with processes of self-maintenance. The enactive approach continues in the tradition of Maturana and Varela (1987) and describes self-maintenance in terms of autopoiesis (or autonomy more generally). The SIF borrows from the Fristonian account (Friston, 2009, 2010) and describes self-maintenance in terms of the free energy principle (FEP). As Kirchhoff (2016) points out, comparing the originary accounts, they both “converge on . . . the organizational property for living systems: self-maintenance through a process of autopoiesis” (p.

8). “One can show,” Kirchhoff goes on, “that the process of autopoiesis is a process that minimizes free energy” (Kirchhoff, 2016). Given the demands of space, the extent to which this claim is true or not is not explored here (see Kirchhoff, 2016, for discussion). Rather, by contrasting the concepts typically used to describe the activities that support self-maintenance, *sense-making* and *tending toward optimal grip*, we can begin teasing out the compatibilities that will be reverent to the positive account later on.

Sense-Making and Tending Toward Optimal Grip

Sense-making, within enaction, describes the activity of an adaptive autonomous body directed at its ongoing viability. In short, it describes a “bodily process of adaptive self-regulation” (Di Paolo and Thompson, 2014, p. 9). The self-production of the biochemical networks constitutive of organismic life, or *autopoiesis*, requires ongoing and periodic access to various material and energetic resources. As such, actions are appraised as better or worse according to their ability to satisfy these requirements. Consequently, the autopoietic instantiation provides a meaningful background against which activities and events are made sense of, a “natural perspective from which encounters in the world are intrinsically meaningful for the organism following the norm established by the continuing process of self-production” (Di Paolo, 2005, p. 429–430). Thus, the job of sense-making is the *maintenance* of the identity of the organic body. Recently, however, sense-making has been expanded to include not just the maintenance of autonomous biochemical identities (life), but sensorimotor identities also, in the form of habits, networks of habits (ways-of-life), and so on (Barandiaran, 2017; Di Paolo et al., 2017).

In the SIF, sense-making is replaced with the notion of *tending toward an optimal grip*. Kiverstein and Rietveld (2018) write that “We characterise ... sensemaking activity in terms of the tendency toward an optimal grip on multiple affordances” (p. 156). This notion originates in the work of Merleau-Ponty (1945) and has been long championed by Dreyfus (2002).

“According to Merleau-Ponty, in absorbed, skilful coping ... acting is experienced as a steady flow of skilful activity in response to one’s sense of the situation. Part of that experience is a sense that when one’s situation deviates from some optimal body–environment relationship, one’s activity takes one closer to that optimum and thereby relieves the “tension” of the deviation. One does not need to know, nor can one normally express, what that optimum is.”

(Dreyfus, 2002, p. 378)

The agent is moved to improve its grip on its environment by neutralizing tensions in the relationship, by continually negating deviations from an optimum. As Bruineberg and Rietveld (2014, p. 12) put it, “an organism self-organizes by reducing a disequilibrium in the brain–body–environment system.” As tensions manifest in our experience, they “solicit” action. There is not necessarily some explicit goal state organizing action here, “the skilled individual does not have an explicit goal in mind, but rather is solicited or invited by the field

of affordances ... what is at the root of skilled activity is not a set of desires or goals, but rather the ongoing modulation of coupled self-organizing dynamical systems that results in the adequate interaction of an organism with its environment” (2014, p. 3). Illustrative examples include finding the best angle for a photo, adjusting your distance in a queue, editing a text, or playing chess. Living systems are continuously striving to improve grip (Kiverstein et al., 2019). Consequently, tending toward optimality might be considered a very basic norm shaping the regulatory dynamics of the organism–environment relation that support self-maintenance. In line with the FEP account, tending toward optimal grip entails the progressive movement of the organism toward better “models” of their environment over time. Unlike closely related Bayesian constructions that focus on brain processes (e.g., Clark, 2015; Kiefer and Hohwy, 2018), this does not posit structural representational models carrying representational content. “Under the FEP, models are not explicitly encoded by physical states ... states of the brain. Rather, it is the adaptive behavior of the system that implements or instantiates a generative model” a statistical “prediction” or anticipation of optimal behaviors in their particular “econiche” (Ramstead et al., 2019). The agent resonates with its environment in ways that prepare it for acting therein. They are attuned. The language of “modeling” will be troubling here for some, as decoupling it from its representationalist implications is something of a challenge (see Ramstead et al., 2019, for an insightful account that supports the use of the language of modeling in non-representationalist terms)⁶. Having introduced these central notions, we can now consider some of the tensions and compatibilities that follow.

Habits and Abilities

Habit is a relatively recent development within enaction (Di Paolo, 2003; Barandiaran, 2008, 2017; Barandiaran and Di Paolo, 2014; Ramírez-Vizcaya and Froese, 2019; James and Loaiza, 2020). However, it is an important one, for it is said to supply a “blending category between the biological and the psychological,” and “a theoretical building block for an organicist conception of mind” (Egbert and Barandiaran, 2014, p. 2). Barandiaran has defined habits as “self-sustaining patterns of sensorimotor coordination formed when the stability of a particular mode of sensorimotor engagement is dynamically coupled with the stability of the mechanisms that generate it, and which is reinforced through repetition” (Barandiaran, 2008). Habits demonstrate forms of circular self-production analogous to other autonomous forms, such as autopoiesis. A single habit, contends Barandiaran (2017), provides “a first analogy with life and a first approximation to a sensorimotor conception of identity and normativity,” whereby “through repetition ... a habit can take on a life of its own: it is both the cause and the consequence of its own enactment” (p. 13). What emerges within the habit is a minimal sense of identity, a focal point

⁶See Flament-Fultot (2016) for a constraints-based approach that avoids the language of modeling but can still provide principled accounts of anticipation. Fultot makes the case for how a particular context “pre-constrains” the living system, resulting in an “anticipatory poise” relevant to acting therein.

concerned with its own maintenance. Given that any habit relies on certain conditions – rate of repetition, particular sociomaterial structures, etc – boundaries of viability are enacted, stipulating certain actions as required if the habit is to be kept alive, i.e., the norms of its own self-regulation (Barandiaran, 2017). Inspired by this account, but following the constraint cycle position advocated by Loaiza et al. (2020) (included in this topic collection), an alternative definition is offered here. A habit is a self-sustaining ecobehavioral entity in which structure and operation enable each other in a closed circular fashion, relations which are reinforced, growing more autonomous, when repeated within appropriate timescales. The specifics of this definition will become apparent in later sections.

Importantly, the enactive account also moves beyond single habits to self-reinforcing, self-cohering networks of inter-regulating habits that unfold across longer timescales. When the network's plastic interconnectedness is complex enough, sensorimotor regulations engender large-scale equilibrating tensions within the network, whereby "sensorimotor compensations ... take place to maintain the capacity of the agent to keep behaving coherently" (Barandiaran, 2017, p. 14). At this point, the network's self-conservation becomes its basic operational norm, and it enables activities that sustain its identity as such. Now, rather than the organic whole being the sole background against which sense is made, habits and networks of habits are also self-maintaining, norm-generating backgrounds shaping the sense-making of the embodied subjects that instantiate them. Any such structure, regardless of timescale of operation or domain of relevance, will be referred to as a *sense-making* frame, or a *sense frame* (hereafter SF) for short⁷. The idea that sense-making operates within a "frame" and that sense-making entails the reconstruction of such "frames" has surfaced elsewhere in the enactive literature. See Di Paolo et al. (2018, p. 36) or the Di Paolo et al. (2017, p. 167) – the epigraph of this article) for examples of this language. Although Di Paolo et al. (2017) do not elaborate on the notion, what they are pointing toward is precisely the kind of autonomous organizations considered here. Habits, bundles of habits, and autopoietic biochemical structures all constitute SFs.

As habitual ecobehavioral entities, the norms of SFs can partially decouple from the normative dimensions of the autopoietic structures upon which they lean. As such, they can even instantiate self-regulating norms that function counter to the norms of autopoiesis (Barandiaran, 2017). As Di Paolo (2009, p. 18) puts it, "the inherent regulative tendencies of sophisticated processes of identity generation are likely to sometimes enter into conflict even with basic metabolic values." Examples include participating in extreme sports, excessive consumption of intoxicants, and so on. The behavior of the embodied subject is simultaneously motivated by the self-production of one particular identity (e.g., a way of life as a big wave surfer) while threatening another (the organic living whole) and inhibiting the expression of habits that would otherwise support it. This

can result in challenging states of dissonance. Indeed, many so-called "bad habits" get their name for this reason (Ramírez-Vizcaya and Froese, 2019). Thus, one recognizes some inter-regulatory dynamics at work in the relationship between different forms of autonomy.

Where enaction speaks of skillful action as subtended by integrated networks of habits, the SIF speaks of *abilities*. Within the SIF, affordances are the relationship between features of a sociomaterial environment and abilities in a form of life (van Dijk and Rietveld, 2017, p. 10). Any individual, at any time, is embedded within a "field of affordances," however, only some subset of the field stands out as relevant, the "field of relevant affordances." To say that they "stand out" suggests that they are experienced as soliciting behavior (Dreyfus and Kelly, 2007; Rietveld and Kiverstein, 2014). This depends upon a bodily "action readiness" on the behalf of the skilled actor (Frijda et al., 1989) whereby within a given situation the individual is attuned, or "selectively open," to certain features of their environment, anticipating what they are likely to encounter, and readying themselves to act so as to be responsive to the demands of the situation (van Dijk and Rietveld, 2017). The abilities of a given individual then, which have taken shape through a history of engaging in sociomaterial practices (Rietveld, 2008), are reflected in the patterns of action readiness, selective openness, and skillful response that manifest in any particular situation. Tending toward optimal grip, one is continually responding to solicitations, and thus constantly reorganizing the dynamics of the body–environment system such that the field of relevant affordances is in continuous flux.

The emphasis in this account, as previously noted, is more on the side of the environment. Given such emphasis, however, the SIF fails to account for the richness of "abilities" that the inter-regulating plastic structures captured in the enactive account suggest. Abilities are simply far too coarse-grained a notion. For instance, one does not merely have abilities or not have abilities. Rather, one has abilities and varying degrees of integration of those abilities within larger competencies. Consider an example common to didactic situations, where one uses a heuristic from one domain in another to facilitate learning, e.g., if one is asked to switch the hips in Brazilian Jiu-Jitsu with a back kick of the leg, but struggling until instructed, "like you are kicking your leg to propel yourself on a skateboard," and suddenly, given the alternative frame, the ability is available. Here, the ability existed already in some genuine sense. And even though one could notice the affordance for a certain kind of backward kicking of the leg, it was not integrated into the larger competency network, and thus unavailable.

On the other hand, although the account of SFs suggests something about the rich topography of inter-regulatory dynamics characteristic of action, it is limited to a purely relational view of affordances, and how novel SFs (and their attendant affordances) emerge is not yet apparent. Moreover, Szokolszky et al. (2019, p. 17) write that "Enactivism has the ... disadvantage of lacking an approach to perception that allows a coherent account of how organisms are connected/related to their surrounds." But obviously such relations are assumed. The notion of structural coupling implicates the availability of

⁷I extend this language to the social too, wherein I speak about *participatory sense-making frames* (see James, 2020, for discussion).

enduring structures in the habitat. The ongoing reproduction of a particular *umwelt* (effectively a collection of autonomous sense frames) depends upon the ongoing availability of and connection with particular features of the habitat. Just as life requires the flow of certain biochemical structures for its reproduction, ways of life require the flow of certain sociomaterial structures too. Again, one can see here how the compatibilist approach is necessary. The abilities gearing an individual into a particular field of affordances are compatible with the networked structures characteristic of SFs, which are dependent upon the sociomaterial affordances in the form of life for their ongoing reproduction.

Timescales

With the characterizations of the previous section in mind, the multiscale approaches of the enactive account and the SIF are mostly compatible. In both, any activity is always conceived as spilling over multiple scales simultaneously. Di Paolo et al. (2017, p. 147) write that “Habits do not stand in isolation as egotistically self-sustaining behavioral patterns. On the contrary, habits are nested in hierarchical, sequential, and ultimately networked relations in a kind of ecosystem ...”. One such hierarchy is a temporal one. A simple “habit scheme,” such as *picking up the soap with your right hand*, is embedded in a larger “activity” (a habit network), *washing your hands after going to the toilet*, which is itself embedded in a “micro-identity” (a network of networks), *getting ready for bed*. As a general rule, we can see that activities that unfold at shorter timescales, such as short-lived sensorimotor coordinations on the timescale of milliseconds to seconds, are entrained (largely) to those at longer timescales, such as activities that unfold on the timescale of seconds to multiple seconds, and so on⁸. This provides conditions for adaptive responses at shorter timescales to accommodate the particularities of the situation while maintaining a course of action at the longer timescales. The organizational dynamics characteristic of each informs the normative dimensions of the unfolding situation.

In the SIF, when tending toward optimal grip, a compatible account is apparent. van Dijk and Rietveld (2018, p. 2) write that “when driving to a store, writing a text, or building a house, skilled individuals also adjust their activity in an anticipatory manner – people act adequately by anticipating situations as they unfold across larger scales, although often in a less certain manner than activities on smaller timescales.” These anticipatory dynamics depend upon action readiness patterns that are the consequence of being embedded in a “landscape of affordances” (e.g., Kiverstein and Rietveld, 2012). The concept of the landscape of affordances is intended to capture the multiscale entanglement of available affordances. As Bruineberg and Rietveld (2014, p. 3) put it, “The affordances of places (libraries, restaurants, etc.) typically constrain behavior over a longer timescale, while the affordances of objects nested in such a place, say the door to the library’s reading room, typically constrain behavior on a shorter

timescale.” And so, when tending toward optimal grip, one is always mediating between the demands of multiple timescales.

There are some important shortcomings here, however, reinforcing the need for the compatibilist account. On one hand, without the autonomy of SFs, one cannot see how tensions emerge between timescales, something that is apparent in our experience, e.g., the tensions between one’s smoking habit and one’s identity as someone who lives a healthy lifestyle. Given that tending toward optimal grip pertains to the situation writ large, one might expect to be always achieving some sort of middle ground, but this is obviously not always the case. Sometimes, the norms of the smoking habit are satisfied in the fullest fashion possible, with one’s healthy identity providing a dissonant background. Given the autonomous dynamics of both SFs, it is clear to see how such relations manifest tensions. On the other hand, there are occasions where we experience solicitations over and above that which we have previously habituated at any timescale, possibly even as a resolution to the kinds of tensions just mentioned. This seems to be a consequence of tending toward optimal grip. Below it is suggested that this relation is central to the emergence of novel SFs.

Environment

In *Sensorimotor Life* (Di Paolo et al., 2017), the notion of affordances is not developed in any technical sense. Nevertheless, they do speak about “the world” as “a constitutive part of any instance of sensorimotor coordination” (Di Paolo et al., 2017, p. 105), or about “dynamical mechanisms that allow environmental conditions to ‘call for,’ or resonate with, certain sensorimotor schemes” (Di Paolo et al., 2017, p. 102). For Kirchhoff (2018), the lack of concrete enactive vocabulary concerning the “world” is a consequence of enaction’s focus on self-production, which aims at describing processes of system self-maintenance from within the system itself. As he puts it, within enaction, the “explanatory relation between living systems and the environment” takes “an internalist form, reducing the role of the environment in homeostasis” (Kirchhoff, 2018, p. 3). But, of course, this internalism is also a fundamental tenet of the enactivist perspective, for it highlights that the world “out there” is one about which our knowledge is enacted, and that we cannot but encounter it through our own individual histories of relating to it, even if we can do good science⁹. Given the centrality of this edict to the enactive position, the humble *umwelt* often appears the only environment of import and affordance but a handy term that affords description to certain aspects of experience.

The SIF, by centering the notion of tending toward optimal grip, places the regulatory load at the intersection of environment and embodied subject, suggesting that the developmental aim of the organism–environment system is to grow in synergy over time. Of course, this necessitates that there is something for the organism to synergize with. As Baggs (2018, p. 396) writes, “To understand the animal’s behavior ... we must first understand what the animal’s behavior is directed toward ... Having an account of structure in the environment is important

⁸Of course, there are numerous ways one can conceive of how the timescales of action should be carved up. See Loaiza et al. (2020) for a comprehensive account well aligned with the perspective developed here, but with a different set of heuristics, a “specification hierarchy” (Salthe, 1991), as opposed to the scalar hierarchy adopted here.

⁹See Cummins, 2020, for a compelling presentation of the inescapability of this epistemic framing.

because it provides a basis for understanding how an animal performs a particular task.” This ecological position reflects what Kirchhoff (2018) calls an “externalist causal-explanatory relation.” The externalist position is concerned with explaining self-preservation, which emphasizes the adaptive relationship between a changing environment and a changing organism. It builds upon Friston’s account of the FEP, which proposes that the “structural and functional organization” of a living system “is maintained by causal structure in the environment” and that “the hierarchical [statistical] structure of our brains is transcribed from causal [statistical] hierarchies in the environment” (Friston and Stephan, 2007, p. 418; taken from Kirchhoff, 2018).

Here, the habitat plays a much more explicit role than in the enactive account. In any FEP account, the “job” of the organism is to achieve and or maintain a “maximal fit between their probabilistic models and environmental niche *via* embodied activity,” sometimes referred as *active inference* (Friston et al., 2012; or more recently, *enactive inference* – see Ramstead et al., 2019). Basically, this suggests that organisms act in ways that minimize surprise (which is a measure of free energy) by actively taking part in their environment so as to produce sensory dynamics that align with what they anticipate to be the external causes of those dynamics. Such alignments are spoken about in the SIF in terms of tending toward an optimal grip. Thus, a kind of pervasive norm guiding the activity of the embodied subject is to progressively align with the structures of the habitat¹⁰.

Here again, the value in the compatibilist approach is apparent. Without a structured Umwelt structure in the habitat means nothing, but without structure in the habitat, a structured Umwelt cannot evolve or be sustained. Occupying one perspective and then the other is a little like switching between the different aspects of an optical illusion in which one can only really appreciate one or another image at a time, despite knowing that both are available to perception.

Identity and Normativity

This section highlights some inconsistencies with the above accounts that turn on many of the distinctions already made. These will be central to the positive account that follows and further point to the necessity of a compatibilist approach.

Sense-making describes regulatory activities that support the ongoing individuation of autonomous organizations, be they autopoietic or habitual. However, understood as describing the self-maintenance of autonomous organizations, it runs into trouble, the core trouble in the relational account of affordances also. Namely, we do not just *maintain* existing structures, but bring about novel ones too. The sense-making that supports the maintenance of such organizations requires an existing “identity” to maintain, but it does not account for the emergence of such identities in the first place. Di Paolo (2020) does suggest at one point that sense-making is involved in the “construction” of “frames” (p. 36). But this is not the traditionally held position, nor is there presently any account that addresses this process in a way that overcomes the limitations elaborated herein.

¹⁰ Any environment will, of course, be rich enough that there will be many well-aligned structures.

The production of an identity is somewhat different than its reproduction. To apply a single term to both without significant qualification is not very helpful. Neither is it to apply a term initially proffered to explain the maintenance of life to the maintenance of ways of life. Similar points have been made elsewhere. Beaton (2014, p. 153) asks “how can non-sense ever become sense for us, if perception only ever presents the world within the existing structures of our understanding?” Or Weinbaum and Veitas (2017) write that enactivists “treat closure as an ideal point that delineates the existence of the individual in time, and . . . only from such a point and on sense-making is possible” (p. 382). The latter, looking to Simondon, shift their focus from the individual as their primary ontological category, in which the “genesis of individuals is merely the manner by which one individual transitions into another” and to the processes of individuation, what they describe as “the formation or becoming of individuals” (Weinbaum and Veitas, 2017, p. 376). In part II, I will suggest such a move is necessary when thinking about the coming into being of identities of the habit variety also¹¹.

The recent *equilibration* account also recognizes something of this need. Di Paolo et al. (2017) synthesize an account of the “sensorimotor body” wherein sense-making takes on a broader characterization, more in line with the criticisms above, even if not explicitly. They suggest “Enactivism is concerned with explaining precisely these critical transitions between particular conditions that sometimes afford different functional descriptions and those ‘in-between’ dynamics that (re)constitute these or novel conditions” (Di Paolo et al., 2017, p. 27). However, when isolated, their account suffers. Di Paolo et al. (2017, p. 104) write that “Equilibration does not assume a “functional” source of normativity guiding adaptive change...” and wants to account for all change in terms of the “stability of individual schemes, along with their holistic coherence in the sensorimotor repertoire.” But tending towards optimal grip seems to reflect just such a source, and as will be observed below, when combined with the “stability of individual schemes” and their “holistic coherence,” can provide for an account of the individuation of novel habits in a way that avoids the limitations of existing approaches.

There is an oddity within the SIF also. The SIF borrows from Varela et al. and speaks about normativity, at least in part, as an upshot of identity preservation. For instance, they write that “Autonomous systems... have purposes of their own that arise out of the struggle to sustain their identity through the regulation of their coupling with the environment. They have an individuality and identity, and based on this identity, they are differentially sensitive to an environment of things that matter to them and are thus meaningful and valuable” (Kiverstein and Rietveld, 2018, p. 151). However, identity preservation here refers only to the biochemically individuated entity. Indeed, it does so despite their implications otherwise. They evoke the limitations spoken

¹¹ In recognizing this limitation, that “we tend to treat bodies more or less as givens, as starting points . . .” (2019, p. 2), Di Paolo has also recently aligned the Simondonian perspective with enaction. However, his efforts are conducted in a purely enactivist manner and take a different line than the one taken here. This emerging engagement with Simondon is a promising one for embodied cognitive science and, given the richness and originality of Simondon’s thought, is sure to be productive.

about earlier, suggesting that the normativity governing cognitive systems and that governing life are not straightforwardly equivalent. They also recognize that any living system, in the course of its life, will produce and sustain multiple identities. But despite momentarily recognising that such identities can include “patterns of sensorimotor behavior [that] can quite literally take on a life of their own,” they nevertheless reaffirm the position that they “interpret the enactivist concept of “identity” to refer to the biological organization of an individual that is maintained over time through material and energetic exchanges with the environment” (Kiverstein and Rietveld, 2018, p. 152). Moreover, it is hard to see where the former of these insights, relating to autonomous “patterns of sensorimotor behavior” are integrated into the SIF. Indeed, it seems they cannot be without recognizing that abilities are underpinned by autonomously organized habitual structures with their own self-generating norms.

The proposed solution to the above issues is to argue for a compatibilist approach. SFs supply the norms for the bulk of the self-maintenance, and it makes sense to think in such terms when thinking about the ongoing reproduction of the *umwelt*. But tending toward “an overall grip on the situation” (Kiverstein et al., 2019, p. 2859) can supply a more general norm when existing norms will not do. This tendency enables one to pick up information that supports the production of SFs, establishing novel interdependencies between bodily structures and structures in the habitat, transforming the *umwelt* in the process. In a compatibilist approach, situational demands and the demands of self-production are constantly being negotiated. In part II, such compatibilities support an account of the individuation of novel SFs and the relational affordances they embed.

PART II: ENHABITING

Enhabiting provides an account of the individuation of sense-making frames based on the emergence of interdependencies between bodily structures and structures in the habitat. From a compatibilist perspective, it is the set of process by which features of the habitat of a species become incorporated into and transformed as features of the *umwelt* of a particular individual. This account of enhabiting takes inspiration from the Simondonian account of individuation.

Simondon

Simondon’s philosophy of individuation takes on the question of becoming at the level of individual entities (physiochemical, biological, psychological, social). How do individuals both come into being, and maintain their being thereafter? How do the boundaries and distinctions that characterize the individual take hold without any individual preceding them? Simondon starts with the supposition that what is primary is not the individual but the processes of individuation. Any “individual” is something like a time slice of those processes. Writing about Simondon’s approach, Weinbaum and Veitas (2017, p. 377) suggest that, “For him, the individual is a metastable phase within a continuous process of transformation...” The “individual” then is an abstraction from the primary reality that entails ongoing

processes of individuation. Giving some indication as to what this process might entail, Simondon (1992, p. 300) himself writes, “Individuation must... be thought of as a partial and relative resolution manifested in a system that contains latent potentials and harbors a certain incompatibility within itself...” Technical features of Simondon’s account have already been mentioned. Let me try to disambiguate the core features here before putting them to use.

The first feature is *metastability*. The term, as it is typically deployed today, comes from dynamical systems theory and describes systems that are relatively stable but not occupying any one particular deep well of attraction. Engström and Kelso describe a metastable system as one in which “no stable or unstable fixed points remain, yet dynamical remnants of attractor~repellers linger, giving rise to a dynamical flow...” (Engström and Scott Kelso, 2008, p. 4). Simondon’s use reflects such a definition quite well, although it has its own emphasis. Combes (2012), describing Simondon’s use of the term, speaks about a physical system being “in metastable equilibrium... when the least modification to the parameters of the system (pressure, temperature, etc.) is sufficient to break the equilibrium of the system” (2012, p. 11). An example of a basic system in a metastable state is a wobbling bowling pin, which although kind of stable, might just as likely tip over as come back to standing, depending on the slightest change in conditions. Weinbaum and Veitas (2017) also offer the illustrative example of two people engaged in an argument. One can recognize from such examples a degree of tension is necessary for a system to maintain metastability. Indeed, any such system necessarily harbors potentials that are effectively incompatible. Metastability is ongoing if the system has not exhausted these potentials, e.g., the bowling pin has not come to rest, the argument has not died out.

A second feature of Simondon’s account is the notion of *intensive differences*. Intensive differences (or intensities) are effectively the drivers of individuation. They are “energetic differences that drive structural and state changes in a system” (Weinbaum and Veitas, 2017, p. 376). In the example of the argument, the intensities can include each interactant’s personal convictions. These concerns animate the metastable system, potentially leading to breakdown, but also potentially resulting in *consensual structure*. If they find a point of commonality, or if one is convinced by the other, there is a *determination* of a shared understanding, e.g., an agreed upon solution and a momentary relaxation of intensities. Weinbaum and Veitas write that these “intensities are correlated to the measure of metastability and level of structural changes taking place in the system. Low intensities are associated with relatively more stable dynamics, while high intensities are associated with volatile dynamics and swift structural changes” (Weinbaum and Veitas, 2017, p. 377/8). In other words, if there is no tension, there are no drivers of individuation present, and metastability is unlikely to emerge. Equally, if tensions are too severe, the determination of consensual structure is less likely, or will be much more dramatic. Most individuation proceeds within the sweet spot of low intensities. Think of the likelihood for the determination of

some shared understanding in the context of a tiff as opposed to a bitter row.

Intensive differences arise within the context of a *problematic*. In the argument example, the problematic might be a work situation where the interactants need to coordinate on a project. Differing views on how best to approach it comprise the intensities that drive individuation, ultimately leading to some emergent consensual structure in the form of a shared plan. As Weinbaum and Veitas put it, “individuation of systems in general always starts from a situation of disparity. It takes place in the course of gradually establishing a coordinated exchange of signals among gradually differentiating elements that together bring forth a system” (Weinbaum and Veitas, 2017, p. 378). In this fashion, the system individuates and acquires an identity of its own, resulting from the coherence that has emerged between the involved agents. At any time, the system includes both consensual structure, comprising its previously individuated aspect, and ongoing intensities that drive future processes of individuation and either reproduce the previously achieved consensus or lead to its breakdown. These latent potentials, these unresolved intensities, Simondon refers to as the *pre-individual* elements in a system.

Any particular determination is highly dependent on its context and is in fact a codetermination between structural and behavioral aspects of the elements involved. The ongoing individuation of a persisting entity entails a trail of progressive determinations, a process referred to as *transduction*. For Simondon, this is a very general characterization and is taken to hold across domains, from the physiochemical to the social, in any of which it demands more specific description. However, there is a general logic at work here worth spelling out. The process of transduction describes a chain of operations on structures with each operation serving as a transformation of one structure into another, and every structure mediating between one operation and the next. Structure and behavior thus have a co-constraining effect: structure enabling the behavior that might follow from it and behavior enabling the (re)production of structural coherence. Transduction can start off quite messy and random, but as it progresses, invariants emerge such that “sets of structures and operations become mutually bounded,” and an “individuated entity arises which may either further consolidate or eventually disintegrate” (Weinbaum and Veitas, 2017, p. 379). Such entities, one might notice, have much in common with SFs, in which the organization enables behaviors that in turn enable the reproduction of the organization.

Autonomy and the Pre-individual

Di Paolo has acknowledged the import of the Simondonian perspective for enaction, writing that it “makes explicit the material conditions of autonomy and introduces new elements for enactivism such as the notion of pre-individual criticality as inherent in the living body” (2016, p. 14). Integrating certain ideas from this account with its notions of autonomy, sense-making – ideas that are “only implicit in Simondon” (ibid.) – and tending toward optimal grip, I introduce the notion of *enhabiting*: a compatibilist account of the individuation of the novel SFs that comprise the Umwelt, one that retains a strong

appreciation for the role of habitat (as a source of pre-individual potential) in its production, reproduction, and transformation. As such, the notion of enhabiting is a metatheoretical concept. Straddling frameworks with different starting points, it invites us into a somewhat liminal space that is sensitive both to the Umwelt and the habitat and focuses attention on the point at which the former is transformed within the latter. It, you might say, provides a metastable perspective from which to inquire into the dynamics of habituation and the emergence of relational affordances.

Enhabiting Proper

This is the basic account. Situationally tending toward an optimal grip one is also sense-making at multiple timescales simultaneously and thus acting according to the self-generating norms of multiple relevant SFs. However, intensities can arise between existing SFs at various timescales and situational demands, manifesting tensions with no practiced path toward reduction. If the system does not simply break down or default to existing SFs but can be held as metastable in tending toward an optimal grip¹², a momentary embrace of higher degrees of dissonance can provide an opening in which novel interdependencies can emerge between bodily structures and structures in the habitat, which thereafter form the basis for new SFs. This ongoing process in which novel SFs emerge (or existing ones are further consolidated) I refer to in terms of enhabiting. An example will be helpful.

¹²The notion of tending towards optimal grip may strike one as something of a *deus ex machina* in this context, attempting to explain the resolution of tensions into novel organization with something of a poorly specified “mechanism.” I have some sympathy with this concern, but for now I will simply say this. It is not entirely clear to me at this point how well enactive accounts focused on autonomy and accounts that lean on the FEP ultimately play together, but that our experience reflects a general tendency towards optimal grip over and above the normative dimensions of our existing habits does seem apparent. Thus, the notion of tending towards optimal grip at the very least, has some heuristic value. That said, my feeling is that the tension between these concepts reflects a larger theoretical tension between the theories within which these concepts are typically embedded, i.e. between accounts that center operational closure and those that center thermodynamic openness. Enactive approaches, as we know, tend to build their ideas with notions of operational closure center of mind (even if acknowledging the necessity of thermodynamic openness, e.g. Di Paolo et al., 2017, p. 115), more ecological leaning accounts tend to center notions of thermodynamic openness, even if sometimes acknowledging the role of operational closure (e.g. Chemero, 2009; Bruineberg and Rietveld, 2014; Rietveld and Kiverstein, 2014). In accounting for the individuation of novel habitual organizations, it seems one cannot, ultimately, ignore either perspective. The notion of tending towards optimal grip then, is used here as something of a placeholder, reflecting the dimensions of thermodynamic openness relevant to the individuation of novel habitual forms, but not yet well developed in the relevant literature so as to constitute a “mechanism.” What this mechanism must ultimately account for is the means by which the system can maintain a kind of situational metastability, very much along the lines of the Simondonian account, that enables the resolution of tensions into novel forms. There is ongoing work that explicitly takes itself to be working in the generative space between these two theoretical positions (i.e. operational closure and thermodynamic openness), e.g. Montévil and Mossio (2015), Woermann (2016), Loaiza et al. (2020). Although there is not time or space to develop the relevant histories herein, or work a sophisticated understanding of the insights of such positions into the present account, the compatibilist account under development here can be taken to be allied with such positions. Beyond this thesis, the thinking developed herein will pursue such generative tensions and their relevance for a compatibilist cognitive science more wholeheartedly.

Seeding a Habit

Enhabiting is ongoing all the time to varying degrees. There is, however, a scale of description that might offer a window onto these processes as they apply to our everyday experience. Before developing these examples however, it is important to prefigure them with the recognition that when one applies this as a lens through which to make sense of our everyday experience we are attempting to establish continuities between the domain of theoretical biology, in which these ideas can be more formally worked out, and into what is effectively the domain of folk psychology. Herein, the attempt is to develop accounts that help make intelligible the unfolding of everyday experience from the perspective of one who is concerned with such unfoldings, and hopefully do so in a way that does justice to their unfolding within biochemically instantiated entities in reciprocal exchange with their environment. In this way, the following discussion is one in which assertions of and are always posited as if the rest of the world we able to be held stable, and as if our concepts might reliably map to mind independent features in the world. With these caveats in mind, some examples will be helpful.

The first example developed here is of you attempting to develop a consistent exercise routine. This type of example is chosen for some very specific reasons. Firstly, those actively and consciously engaged in the processes of behavioral change have recognized some basic regularities within the processes themselves, and some guiding principles that make the stabilization of novel trajectories of action more probable (e.g. Fogg, 2019). It so happens that they parallel the Simondonian accounts of individuation quite well. A couple of stereotypical examples of change efforts are outlined and compared. The differences in the efficacy of approaches can help illustrate the details of enhabiting as necessary. As will be observed, what might be recognized as the typically more successful approach better approximates the conditions laid out by Simondon as important to the individuation of novel structure.

Secondly, when actively pursuing a behavior change a kind of meta-normative dimension emerges that works as a kind of implicit problematic (to use Simondon's term) coordinating the various components of the system under change. As such, at least for the purposes of an illustrative example, it offers a more circumscribed set of relevant processes that need to be included in the description, and thus a good starting point. Di Paolo has recently suggested that something that is missing from an enactive account is a "detailed look at the existential structure of becoming in conjunction with an operational/theoretical description of its relevant processes" (Di Paolo, 2020, p.3). What is provided here aims at precisely such an effort¹³.

¹³Such examples reflect an understanding derived from number of autoethnographic efforts (both successful and unsuccessful), familiarity with both popular and academic literatures pertaining to behavior change and frameworks for change, and my own developments towards a systematized practice for behavior change I refer to as Ecobehavioral Design (James, 2018). However, in this context these examples are not intended to be anything other than illustrative of the individuation of novel habitual organizations at multiple timescales, wherein, inspired by the Simondonian account of individuation, the dynamics that more reliably support the emergence of novel invariant patterns in individual behavior can be made intelligible through the compatibilist understanding being developed.

You habitually display a set of activities that reflect a personal identity that might be named "healthy person." Although you have not previously maintained a consistent exercise routine, you find yourself curious about the possibility, though tending to give yourself justifications for why you are not exploring it whenever the opportunity arises: you "haven't got the right space," the "right equipment," the "time to get to a gym" etc. Then, you move into a new house in which your new housemate exercises regularly with some gym equipment in the basement and tells you that you are welcome to join. Now you are resourced with everything you would need to engage the practice. You decide to join her with the ardent commitment that you are going to take it very seriously, envisioning yourself a competent exerciser within no time. However, within a couple of days of exercising one hour per day, you find yourself making excuses, and within the week have fallen off entirely. Your experience is not one of optimal grip, but of wild deviations from optimal. But from what are you deviating from? What is producing the dissatisfaction that now calls for some action or set of actions to bring about its reduction, ultimately leading to the abandonment of the practice?

A necessary starting point is the recognition that herein multiple existing habituated SFs are giving rise to a host of norms shaping your activities across levels of organization and timescales. Of course, in reality, the ecology of relevant habitual structures will be impossible to define and disambiguate. Nevertheless, there are some reasonably clear invariant patterns that suggest a degree of autonomy that can be abstracted and used as lenses through which to discern the various normative dimensions of the situation. At shorter timescales, norms embedded with habits and habit schemes that pertain to the avoidance of pain, the navigation of the gym equipment and the coordination limbs, muscles and breathing patterns in novel ways; at longer timescales, norms embedded within micro-identities of being efficient in your actions so as to get to work on time and within personal identities that might be described as "efficient learner." The experience of optimal grip in part relates to one's actions being concordant with such norms across timescales. Another way of saying this is that one is satisfying the self-generated norms of the SFs presently enacted by acting within the boundaries of viability they supply. However, rarely are norms across all timescales perfectly synergistic within a given situation, and particularly in novel situations such as this. What is more common, and is the case here, are incompatibilities of varying degrees between situational demands and the self-generated norms of SFs at varying timescales.

Initially, your grip on the situation maintains a kind of optimality, for you are satisfying the various norms constraining your action: variables relating to the experience of pain are all within viability, sensorimotor the same, you have plenty of time before having to leave for work, and you appear to be successfully enacting your identity as an efficient learner. Such an experience is likely to generate a deep sense of being well located. However, before long, simply exercising – say, for instance, you have started out on a rowing machine – proves to be something of a chore, and deviations from optimal abound, limits of viability are breached, and the self-regulatory norms that aim at some prior homeorhesis now animate you. You feel pain in your back and something

in the way you are bending your knee feels off, but you don't appear to be able to negate such dissatunements regardless of your adjustments. The warm up program in the machine proves difficult to follow and you start to think that you are truly awful at rowing. All of this seems somehow incompatible with your identity as an efficient learner, and you start to question yourself. By day three you have bailed because you have "too much on at present to give it the time it deserves."

In Simondonian inspired terms, the situation of committing to a practice one has not done before with the specific intention of bringing about a change represents a problematic (a task constraint that helps coordinate the components in the system), and the norms of existing SFs at various timescales (e.g. tendencies to avoid pain, identities as someone who gets to work on time and is an efficient learner) and the structures that support them comprise the intensities. These intensities are pregnant with preindividual potentials, and under this problematic can either lead to the breakdown of the system and its reorganization into some previous structure (as in the above example in which you abandon the practice), or, to the enhabiting of some novel SFs if the system can maintain metastability. In the example thus far, the former is a more apt description. Intensities are simply too pronounced, and thus the system defaults to some pre-existing habitual organization. Let's compare this stereotypical example of a failed effort towards behavior change with an example guided by a core principle of successful behavior change as championed by B. J. Fogg, the founder of Stanford's Behavior Design Lab. The principle is basically this, if you want to develop a new habit, make it small (Lieber, 2016; Al Marshedi et al., 2017; Fogg, 2019; Fogg and Euchner, 2019; Olt and Szasz, 2019). It's important to say here that the "habit" that eventually emerges as the micro-identity that might be described in terms of one's exercise routine, is not at all straightforwardly equivalent to habits as understood by Fogg. The equivalence is rather one in which a new trajectory or set of invariances in one's action is opened up and stabilized. Fogg would likely refer to this as a habit. In the language developed here, however, this new trajectory reflects an multiscale ecology of inter-regulatory habits that acquire some degree of coherence and closure. The present account is thus not intended as advice on how to change behavior (though it may be informative to such an account), and Fogg's work is leaned on only as an orienting device.

Imagine instead of taking the above approach, you commit to exercising for a couple of minutes every day for the first week, increasing each week thereafter for five minutes until you reach a practice time you are happy with. Besides the length of time you have allotted for practice, the same norms are operative. This time, however, norms embedded in habits relating to pain and discomfort are maintained mostly within viability, except for some slight tensions in your back; there is a newness to the sensorimotor coordinations the exercise demands, but nothing too strange; you have plenty of time before having to leave for work; and, you are acting from comfortably within your identity as an efficient learner. Under these constraints, although by two minutes you are experiencing some slight dissatunements and you have a distinct sense of being a "beginner," it is nothing greatly outside of what you might have anticipated. Within a

couple of days, the routine generates no feelings of dissatunement whatsoever, and a host of novel relational-affordances pertaining to the various aspects of the practice are available that previously weren't. Moreover, encouraged by the experience, the practice begins to solicit as a general course of action, and you find yourself looking forward to the slight increase in time each week.

In this example, and, I might suggest, what undergirds the success and attendant popularity of the "tiny habits" approach, the problematic is one in which low intensities prevail. Relatively low intensities are, as previously noted, associated with more metastable dynamics, and so the experience of optimal grip can be somewhat retained even when not acting strictly according to the norms of existing SFs. In other words, although the norms of some existing SFs are deviated from, such deviations are slight enough that the system does not fall back into some previously sedimented SF. Here, an opening is found, one in which novel interdependencies between bodily and environmental structures have the opportunity to stabilize, enhabiting novel SFs with their own self-maintaining norms. Tending toward optimal grip, novel SFs have being enhabited that carry your activity through a particular course of action for a particular period of time. These allow you to make sense of the ongoing therein and adequately anticipate some set of contingencies likely to arise.

Enhabiting emphasizes a kind of transformation in which dispositional affordances in the habitat of a particular species enable the emergence of relational affordances in the *umwelt* of a particular individual. It is the initial mutual bounding of structure and operation resulting from action that transforms or consolidates existing habits, or leads to new ones; the ongoing sensorimotor (or affective, or linguistic) constitution of habit structures at multiple timescales, orchestrated by the tendency towards optimal grip. It is the process, from within a compatibilist perspective, by which an "individuated entity arises which may either further consolidate or eventually disintegrate" (Weinbaum and Veitas, 2017, p. 379). The Simondonian notion of determination most closely resembles the notion enhabiting as developed here. However, given the precarity of SFs and their tendency to dissipate without reinforcement, enhabiting is intended to capture something of the notion of transduction also, in which a given structure can be more or less definitively individuated with successive determinations. Thus, we can speak about enhabiting in terms of degree, suggesting something about the degree of closure a given habit has acquired through repetition. In other words, SFs may start out as autonomous systems with poorly defined boundaries and so on, progressing towards greater degrees of autonomy with time and repetition, becoming more clearly articulated, more obdurate, and more trans-situational. Think of how the exercise habits of the beginner will be precarious, fragile, and dependent upon an ecology of supporting habits, whereas the habits of the longtime exerciser, who has personal-identities that have consolidated around such practices, will be much less dependent upon the enabling constraints of one particular environment (though they of course remain part of a larger ecology mediated by particular environmental structures). At such a level of organization an interesting dynamic is present, such that the endogenous side of the structural coupling begins to take some precedence. The

traveling exerciser who carves out a space for their routine upon getting to a new room, and so on.

Hesitation and Symmetry Breaking

Although there is not adequate space to develop them properly, there are a couple of promising ideas that might help deepen an understanding of enhabiting. The first is the Bergsonian notion of *hesitation*, particularly as it has been revived within critical phenomenology (e.g., Al-Saji, 2014, 2018). Alia Al-Saji has been central in this effort, applying it to an understanding of interrupting racializing habits of perception. However, it can be applied more broadly too. In short, hesitation simply points to the “temporality and space required to interrupt habitual patterns of perception” (Dolezal and Petherbridge, 2017, p. 7). Precisely such an interruption is necessary if novel interdependencies between bodily and sociomaterial structures are to stabilize. Reflecting the dynamics of enhabiting articulated above, in which existing SFs are not adequate to the task, Al-Saji writes the following:

These are events for which we cannot account from within our instituted system of meaning – events that reveal, if we are open to them, the fractures in the coherence of the visual field. There are two ways of responding to such events: by maintaining the normative organization of the field and refusing to see them, or by receptively allowing an event to insinuate itself into our vision as the dimension according to which the visual field is restructured – thus changing how we see.

(2014, p. 155).

Although Al-Saji refers solely to the visual field here, there is no principled reason why this precise understanding may not be applied to the processes of habituation more generally. When we hesitate, we allow “the time both for a situation to be undergone and affectively registered and for marginal self-awareness, searching, and recollection to take place” (Al-Saji, 2014, p. 146). What results, according to Al-Saji, is an “opening,” which must be “*taken up* for new possibility to be created” (Al-Saji, 2014, p. 149). By maintaining a grip on the overall situation, by hesitating and resisting the overdetermination of the situation by falling back on existing SFs, we can “take up,” or “enhabit,” new relationships that reflect new routes, modes and patterns of being, becoming “responsive to what . . . [we have] . . . been unable to see” (Al-Saji, 2014, p. 147).

The second notion is the idea of *symmetry breaking*, which comes from the maths of pattern formation, and abstractly describes a process in which order emerges in physical systems. For mathematicians, the degree of symmetry in a system is the degree of invariance present in that system under transformation. The more transformations that can be made that leave it looking unchanged, so-called *symmetry operations*, the greater the symmetry (Ball, 2009, p. 20).

Consider a perfect sphere. The sphere can be rotated indefinitely upon its axis without variance. Moreover, reflections across its axis, in which one side is mirrored back upon the other, are also infinite. It has an infinite number of transformations without change under the operations specified here and thus has high symmetry. Contrast this with a five-sided star, which has only five rotations and five reflections across its axis, a total of 10 possible symmetry operations under transformations accounted for here. In the five-sided star, we observe more order

than in the sphere, but this order, somewhat counterintuitively, is the result of a breaking of symmetries. Thus, the transition from uniformity to order can be thought to entail symmetry breaking. As Brender puts it, “the question of the genesis of form is not how symmetry arises out of disorder, but rather how the symmetry of disorder gets *broken* in determinate ways to produce the characteristic asymmetries of the forms we find in nature” (2012, p. 267).

Brender (2013) has tied these ideas to the notion of sense-making. Following Merleau-Ponty, who was wont to point out that it is the difference between figure and background that makes perception possible, Brender contends that it is the “asymmetry of the body’s environment that makes the perceptual regulation of movement possible” (2012, p. 240). The texture of such differences is precisely what allows for the getting of a perceptual “grip.” Such asymmetry, however, is also revealed by movement. Bodily movement helps reveal asymmetries as variation under transformation, the movement itself being the transformation which engenders variations in the perceptual field. Importantly, differentiation here is not a one-sided affair but is something that happens in the whole body–world relation. Combining these ideas with the notion of hesitation, one might suggest that hesitation provides the conditions for subtler forms of transformation, which in turn helps bring forth distinctions not previously available. If such distinctions support the general tendency toward optimal grip, structural interdependencies and new situational specific norms can be stabilized. The extent to which these ideas work well with the above account has not yet been adequately explored, but they seem promising.

Environments in Enhabiting

A final point in need of emphasis is the role of the environment in enhabiting. Enhabiting novel SFs is a process of establishing interdependencies between structures in the habitat and structures in the body that thereafter support the maintenance of our ways of life. The enduring invariant structures that any habitat provides prior to being “internalized” in the process of enhabiting supply potentialities which when in contact with the perceiving subject limit that subject such that only some forms of relation are possible. Speaking about the role of environment in Simondon’s account of individuation, Mark Hensen writes the following:

. . . the upward spiral of individuation is driven . . . [in part by] . . . the coupling of individuation with the entire environment as a source of “preindividual,” “metastable” potential. [This helps]... ensure that emergence qua individuation involves a recursivity that is not driven solely or primarily by the organism’s demands but that instead draws from the global situation – the preindividual as potential – within which all individuations necessarily occur.

(Hensen, 2009, p. 134)¹⁴

This position supports the ecological claim that affordances are enduring structures in the environment that drive adaptation, and the attendant SIF claim that tending toward optimal grip

¹⁴Text in brackets is my addition.

progressively realizes an attunement between organism and environment. Moreover, as previously mentioned, Di Paolo has written that, Simondon “makes explicit the material conditions of autonomy and introduces new elements for enactivism such as the notion of pre-individual criticality as inherent in the living body” (Di Paolo, 2016b, p. 14). Here, one can see that these contributions do not simply relate to the biochemical resources supplied by our physical environments but also the sociomaterial resources supplied by our habitats. Enhabiting recognizes a process that extends beyond the embodied subject at its center and is in contact with the raw materiality of the world beyond. With our ways of life, we brush against the world and rub off it. The notion of enhabiting offers a bridging concept, a point of contact that can be acknowledged by both ecological and enactive approaches. To enhabit is to bring forth (to enact) within (to inhabit)¹⁵. We do not simply inhabit our worlds, we enhabit them, growing them in this or that direction according to the actions we take, reinforcing existing corners through revisiting them and letting the ones that no longer serve us die off due to our absence. Thus, it may be more accurate to speak of the habitual organizations that shape our umwelts at various timescales as “enhabitings”, emphasising their nature as active entities that animate our being in the world.

CONCLUSION

The notion of enhabiting supports a dual-aspect view of phenomenal matter and can help deepen our sense of the compatibilities between ecological and enactive approaches in line with a radical embodied cognitive science. In doing so, it also provides a framing within which theories of learning from each approach, such as the enactive account of *equilibration*, or

¹⁵ I am aware that the suffix “en” does not capture the meaning of “bringing forth.” “Enhabit” is simply a portmanteau of enact and inhabit. Elsewhere, I speak of “coenhabiting,” extending these ideas to the social domain also (see James and Loaiza, 2020).

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- the ecological account of *direct perceptual learning*, can maintain productive conversations. Acknowledging such perspectivalism entails something of a metatheoretical move. In the philosophy of science, such moves are not without precedent. For instance, Roy Bhaskar’s philosophy of critical realism advances a so-called four planar theory in which any aspect of reality is to be understood as constituted by “four dialectically interdependent planes: of material transactions with nature, inter-personal action, social relations, and intra-subjectivity” (Archer et al., 2013, p. 566). In Bhaskar’s view, any of the planes can serve as a lens through which to make observations and conceptual distinctions, but any such lens is always in conversation with the others too, and any explanation given only in terms of one or another is only ever partial. I am not positioned to either endorse or reject Bhaskar’s view, I simply point to it as a precedent for the kind of move attempted here. However, given the epistemic limits set by enaction, the Umwelt does hold something of a privileged position. This should not be taken as a stain on our abilities to do good science, but rather an injunction against excessive hubris. Herein I have attempted to make sense of the frames through which we make sense. This is an odd task. At times like this one does well to remember that the map is not the territory (Korzybski, 1933), neither two compatible ones!

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Levels and Norm-Development: A Phenomenological Approach to Enactive-Ecological Norms of Action and Perception

Miguel A. Sepúlveda-Pedro*

Department of Philosophy, University of Montreal, Montréal, QC, Canada

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Université de Technologie
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Michael Wheeler,
University of Stirling, United Kingdom

*Correspondence:

Miguel A. Sepúlveda-Pedro
miguel.sepulveda.philo@gmail.com

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The *enactive approach* and the *skilled intentionality framework* are two closely related forms of radical embodied cognition that nonetheless exhibit important differences. In this paper, I focus on a conceptual disparity regarding the normative character of action and perception. Whereas the skilled intentionality framework describes the norms of action and perception as the capacity of embodied agents to become *attuned* (i.e., skilled intentionality) to preestablished *normative frameworks* (i.e., situated normativity), the enactive approach describes the same phenomenon as the *enactment of norms* (i.e., as sense-making) at different levels of organization that go from individual biological agents to linguistic encounters. I will argue that although both accounts accurately recognize important features of the norms of action and perception, they also have significant shortcomings. Norm-attunement accurately sees normative, ecological frameworks as the necessary set of constraints for the existence of norms at play in sociocultural bodily practices, but it fails to acknowledge the temporal and open-ended character of these norms and frameworks. Norm-enactment, by contrast, acknowledges that norms of action and perception are temporally open-ended, but fails to explicitly recognize that environmental normative frameworks are necessary for the enactment and development of all sort of norms in the interactional domain of an agent-environment system. To overcome these problems, I propose an enactive-ecological approach to norms of action and perception. This approach consists in describing norm-enactment as a result of a developmental process I call norm-development. This process describes the enactment of norms from the background of ecological, normative frameworks. These frameworks are norms enacted in the past of the interactional history of the agent-environment system that remain open to new configurations (new norms) in the present. To clarify conceptually norm-development, I appeal to Merleau-Ponty's descriptions of *norms of perception*, and more particularly to his concept of *spatial levels*. Like the enactive approach, Merleau-Ponty recognizes that perceptual norms emerge in the interactional history of the agent-environment system, but, like the skilled intentionality framework, he also posits that normative frameworks, that he calls levels,

enable and constrain the emergence of perceptual norms and its development. Levels are therefore a phenomenological description of ecological normative frameworks that has been temporally constituted and that stay temporally open-ended as a fundamental requisite for the enactment and development of norms of action and perception.

Keywords: enactive approach, skilled intentionality framework, phenomenology, normativity, affordances, Merleau-Ponty, embodiment, perception

INTRODUCTION

The enactive approach and the ecological approach of the skilled intentionality framework are two radical forms of embodied cognition that reject the orthodox conception of cognition as a computational function that is physically implemented in brain processes (e.g., Anderson, 2007; Metzinger, 2009). Instead, both the enactive approach and the skilled intentionality framework conceive cognition as an activity rooted in the dynamic sensorimotor coupling of the body and the environment (Rietveld and Kiverstein, 2014; Varela et al., 2016). This coupling permits cognitive agents to establish successful cycles of action and perception in bodily practices (Di Paolo et al., 2017; Rietveld et al., 2018), and to lay the foundation for other, more complex forms of cognition (Di Paolo et al., 2018; Kiverstein and Rietveld, 2018). Despite these shared convictions, there are important differences between these two approaches that prevent their *prima facie* potential complementarity (Chemero, 2009; Heras-Escribano, 2016).

One of the most important discrepancies between the enactive approach and ecological approaches to cognition is Gibson's claim affirming that ecological information (environmental structures of sensorimotor correlations) exists as a necessary condition for perception (Gibson, 1979/2015). For the enactive approach, perception depends on the enactment of a normative domain of sensorimotor interactions between an agent and the environment (Thompson, 2007). This normative domain is enacted in the concrete history of interactions between each individual agent and the environment, and no pre-given norms are given before this concrete sensorimotor history. The existence of ecological information as a necessary condition for perception is thus rejected by the enactive approach (Varela et al., 2016).

In this paper, I focus on a more contemporary difference that nonetheless recalls the earlier one. This new divergence arises when the supporters of both approaches claim that cognition is a phenomenon based on norms. Whereas the skilled intentionality framework describes skillful action as a process of *norm-attunement* (skilled intentionality), the enactive approach describes the same phenomenon as *norm-enactment* (sense-making). Norm-attunement implies the existence of normative frameworks (situated normativity) toward which individual subjects become attuned to once they acquire mastery of a bodily skill. Norm-enactment, by contrast, describes the enactment of norms based on the concrete history of interactions of the agent-environment system, but without explicitly acknowledging that normative, ecological sets of constraints are necessary for this process.

I will argue that both accounts of norms possess accurate descriptions and explanations of norms of action and perception,

but that they also have important shortcomings. Norm-attunement accurately describe the existence of normative, ecological frameworks as the necessary set of constraints for the existence of norms of sociocultural bodily practices, but this description fails to acknowledge the temporally open-ended nature of these norms, and their frameworks. The skilled intentionality framework recognizes that norms change over time due to transformations in the environment and as a result of the purposive activity of agents. However, this approach misses a crucial aspect of all embodied practices: the need for a spontaneous transformation of normative frameworks due to the internal dynamics of the interactional space between and agent (or multiple agents) and the environment. Norm-enactment, by contrast, acknowledges that norms of action and perception are temporally open-ended and, consequently, are open to constant changes in light of the complex dynamics of bodily practices, but the enactive approach fails to explicitly recognize that ecological and normative frameworks are necessary for the enactment and development of all sort of norms in the interactional domain of an agent-environment system.

I propose therefore an "enactive-ecological approach" to norms of action and perception as a way of overcoming these descriptive shortcomings of the skilled intentionality framework and the enactive approach. My proposal is to refine the account of norm-enactment with what I will call *norm-development*. This descriptive model not only conceives of norm-enactment as a temporally open-ended process, but accords with the ecological, normative frameworks that such a process requires.

To clarify this idea of norm-development, I propose to go back to the phenomenological work of Merleau-Ponty. He recognizes that perceptual norms emerge in the interactional history of the agent-environment system, but he also posits that normative frameworks, that he calls levels, enable and constrain the emergence of perceptual norms and its development. From a phenomenological perspective, the concept of spatial levels designates the ecological frameworks that has been temporally constituted and that stay temporally open-ended, fulfilling thus the description of norm-enactment as norm-development.

ECOLOGICAL NORMS: NORMATIVE FRAMEWORKS AND NORM-ATTUNEMENT

In the context of cognitive science, normativity usually refers to the correctness or incorrectness of actions based on activities such

as perceiving, remembering, imaging, reasoning and so on¹. The subject of norms and normativity has been one of the main axes of the ecological approach of the skilled intentionality framework because this approach has been always concerned about the way that individual cognitive agents acquire the required skills to participate in sociocultural practices (Rietveld et al., 2018). In this regard, the skilled intentionality framework has two different but interrelated descriptions of norms and normativity: (1) *situated normativity* (Rietveld, 2008), and (2) *skilled intentionality* (Bruineberg and Rietveld, 2014). In what follows, I will unpack these two fundamental concepts.

Situated Normativity

The notion of situated normativity is motivated by Wittgenstein's accounts of how a skillful agent is moved to take a particular set of actions to produce a satisfactory outcome of a sociocultural practice. Skillful agents, like tailors and architects, for instance, feel discomfort and discontent if they find the conditions of their practices unsatisfactory (Wittgenstein, 2007). If they have enough expertise, they can be moved to take action to improve these conditions (Rietveld et al., 2018). This can happen without the need for conscious reflection, because it is the feeling of dissatisfaction, and the felt demand or solicitation to take a particular set of actions, that actually describes the lived experience of skillful agents in action (Rietveld, 2008). This description reveals that skillful agents are already attuned to a normative framework that is not individual or private, but social and public. Sociocultural practices like tailoring and architecture have standards that are explicitly or tacitly accepted by a community to which tailors and architects belong. Thus, feelings of dissatisfaction and solicitations of action are grounded on public standards. This description led scholars in the skilled intentionality framework to adopt the idea that situated normativity does not refer to norms enacted by individuals, but to norms that rule the habitual patterns of bodily practices of a sociocultural group. These patterns were called, after Wittgenstein, a *form of life* (Rietveld and Kiverstein, 2014; Rietveld et al., 2018).

A form of life does not occur in a vacuum though. They are entangled with material structures or physical constraints that help to constitute and shape the norms of practices. For this reason, the skilled intentionality framework designates the environmental conditions of a human practice as a *sociomaterial environment* (van Dijk and Rietveld, 2017). Hence, there is a sociomaterial entanglement in the form of life of human beings. The paradigmatic case of a form of life is a sociocultural human group, but the notion of a form of life, nonetheless, is not exclusive to human beings. Human and non-human animals'

forms of life inhabit spatial regions that can be described as *ecological niches* (Rietveld and Kiverstein, 2014). These niches are not simply the raw material composition of a spatial region, rather these niches are best seen as the entanglement of this materiality with a form of life; indeed, an ecological niche refers to the whole set of a *landscape of affordances* for a form of life (Bruineberg, 2018).

The notion of affordances was originally defined by Gibson as the possibilities for action that the environment affords to an animal, for good or for ill (Gibson, 1979/2015). Although affordances are perceived in the environment, they cannot be understood without reference to the animal that perceives them, and for this reason it has been argued that affordances are relational properties of the animal-environment system as a whole (Gibson, 1979/2015; Warren, 1984; Heft, 1989). Chemero has argued, nonetheless, that affordances are more than relational properties: they are relations between the bodily skills of an animal and the relevant "features of the environment" (Chemero, 2009). This is because affordances are only perceived by animals that possess the required bodily skills to exploit the resources the environment affords, and because affordances do not refer to properties of objects but to the contextual conditions of a situation.

For the skilled intentionality framework, however, affordances should not be understood as relations between an individual animal and the environment, but between a form of life and the material (and in the case of humans, the sociomaterial) environment (Rietveld et al., 2018). The skilled intentionality framework distinguishes between two different sets of affordances: the first being a *landscape*, and the second being a *field of affordances* (Rietveld and Kiverstein, 2014). Whereas a landscape of affordances represents all those affordances available to a form of life, a field of affordances refers to a subset of this landscape, composed of affordances relevant for the task of a skillful agent. Such affordances can be seen as the *solicitations* that move an agent to act (Rietveld et al., 2018). As a result, an ecological niche entails the whole landscape of affordances of a form of life. In the case of non-human animals, the ecological niche is the relation between the patterns of behavior of a species, and the material conditions of their environment. In the case of humans, the ecological niche is the relation of patterns of behavior of a sociocultural group and the broader sociomaterial environment. In both cases, the normative framework is defined in reference to a group of individuals, and not to individuals as such.

Skilled Intentionality

The notion of skilled intentionality is built on two main pillars: Merleau-Ponty's phenomenology and Friston's free energy principle (Bruineberg and Rietveld, 2014). Skilled intentionality relates the process of attunement of a skillful agent to the relevant affordances. Phenomenologically, skilled intentionality can be described as the movement of a body toward an optimal equilibrium of the practical situation, or toward what has been called an optimal grip (Bruineberg and Rietveld, 2014). This tendency was originally defined by Merleau-Ponty in the following paragraph:

¹In the more specific context of 4e cognition, some philosophers influenced by Wittgenstein's late philosophy insist that norms and normativity apply only to actions concerning sociocultural practices, because only these practices implicate a criterion of correction that is agreed by a community (Heras-Escribano et al., 2015). The supporters of the enactive approach hold a wider conception of norms that include multiple aspects of life and sensorimotor interactions between biological agents and the environment (Barandiaran and Egbert, 2014). I depart from this general definition because later, the more specific conceptions of norms of the skilled intentionality framework, the enactive approach, and Merleau-Ponty's phenomenology will be defined.

For each object, just as for each painting in an art gallery, there is an optimal distance from which it asks to be seen – an orientation through which it presents more of itself... The distance between me and the object is not a size that increases or decreases, but rather a tension that oscillates around a norm (Merleau-Ponty, 2012, p. 315–316).

Following Merleau-Ponty, the skilled intentionality framework sees skillful agents as sensitive to the adequate affordances in a situation, and this sensitivity entails the capacity of agents to take the required action to change the equilibrium of a situation, bringing it closer to its optimal state. This supposes that each practical situation entails a norm or an optimal state that is dependent on the goals of individuals, as well as on conditions in the sociomaterial environment (Bruineberg and Rietveld, 2014).

The distinction between a field of affordances and a landscape of affordances is crucial, because whereas the landscape of affordances is defined by situated normativity, the field is better defined by skilled intentionality. The field of affordances, contrary to the landscape, is dynamic and can change at multiple temporal scales. At the behavioral scale, for instance, during the execution of a practice, the actions required to reach the optimal grip change constantly, because of the dynamic change of the practice itself (Bruineberg and Rietveld, 2014). At the developmental scale, the change of interests of an individual and changes in the material conditions of the environment can alter the relevant affordances (Chemero, 2009). At the sociohistorical scale, the nature of the practices, for example the customs and traditions, can also change, altering the field of affordances (Malafouris and Renfrew, 2013). Therefore, we can view skilled intentionality as a more flexible and dynamic description of normativity than that found in situated normativity.

Nevertheless, for the skilled intentionality framework, skilled intentionality and situated normativity are interrelated and complementary. Situated normativity, and the concept of the landscape of affordances, describes subject-independent aspects of norms of cognition. Skilled intentionality and its field of affordances describes the more contingent and subjective aspects of these norms (Rietveld et al., 2018). However, the dynamic development of a field of affordances can also alter the conditions of the environment, producing a dialectical movement between the agent and the environment that constantly alters the field of affordances (Bruineberg et al., 2018). Following theories of self-organization, the skilled intentionality framework shows how the conditions of the environment can constrain the self-organization of a system and reveals how the processes of self-organization can alter environmental conditions. This produces an effect of circular causality, where agents and environments become entangled because they are mutually constrained (Bruineberg and Rietveld, 2014). The result of this dynamic movement is the constant change of the field of affordances.

The naturalization of skilled intentionality by proponents of the skilled intentionality framework succeeds thanks to Friston's account of the free energy principle (Friston, 2010). This principle offers a statistical and dynamical model for understanding how

the brain-body-environment system organizes itself to reduce uncertainty, or what is known as *variational free energy*².

Uncertainty, or variational free energy causes an organizational disequilibrium in the brain-body-environment system that is affectively felt by cognitive subjects as a bodily tension that must be reduced (Bruineberg and Rietveld, 2014). The organizational composition of the body and the brain allows subjects to modulate their coupling with the environment in order to reduce variational free energy by a process called *active inference*. Active inference can produce changes in the system that reorganizes the brain, body, environment system, thanks to processes of motor action (Bruineberg et al., 2016).

The tendency to reduce affective tension explains the movement of the body to reach the optimal grip. This activity directed toward the optimum can either occur by changes in the self-organization of the brain-body system or by changes in the structure of the environment. The optimum is thus a norm that tacitly leads agents' behavior and their perception of affordances.

In sum, the skilled intentionality framework holds two different accounts of norms and normativity. On the one hand, situated normativity describes normative frameworks of social and biological groups, while on the other hand, skilled intentionality describes the more concrete attunement of individuals to those normative frameworks. I will call the first phenomenon *normative frameworks* and the second *norm-attunement*.

THE NORMS OF LIFE AND COGNITION

The enactive approach rejects the traditional definition of cognition as information processing and proposes instead an understanding of cognition as a form of *sense-making* (Di Paolo and Thompson, 2014). Sense-making basically implicates the enactment of normative domains of interaction between an agent and the environment. There are four main forms of sense-making related to four different levels of agency: the vital, the sensorimotor, the intercorporeal, and the linguistic levels. In what follows, I shall unpack the main aspects of the different forms of sense-making and the norms of cognition, according to the tenets of the enactive approach.

Vital Norms

For the enactive approach, life and cognition share the same type of formal organization (Thompson, 2007). Cognition is a more complex form of the basic modes of interaction of living organisms and their environments, and it is for this reason that any account of cognition must be derived from the basic descriptions of life (Di Paolo et al., 2018).

²In physics, the second law of thermodynamics states that all physical systems have the tendency to increase chaos and disorder, which is analogous to saying that systems have the tendency to reduce (thermodynamical) free energy. Claude Shannon made a similar claim for his theory of information, positing that all informational systems have the tendency to reduce uncertainty in the same lawful manner that physical systems reduce thermodynamical free energy. In the case of informational systems like cognitive systems, however, we are talking about variational, rather than thermodynamical free energy (Kirchhoff and Froese, 2017).

In this regard, the enactive approach sees living organisms as autonomous systems in precarious conditions with adaptive behavior (Di Paolo and Thompson, 2014). They are autonomous systems because organisms are systemic wholes of interrelated processes that have *organizational closure* (Varela, 1979). This means that living systems are composed of a network of processes that are causally interdependent, allowing living systems to constantly produce and maintain networks of processes (Di Paolo and Thompson, 2014). As with any other physical system, living systems increase entropy with time (Ruiz-Mirazo and Moreno, 2004), risking the loss of their autonomous organization, and ultimately, death (Weber and Varela, 2002; Di Paolo, 2005). To avoid destruction, organisms need to exchange matter and energy with their surroundings through processes of metabolism. As such, organisms should be understood as thermodynamically open systems that constantly renovate their material components to assure the viability of the system (Di Paolo, 2005). To accomplish these interactional processes with the environment, organisms must adapt or modulate their behavior according to norms that allow the system to remain viable (Barandiaran and Moreno, 2008). This means that the environment is primarily disclosed to organisms in light of their own fundamental concerns, which can be understood as moving away from destruction (Di Paolo and Thompson, 2014). Vital norms are thus norms that allow living organisms to satisfy biological needs and maintain *viable* their autonomous organization.

It should be noted that even this basic form of sense-making is more affective than purely cognitive, because the way the environment is disclosed by an organism is related to how the environment causes affective bodily states in the organism (Colombetti, 2014). This is to say that it is the body-environment state of organizational disequilibrium, and not the environment as a neutral landscape, that is felt by the living organism. This basic affectivity of life is akin to the affective state of humans described by Damasio (1999) as the feeling of being alive, which implies all of the brain activity related to the basic regulatory processes of the body. This feeling of being alive is arguably the basic requirement for any kind of sense-making and cognition (Fuchs, 2018). Therefore, for the enactive approach, the norms of cognition involve fundamentally affective states, and not merely cognitive states.

Sensorimotor Norms

At the sensorimotor level, where properly speaking, cognition appears (Barandiaran, 2017), a new form of sense-making arises thanks to the self-organization of the brain-body-environment system. This process of self-organization allows living agents to interact with the environment to accomplish practical tasks, from fulfilling biological needs, to tasks unrelated to these basic needs (Di Paolo et al., 2017).

Sensorimotor interactions are based on patterns of self-movement correlated to changes in the sensorial field. These correlations are known as *sensorimotor contingencies* (O'Regan and Noë, 2001). When these sensorimotor contingencies involve the coordination of many parts of the body, including brain

activity, they are called *sensorimotor coordination* (Buhrmann et al., 2013). When the coordination of the brain-body-environment system accomplishes a determinate practical task, implicating a normative outcome, sensorimotor contingencies implicate processes of self-organization called *sensorimotor schemes* (Di Paolo et al., 2017). These schemes are formed and reinforced by the successful realization of tasks, forming clusters of interdependent schemes that create the bodily or sensorimotor *habits* we observe in our everyday tasks. These tasks are given in specific contexts that solicit the enactment of a whole set of interrelated habits, establishing what the supporters of the enactive approach call a *microworld* (Varela, 1999; Di Paolo et al., 2017). Thanks to this self-organization of habits, the living body of cognitive agents acquires a new identity, a “sensorimotor self” that becomes different from the self-identity of life, because this new self is constituted by particular *sensorimotor norms* (Di Paolo et al., 2017, p. 142).

Although these sensorimotor norms can be rooted in biological needs, such as when human and non-human animals look for food and shelter, they can be also founded on the incorporation of sociocultural practices, such as cooking a dinner or dancing. Nonetheless, even if sensorimotor norms are originated in social frameworks rather than in the biological activity of the body, such norms need to be incorporated by the living body to enact meaning or relevance for the body's interactions with the environment (Di Paolo et al., 2017).

Intersubjective Norms

The third relevant form of sense-making and normativity articulated by the enactive approach is the enaction of norms that occasionally emerge from the interaction of two or more autonomous systems, called *participatory sense-making* (De Jaegher and Di Paolo, 2007; Froese and Di Paolo, 2009). When two or more autonomous systems interact, they often need to coordinate bodily movements in a way that allows each system to adapt its bodily self-organization for the accomplishment of a common goal. On some occasions, these interactions can produce a pattern of coordination that constitutes an emergent form of self-organization that becomes partially autonomous in relation to the purposes of individual participants.

The effect of this emergent self-organization of the interactive system forces individual participants to modulate their own sensorimotor norms, producing conflict between two different levels of normativity: the individual, and the collective (De Jaegher and Di Paolo, 2007). Such readjustment of the norms of individuals, caused by the emergent participatory system, allows these individuals to acquire new forms of sense-making, that is, new normative ways of interacting with the environment. These emergent participatory norms cannot be achieved individually, because it is only in the interaction with another participant that such forms of sense-making can be enacted (McGann and De Jaegher, 2009). However, they can permanently alter the sensorimotor norms of individuals even if they are not actively engaged in a participatory practice (Di Paolo et al., 2018). Therefore, for the enactive approach, there are norms of sensorimotor interactions that exceed the autonomy of individual

living beings because these norms are enacted in a system of coordination that is composed of more than one individual.

Linguistic Agency and Social Normativity

The model of participatory sense-making has now moved one step forward and describes the emergence of a new form of agency that can fully account for the normativity at play in sociocultural bodily practices (Di Paolo et al., 2018). This is a linguistic agency that emerges thanks to the permanent tension at play in the social interactions between individuals and social norms. This primordial tension can produce metastable processes that can function as instruments for the coregulation and meta-coregulation of social coordination, and eventually, to the use of public utterances that open a linguistic dimension for participants in a community. Although this model is too complex to be fully outlined here, it is enough to bring forth its main features to illustrate how, for the enactive approach, different degrees of social normativity emerge in the dialectics of participatory sense-making.

The original model of participatory sense-making already exhibits a permanent tension between the individual and the social or interactive levels of normativity. In the updated model of participatory sense making, this tension remains constant through different stages of conflict (dissonance) and harmonization (synergy) between the two levels of normativity. This tension initially forces individuals to adjust their own sensorimotor norms (sensorimotor regulation), but eventually such adjustments must be carried out jointly (sensorimotor coregulation). The sensorimotor coregulation of social interactions eventually produces social acts that serve to make these coregulatory acts more efficient. This is a process of meta-coregulation that will be present all across the following stages of the enactive model.

The efficiency of social acts of coregulation and meta-coregulation in wider social groups lead agents to the mutual recognition of other participants as agents. This becomes explicit in the emergence of a dialogic interaction, where the roles of an active regulator and a passive regulated member are interchangeable. At this dialogical level, agents use utterances to regulate social interactions, and there is a progressive construction of dialogical networks of utterances that are shared by a community in particular contexts of bodily actions, one that Di Paolo et al. (2018) call *participation genres*.

Participation genres bears similarities to the notion of micro-worlds at the sensorimotor level of autonomy, although in the former case, the normative structures of interaction involve not only networks of dynamic sensorimotor processes, but also a network of utterances.

Although these networks are constantly regulated by processes of mutual interpretation between multiple participants, these regulations may also take the form of self-interpretation. This can occur when a user of utterances becomes aware of an impairment between the pragmatic and expressive aspects of her own utterances (e.g., the utterance does not produce in others the responses she is expecting, according to what she is trying to express). This moment is crucial in the enactive model, because a new level of reflective, dialogical dynamics is incorporated to

the intersubjective skills of an agent. The successful utterances become regular patterns of dialogical practices for individual participants (either for their interactions with other agents or for their own interactions with the environment). The norms, co-enacted with others and embodied in networks of utterances (participation genres), now play a more explicit role as tools for self-regulation. Utterances are incorporated by individuals as regulatory tools for their expressive and pragmatic goals, and the new dialogical networks, afford the possibility of making explicit and questioning the already existent normativities at play. This gives to agents the opportunity to dialogically reshape and move forward the already existent norms.

The enactive approach has been criticized for being incapable of explaining social normativity because its account of vital, sensorimotor, and intercorporeal forms of sense-making refers exclusively to the normative domain of individuals (e.g., Heras-Escribano et al., 2015). Now, however, this approach offers a theoretical sketch of the emergence of social norms as arising from tensions inherent to the social interactions of autonomous agents. Recognizing situated normativity in this long and complex model of the enactive approach is not easy and requires an analysis that exceeds the scope of this paper. However, it is possible to recognize in this model how individual agents progressively acquire new regulatory processes that emerge from social interactions. It is at the final stages that the actions of agents are more explicitly guided by norms that are social and public, but from the early stages, individual agents are constrained by norms that are jointly enacted by more than one individual.

We can therefore conclude that the most relevant notion of norms found in the enactive approach can be located in the emergence of an interactional domain between one or many agents and its environment. These sense-making norms continue unfolding in time, according to constraints located in the history of interactions of the agent-environment system (Thompson, 2007; Varela et al., 2016). This descriptive account of norms is what I shall call *norm-enactment*.

ENACTING NORMS OR FOLLOWING RULES?

In traditional cognitive science, perception consists of simply retrieving information from the environment, thanks to the brain's capacity to produce internal representations or models from sensorial stimuli. It is assumed in these models that the facts of the world are independent of the subject, and the role of cognitive systems is simply that of accessing this ready-made reality. From this perspective, if cognition and meaning are normative, it is only because the contents of internal representations are more or less accurately correlated to the facts of a ready-made world (e.g., Millikan, 1984).

Neither the enactive approach, nor the skilled intentionality framework assumes that cognition consists in the production of internal representations of a ready-made world (Di Paolo et al., 2017; Rietveld et al., 2018). Rather, for these approaches, it is the active engagement of embodied agents that makes possible the experience of a meaningful world. Sensorimotor

interactions establish the primordial link between agents and the environment, and it is in this domain that fundamental norms of interaction and perceptual meaning emerge. The primordial layer of perceptual meanings is better understood as the opportunities for action that the environment provides for the accomplishment of sensorimotor tasks. However, these perceptual meanings depend on the bodily skills of agents. Although this basic picture works for the enactive approach and for the skilled intentionality framework, there is nevertheless one fundamental divergence in their claims that should call our attention. Whereas the enactive approach describes the constitution of cycles of action and perception in individuals as *the enactment of norms*, the skilled intentionality framework describes them as *the attunement of individuals to pre-given normative frameworks*. In my view, both accounts of norms have relevant shortcomings on this account.

Norm-attunement sees normative frameworks as pre-given sets of constraints that shape the embodiment of skillful agents, but these constraints are not themselves reshaped by dynamic processes of embodiment. The normative frameworks described by situated normativity are not eternal nor unmovable; they change as a result of transformations in the material structure of the environment and in the body (Bruineberg and Rietveld, 2014). Ultimately, they can change as a result of the intervention of agents possessing higher forms of cognition (Rietveld et al., 2017, 2018). Significantly, these descriptions leave out, however, one crucial aspect of all bodily practices (social or not), and it is this: the incessant transformation of norms due to the dynamical interaction of agents and the environment.

Norm-enactment, by contrast, fails to explicitly acknowledge the central role that ecological (normative) structures play in constraining the interactional domain of an agent(s)-environment system. These ecological structures, we must be clear, are not raw physical structures, but material structures impregnated with meaning. These environmental structures are not only necessary for explaining the enactment of norms, but also for understanding their progressive development.

Ecological and normative frameworks, however, are temporally open-ended structures that may constantly change due to tensions and ever-present movement within bodily practices. I will describe later how these sorts of temporally open-ended and ecological structures are necessary for the enactment of norms. I will call the descriptive account of the enactment of norms that includes these type of structures *norm-development*.

Breaking the Rules: Creativity and Improvisation

As we've seen, the norm-attunement element of the skilled intentionality framework offers a well-grounded theory of how, from a third-person perspective, individual agents incorporate the normative standards of a community for the realization of a bodily practice. This approach accurately recognizes that to explain the normative regulation of bodily sociocultural practices, normative frameworks, based on social conventions, are required. Norm-attunement, however, does not acknowledge that the constitution and progressive development of social norms are not extrinsic to the active participation of individuals.

The process of incorporation of sensorimotor norms (social or not) actually implies an internal dynamic movement that causes a self-movement, or a natural development of norms. Let me illustrate this phenomenon with the paradigmatic case of jazz improvisation.

Jazz improvisation requires some normative frameworks that jazz musicians respect, such as harmonic shifts and progressions (Walton et al., 2015). Jazz standards also provide a framework for improvisation. The personal style of each musician embodies their own normative way of playing jazz (Sawyer, 1992). Nonetheless, the improvisation – a good one at least – entails a dimension where all these norms are structures allowing agents to engender new ways of expression (Montuori, 2003), that is, new norms. This is true first of all because jazz improvisation consists in renewing the normative framework of jazz standards according to the current conditions of the environment. Such an environment may include the emotional states of participants, their interactions (Linson and Clarke, 2017), as well as the public (Sawyer, 1992; Walton et al., 2015). However, it is important to see that the success of an improvisation (or acting according to a norm) consists in doing the same thing, but always in a new way (Schiavio and Cummins, 2015), i.e., in a way that breaks pre-established rules (Barron, 1963). Successfully establishing a new norm in an improvisation (a new way to do things right) is more often than not a pre-planned action. Rather, success is the result of enacting a new “sense” when agents are immersed in the dynamics of the practice (Walton et al., 2015). This does not mean that jazz improvisation consists in unreflective action, since reflective and unreflective actions can be at play (Sawyer, 1992) at the same time. Instead, committing errors or breaking rules in unpredictable ways allows agents to reshape the pre-established normative framework and thereby enact new norms (Montuori, 2003; Walton et al., 2015).

In jam sessions, improvisation already exhibits an open-endedness in its interactional norms, but the dynamic “self-movement” of this practice goes further. In these sessions, musicians constantly and collectively create new structures of sense (new melodic patterns, licks, riffs, etc.) from previously given structures (standards, personal styles, musical rules). Some of these new melodic patterns are successful and may become part of the habitual repertoire of one or more of the practitioners. These new musical patterns are also open-ended structures, because even as repetitive musical phrases, they nonetheless vary all the time. The accumulation of new musical patterns can eventually transform and update the current personal norms of each musician (a personal style), as well as the norms of the particular collectivity (a group's style). The personal style of a musician, or the collective style of an ensemble can acquire a level of success that influences musicians in a wider community, and create a whole new style (e.g., Miles Davis and the birth of Cool Jazz). Once again, all along this process, reflective and unreflective actions take place, but the transformation of an old social norm (let's say Bebop) into a new one (e.g., cool jazz) cannot happen if musicians do not break (intentionally and unintentionally) previously given norms.

Jazz improvisation is a paradigmatic example of interactional dynamics moving forward the development of norms because,

for jazz practitioners, spontaneous creativity and novelty is an explicit command for the right accomplishment of this practice. This creativity nonetheless is not an aesthetic luxury for other bodily practices, it is a necessity.

The use of recurrent and historically acquired patterns needing constant adjustments to deal with new circumstances takes place in all sorts of bodily practices. Baber et al. (2019) for instance, describe how goldsmiths need to constantly adjust and adapt previously acquired techniques, in light of the type of “responses” the material sends back to their bodily actions. This dynamic process of re-adaptation involves a continual re-interpretation of the space of available affordances, one that keeps changing insofar as the process of making jewelry continues. The expertise of a goldsmith actually consists in being capable to make the proper adjustments of their habitual patterns of interaction to suit contextual demands.

Likewise, Ingold (2010) claims that many social practices consist in the constant adaptation of action to the constant flow of both material and forces. For Ingold, the paradigmatic example of bodily practices is textile weaving, whereby weavers use available material to design a unique path of becoming, one that embodies the context of the weavers. Ingold contrast how weavers deal with the dynamical flow of materials with modern architecture. Ingold claims that modern architects are distant from the process of building, and instead of dealing with the flow of materials, they reflectively imagine and plan the form and shape that materials will acquire. This modern practice is in sharp contrast with that followed by medieval architects. The architect responsible for the cathedral of Chartres, for instance, was the master of builders, and, as such, he stayed on site in the building process to deal with the contingencies of his endeavor. In this case, there was actually no plan in advance, and the final outcome was the result of the process of dealing with both the available material, as well as contextual demands (Ingold, 2010).

The status of architecture has been a major concern for supporters of the skilled intentionality framework. Contrary to Ingold, I do not think contemporary architecting is a disembodied practice as he describes it. The skilled intentionality framework has convincingly argued that architecture is tightly connected to affective bodily sensitivities (Rietveld and Brouwers, 2017; Rietveld et al., 2017). This argument is helpful in closing the gap between basic and complex forms of cognition (Rietveld et al., 2018). For the practice of architecture, the complex entanglement of different bodily actions involving the use of many cognitive and technological resources needs further analysis, so that we may understand how a contemporary architect deals direct or indirectly with the material flow. Be this as it may, I am convinced we should not describe architecture as a disembodied practice, but rather as a very complex form of embodied and enculturated practice.

It is important to understand that the dynamic development of norms is not restricted to social practices. Social interactions between agents and technological artifacts such as tools make the internal dynamics of bodily practices more complex, but in the direct relation between a solitary agent and the environment, there is already a need for constant adjustment of sensorimotor

norms. I will describe these processes in section “Sensorimotor Development.”

In sum, whether social or not, bodily practices involve a dynamic encounter between the habitual past and the unexpected demands of the environment in the present. For this reason, norms of action and perception are always subject to a continuous development. How practitioner adapt to the contingencies of the present does not always entail significant change, so we can assume that a static set of norms are at play in many practices over long periods of time. This does not mean that the permanent dynamics of bodily practices are not at work. It is precisely for this reason that norms of action and perception should be seen as temporally open-ended norms, subject to changes in the endogenous interactions of a bodily practice. This is an aspect that the skilled intentionality framework fails to acknowledge in their descriptions of norm-attunement.

The Self-Movement of Norms

The enactive approach offers a more accurate description of the temporally open-ended nature of norms than the skilled intentionality framework. Norm-enactment not only acknowledges the constant dynamic adjustment of norms in light of environmental contingencies, it also sees the constitution of social norms as a dynamic process of tensions and coregulations between autonomous agents that involves the constant movement and development of norms. This does not save the enactive approach from an important shortcoming. This is the neglect of the role that ecological structures can play in the constitution and development of norms (cf. McGann, 2014).

Sense-making is the enactment of norms at the biological, sensorimotor, and social scales. At the biological level, in the paradigmatic descriptions of vital norms, it is clear that these norms are constrained by the physical conditions of the environment. At the same time, it is not equally clear if they are constrained by precedent normative frameworks as well. In the classical example of the enactive approach, where *E. coli* bacteria respond behaviorally to the presence of glucose, it is argued that bacteria make sense of this chemical compound according to their metabolic needs (Thompson, 2007, p. 74), thus bacteria make sense of the glucose as food.

This description suggests that, for the enactive approach, meaningless physical matter acquires meaning thanks to the interests (teleology) of the organism. In this regard, De Jesus (2018, p. 873) criticizes the enactive approach for what he names an “epistemic perspectivalism” of this approach. He argues that sense-making involves the description of the world “in itself” that appears differently (as meaningful worlds) to subjects with different bodies. Such a picture described by De Jesus, however, presupposes a distance between the environment and the agent that is surmounted epistemologically. This description of sense-making is inaccurate.

For the enactive approach, the world described by physics and chemistry (e.g., glucose) is not a description of the world-in-itself, or an objective reality independent of any agent as it is for mainstream scientific approaches. Enactivists see the descriptions of science as part of the meaningful

world of humans, and as the result of an embodied and enculturated practice. For the supporters of the enactive approach, scientific descriptions are not descriptions of an objective world (Thompson, 2016). Therefore, the meaning “food” for bacteria, and what a scientist conceives of as “glucose” are not two epistemic perspectives of the same object. Instead, they are two different forms of an agent-environment entanglement.

We need to be clear that the birth of norms is not the result of putting in connection two alien objects, but a reorganization, a new sense of a pre-given form of an entanglement already at play. When we describe the emergence of a vital norm, like *E. coli* bacteria perceiving glucose as food, we cannot state that an organism projects meaning on a raw physical substance. It is more proper to say that an organism *incorporates* an aspect of the environment into its interactional domain (*Umwelt*). An incorporation, in this case, means a reorganization of the agent-environment system, the acquisition of a new sense or a new norm for the sort of interactions this system maintains. For instance, Barandiaran and Moreno (2008) posits that normativity, at the level of life, entails two different kind of processes: constructive processes and interactive processes. The first set of processes consists in the network of processes needed to maintain the autonomous organization of a living organism. They are topologically localized into the boundaries of the organizational closure of the system. The second set comprises the processes of interaction between the agent and the environment that are needed to maintain the viability of the system. It is important to note that both set of processes are necessary to preserve the viability of the system; i.e., both constructive and interactional processes are constitutive of the vital norms of a living organism.

As part of one single system, any change in the norm of interactions means a reconfiguration of the whole system (Gestalt). This is precisely what happens when *E. coli* bacteria find lower levels of glucose and high levels of lactose. The bacteria change its constructive processes (its gene expression) to metabolize lactose instead of glucose, adapting their interactional processes to the current conditions of the environment (Barandiaran and Moreno, 2008). In this case, the adoption of a new norm consists in a reconfiguration of the whole Gestalt, and not simply on the way the agent makes sense of the environment. Since the acquisition of a new norm implies changes in the body of the living agent, or in its constructive processes, the adaptive behavior of an agent also entails some sort of incorporation.

It is common to speak about incorporations in the literature of the enactive approach when human agents change their sense-making capacities through the habitual use of tools (Di Paolo, 2009; Thompson and Stapleton, 2009). This is called *tool-incorporation* (Fuchs and De Jaegher, 2009). There is, however, another sort of incorporation that occurs when other living agents transform our sense-making. This is called *mutual incorporation* (Fuchs and De Jaegher, 2009). There is a third form of incorporation that is not the integration of an environmental aspect into the boundaries of the body, but the incorporation of aspects

of the environment into the perceptual field of agents and that are not necessarily affordances. This is something I will call *excorporations*, and I will explain their relevance in the section that follows.

Excorporations and Norm-Development

The term *excorporation* was coined by Merleau-Ponty scholar David Morris to describe, from a phenomenological stance, those aspects of the environment that are vital for the body, but that remain external to the body (Morris, 2004, p. 131). He describes *excorporations* as the counterpart of bodily habits topologically situated in the environment. The idea of *excorporation* is similar to that of affordances in the language of ecological approaches, but different because the term does not refer to specific practical meanings of things, but to anchorage points of the environment that allow agents to become situated in place (to reside or to inhabit it).

Contrary to incorporations, which are portable aspects of the environment (e.g., the cane of a blind person) *excorporations* are not portable and remain situated in places (e.g., the door frame of my bedroom). As a result, they appear to be subject independent, but they are not. They are the counterpart of bodily habits, or, better yet, bodily habits are the counterpart of the places a body inhabits. As an example, Morris describes how Earth *excorporations* are constitutive aspects of the way we inhabit as bodily agents of our planet (Morris, 2004). A further analysis of *excorporations* can be revealed by examining the notion of spatial levels in Merleau-Ponty's phenomenology. I will come back to this subject in the last section. For the time being, we need to understand that the idea of *excorporation* shows us that the environment is entangled to the body in such a way that we must stop thinking of the agent and the environment as two separated objects that become linked only when a sense-making norm arises. The agent-environment entanglement always precedes the enactment of a norm. This enactment is a reorganization or a reconfiguration of the agent-environment entanglement, and the actualization of a pre-given norm.

For this reason, the analysis of sense-making should show us that the enactment of a norm is the result of the actualization of the historical past (a pre-given norm) of the agent-environment system in the current flow of the present. In this case, actualization does not mean a mere adaptation or a transformation of the historical past into the present conditions, as when we change our old-fashioned clothes for the latest fashion designs. Actualization means the conflict arisen from the encounter of bodily habits and the unexpected conditions of the present. This encounter produces a disparity or a tension between the past and the present, making the agent-environment entanglement move forward while engendering concrete living acts that constantly reorganizes the agent-environment entanglement (see Morris, 2017 for a phenomenological interpretation of this phenomenon).

Somehow, every action and perception cycle are the enactment of a new norm, or at least, its actualization (you could not step in the same river twice). But the tendency of agents to reduce the tension created by the disparity between the habitual past and the unexpected present produces a stabilization

or a balance that normalizes agent-environment interactions. However, when the disparity creates an important amount of tension, a major reconfiguration of the entanglement is needed, and the enactment of a fully-fledge new norm occurs, which can be understood as a new normalization of the interactional agent-environment domain. Piaget's theory of equilibration, evoked by the enactive approach to explain the development of sensorimotor norm (Di Paolo et al., 2014, 2017), resonates with this conception of norm-development.

Sensorimotor Development

For the enactive approach to sensorimotor norms, *Piaget's theory of equilibration* illustrates the adaptation and transformation of sensorimotor schemes (see section "Skilled Intentionality") for generating new ways for these schemes to function, when agents find new challenges in the environment (Di Paolo et al., 2017). Two processes are crucial here: *assimilation* and *accommodation*.

Assimilation refers to the integration of an environmental aspect into the physiological or cognitive/behavioral structure of the agent (Di Paolo et al., 2017), and, in the words of scholars of the enactive approach, this is "one way of saying that the agent and environmental sides of a sensorimotor scheme are in agreement according to the relevant norm" (Di Paolo et al., 2017, p. 84). This resonates with what I have called an incorporation of the agent-environment entanglement.

Accommodation, on the other hand, describes the processes by means of which an agent modulates its physiological and/or behavioral structures to facilitate the assimilation of an aspect of the environment that is not yet assimilated. Equilibration, thereby, is the process by which a sensorimotor organization reaches a new stability, reducing the tension and the disparity caused by the encounter of the novel. The result is thus a dialectical process that transforms the past into a new present, reducing the tension between the two, and engendering a new norm. This is what I mean by norm-development.

The only aspect that needs to be reconsidered in this theory is the idea that the enactment of a new norm involves a modulation or an adaptation of the body of an agent and its pattern of behavior, without considering that changes in ex incorporations also occur. These changes transform the sense of a situation and, consequently, change the specific meaningful aspects of the environment. For instance, learning to swim can be understood as the acquisition of a new skill that comprises multiple sensorimotor schemes (e.g., kicking, stroking, and breathing). In this example, the water of the pool ex incorporates a sort of place where I can find affordances for floating, diving, toppling, etc. This new agent-place entanglement becomes pregnant with a new realm of possibilities for learning different swimming styles, explorations, dancing, etc. Before the basic swimming-norm was acquired, the water of the pool was not a place of residence, nor it was imbued with a rich landscape of affordances and solicitations. Instead, the pool was a place where doing things in-the-water were senseless.

Norm-development is thus the result of enacting norms, and not a process of following static rules. For this reason, the notion of sense-making is more adequate for understanding the norms of perception than notions of situated normativity and skilled

intentionality³. The descriptions of the skilled intentionality framework and ecological approaches are nonetheless quite useful for explaining the nature of what I've been calling ex incorporations. A field and a landscape of affordances are useful concepts for understanding the counterpart of bodily habits which has been the focus of the enactive approach. Nonetheless, a truly enactive interpretation of these concepts is needed. As a first step to understanding the ecological realm from an enactive perceptive, I will describe the account of norms and spatial levels found in Merleau-Ponty's phenomenology. This should help us to understand the logic of norm-development from a full-fledged enactive-ecological approach.

NORM-DEVELOPMENT AND THE DIALECTIC MOVEMENT OF LEVELS

In this last section, I specify the characteristics of norm-development, in light of the normative account of perception described by Merleau-Ponty (Merleau-Ponty, 2012, 2013), with a special focus on the notions of *spatial levels* and *levels shift* (Talero, 2005; Marratto, 2012; Morris, 2017, 2018). In the first section, I will introduce the context of perceptual norms from the standpoint of phenomenology. In the second section, I will refer explicitly to the notion of levels and, in the last one, how levels shift involves a phenomenological description of norm-development.

Horizons and Virtual Fields

Phenomenology comes with its own conception of norms that must be clarified before we put forward a phenomenological account of norms of perception that can productively dialogue with the enactive approach and the skilled intentionality framework. I will start by sketching out the normative character of experience in the context of phenomenology.

Phenomenology describes and analyzes subjective experience, but phenomenology is not a description of the contents of our subjective experience. Instead, phenomenology aims to describe and analyze the structural aspects, or the invariants of experiences (Gallagher, 1997). In this regard, phenomenology is a *transcendental philosophy* because it is concerned with the conditions of possibility for having experiences, i.e., for those necessary structures that constitute our perception, remembering, thinking, and so on.

To accomplish a transcendental analysis of experience, Husserl applied a strategy known as the phenomenological *epoché* (Husserl, 1982, p. 61). This epoché puts aside any judgment about the positive existence of the objects we experience, something we spontaneously do in our everyday lives and even in our scientific claims. Husserl called this the *natural attitude* of experience (Husserl, 1982). By utilizing the epoché, we can shift our attention from *what* things are given in our experience, to *how* these things are given in experience, thereby adopting a *phenomenological attitude*.

³However, the specific notion of active inference, part of the conceptual repertoire of the skilled intentionality framework, may suggest that such development occurs (cf. Ramstead et al., 2019).

From this transcendental standpoint, Husserl, similarly to Brentano, holds that acts of consciousness (i.e., perception, memory, imagination, etc.) are usually directed at something (perceptual objects, memories, expectations, etc.). This relation between acts of consciousness and objects of experience is named *intentionality*. This intentional relation between acts and objects is normative mainly because it implies what Husserl called a *structure of fulfillment* (Husserl, 2001, p. 280–283), which simply refers to how the intention of an act can be fulfilled by the intended object (Crowell, 2013; Doyon, 2015).

The intentional structure of fulfillment is particularly important for describing perceptual experiences, because the intention of perception is always directed toward a real and concrete object, and not merely to an imaginary or an abstract one. My visual perception of a tree intends the actual tree, not the concept or the re-presentation of a tree. However, perceptual objects will never fully fulfill my perceptual intentions because perceptual objects are always presented only partially (cf. Husserl, 2013). For instance, my perception of a tree from the window of my house presents only one sensorial profile of the tree (e.g., a couple of branches), whereas many other profiles remain hidden to my view (the backside of the branches, the trunk, the roots, etc.).

Despite this incomplete fulfillment, my perception is about the whole tree, not about one profile of the tree. This is nowadays called the problem of perceptual presence (Noë, 2004). This problem raises the question of (1) what conditions make possible that the sensorial givenness of only one profile of the tree evokes my experience of the tree as a unified whole; and also the question of (2) what makes one profile match with the anticipation of my intentional act that perceptually intends a tree. To respond to these questions, we need to clarify what the constitutive aspects of my perceptual experience are, as well as the character of the norm that relates the profile and the object.

The response of Merleau-Ponty to these questions originated in Husserl's works⁴ is essentially that (1) the presence of perceptual objects as we perceive them is given thanks to a fundamental link between the bodily motor skills of a subject, and the motor significances of things. Merleau-Ponty called this link *motor intentionality* (Merleau-Ponty, 2012, p. 113). For Merleau-Ponty, the lived body of a subject implies an articulated unity that he called body schema (Merleau-Ponty, 2012, p. 100–103). This articulation is performed according to the needs of practical task. That is to say that the body schema is basically the self-organization of the body according to sensorimotor norms (cf. Gallagher, 2005). The lived thing, by contrast, is a unity of motor significances correlated with the motor skills of the body schema. We can interpret motor significances here as affordances. Hence the lived thing is the unity of affordances correlated with the motor skills of the body unified in the body schema (Merleau-Ponty, 2012, p. 334).

⁴The normative condition of experience and more particularly of perception was originated in Husserl's work (Crowell, 2013; Doyon, 2015, 2019). It was Merleau-Ponty, however, who more systematically develop this subject. Since I find relevant the notion of spatial levels from Merleau-Ponty's phenomenology to improve our understanding of norm-development, I will refer almost exclusively to Merleau-Ponty's work.

The synthesis of the thing (as a unity of affordances) is nonetheless a temporal synthesis or a synthesis of transition (Merleau-Ponty, 2012, p. 344). Only one profile of a thing is given at the present moment, however, the profiles non-viewed of the thing are lived as anticipations for motor actions. For instance, I cannot see the backside of my computer, but I can anticipate that if I turn it around, I will see its backside. This synthesis depends nonetheless on the synthesis of the body which is also temporal because the lived body is articulated thanks to its acquisition of bodily habits. These habits anticipate the encountering of perceived things in the way our body is familiarized to do it. The synthesis is, however, unfinished because both the body and the thing remain open to unexpected encounters, to failures in the norm that coordinate the movements of the body and the constraints of things (cf. Merleau-Ponty, 2012, p. 476).

Returning to the second of our earlier questions, (2) what allows for the disclosure of a thing, as a whole, from the sensorial givenness of only one of its profiles are the motor significances that such a profile affords to the body. Motor significances are invitations that the thing manifests or presents to my body from the current sensorial presence for exploring and manipulating it (Merleau-Ponty, 2012). The tree is given as a whole not because I imagine or represent the whole tree from my partial view of it, but because the tree itself affords further explorations to my motor skills, and its profiles, even those that remain invisible, are not really absent but *present* as correlates of my motor skills (Merleau-Ponty, 2012).

However, since things are never given as fully present, the possibility remains that my anticipations mismatch the actual conditions of things. Maybe if I get closer to the window, I can realize that the tree is not a real tree but a hologram of a tree, and then I won't be able to touch it, to climb it, or to see its back, as I anticipate it. It was just an illusion. Perception, therefore, rests on anticipations that are never completely fulfilled. Nevertheless, there are still some angles or perspectives from where things are disclosed optimally. In this context, Merleau-Ponty claims that the optimum of perception (the optimal grip) is the way that an object present itself more clearly (Kelly, 2005), that is to say to find the right bodily articulation that better disclose the affordances of things (see section one). However, for Merleau-Ponty, the optimum (or the norm of perception) is not constituted by the characteristics of the thing itself, nor even by the relation between the body and the thing, but by the whole horizontal structure within which the body-thing correlation is enveloped (Merleau-Ponty, 2012).

A horizon is a phenomenological description of many structural aspects of experience that accompany the intended objects. For Husserl horizontal aspects or experiences are co-intended or co-given (Husserl, 1982, p. 94). Hence, horizons, roughly speaking, are those aspects of the perceptual field that play the role of a background for those objects I'm focusing my attention. However, horizons are more than a mere accompaniment to focused objects; they are a constitutive part of my lived experience of them. For this reason, Merleau-Ponty holds that the optimum of perception involves the equilibrium

of internal and external horizons (Merleau-Ponty, 2012, 316). Husserl defines the internal horizons of perceptual objects as those aspects that are not directly intended, but are still part of the intended object, as with the unseen profiles of the tree. The external horizons, by contrast, are those elements that surrounds the object, like the garden where the tree is rooted, the blue sky that contrasts with the green of its leaves, etc. (Husserl, 1982).

Horizontal aspects of experience are not only those elements implicit in the perceptual field, but also the motor skills that correlate the motor significations of things. That is why Merleau-Ponty claims that the body is the third element implicit in the figure-ground couple of perception (Merleau-Ponty, 2012, p. 103). However, these bodily skills are constrained by the whole relation of forces present in the field. As Merleau-Ponty claimed in *The Structure of Behavior* (Merleau-Ponty, 1963), the soccer field, for the player, is not an object but a field of forces where consciousness consists in the dialectics between the milieu and the body. Moreover, this field constantly changes considering the actions accomplished by the body, establishing new lines of forces (Merleau-Ponty, 1963, p. 168–169). Therefore, the norms of perception are not constituted by the characteristics of things as such, so much as these characteristics are implicitly correlated to the abilities and skills of the body, and all those horizontal aspects that structure the whole condition of the phenomenal field where any focused aspect is always embedded.

The whole normative framework of perceptual experiences is thus ecological because such a framework depends on structures present in the environment that constitute the way an object can be optimally disclosed by a perceiver. The adjective ecological, in this case, does not only implicate the relation between an agent and the environment, as ecological approaches affirm, but also the subjective engagement of an agent into its environment. That is, how the environment appears for the agent according to its embodied subjectivity.

The optimum is thus the norm of a whole situation that can involve many worldly aspects that constitute the forces of the field, but that can be also altered, changing the orientation of these forces, manifested in a new sense of perceptual experiences. To improve our understanding of these perceptual norms, Merleau-Ponty's scholars have been lately appealing to the notion of spatial levels that I will review in the next section.

Levels of Perception

In his *Phenomenology of Perception*, Merleau-Ponty describes the general notion of space from a phenomenological standpoint, including the body as a constitutional aspect of this dimension. Merleau-Ponty highlights that our experience of space, in normal conditions, implies a particular orientation (e.g., up, down, left, right) that is given to us without the need of conscious reflection (Merleau-Ponty, 2012, p. 259). The primordial sense of space, for Merleau-Ponty, is not an abstract geometrical dimension that works as a sort of container for the objects and events that exist in the world, which is what Merleau-Ponty calls *positional spatiality* (Merleau-Ponty, 2012, p. 102). Rather, for Merleau-Ponty, the primordial form of spatiality is a *situational*

spatiality that involves the active engagement of the body in the accomplishment of motor tasks (Merleau-Ponty, 2012, p. 102). This general notion of space entails the horizontal domain of all our possible bodily actions (Merleau-Ponty, 2012, p. 260).

There are more concrete or delimited spatial regions that following Casey (1996, 1998) we can call *places*. These places possess *anchorage points* that allow our bodies to situate themselves in or inhabit them (Casey, 1998, 229; Merleau-Ponty, 2012, p. 259). The anchorage points grant places a kind of stability, establishing what Merleau-Ponty called *spatial levels* (Merleau-Ponty, 2012, p. 259). These levels are normative aspects of perception because they refer to the habitual or preferential ways our body interacts with the environment, something that presupposes a previous attunement or “a pact,” between the body and world (Merleau-Ponty, 2012, p. 261).

The kind of normative character of levels thus does not refer to the perception of things, but to the horizontal aspects that accompany it. Talero, for instance, claims that a spatial level “establishes a place or a setting for my actions to range over by inaugurating a preferential perceptual norm within my situational spatiality” (Talero, 2005, p. 448). That is, *levels are norms of Places*. Unlike things, places are not usually the focus of our attention. Instead, places tend to serve as stable settings that background our everyday activities and aspects of the environment that we find relevant (e.g., things, colors, shapes, etc.). Hence, places, from a phenomenological standpoint, are horizontal aspects of our perceptual intentions that work as the counterpart of our embodied subjectivity.

The ubiquitous presence of some spatial levels (the more general ones) requires that we alter the normal conditions of our sensorimotor interactions to be able to recognize them. This is what Merleau-Ponty did through his interpretation of a few classical experiments. First, he refers to a Stratton's experiment where a subject use goggles that invert the visual field for 8 days. The visual field is perceived up-side down at the beginning. After a couple of days of use, however, the subject starts to live the visual field normally but begins to feel that her body is inverted. After 8 days of use, the whole sensorimotor interaction is finally readapted, and the visual field is lived normally (Merleau-Ponty, 2012, p. 255). In the second example, Merleau-Ponty describes Wertheimer's experiment, where a subject is put in a room, but can only see through a mirror that is tilted at an angle of 45 degrees. The subject initially sees everything obliquely, and even the movement of objects in the visual field is perceived with an oblique deviation. However, after a few minutes, the subject starts to perceive the entire scene vertically once again (Merleau-Ponty, 2012, p. 259).

These examples allowed Merleau-Ponty to see that spatial levels exist in our normal sensorimotor coupling, and that some habitual sensorimotor coupling can be altered if we modify the feedback of “normal” sensorimotor loops. Levels thereby are not properties of the environment as such, nor a projection of agents, rather they describe the normative entanglement of both, but more importantly they also describe the open-ended character of the normative frameworks of action and perception

that constantly evolve. This is a phenomenon that (*Level shifts* called Talero, 2005, p. 446).

In level shifts, it is common that the anchorage points or the structure of the original level is transposed into a new level, just as when we transpose a melody from one tonality to another (cf. Merleau-Ponty, 1963, p. 87). This kind of transposition of levels explain why our bodies can become geared, in the same manner, to different environments with similar structures. In the two experiments referred by Merleau-Ponty, the sensorimotor loop is altered but the same form is perceived. From a phenomenological standpoint, this happens because our perceptions are based on anticipations of potentialities for motor actions, but critically these anticipations are grounded on the sensorimotor habits previously acquired by the perceiver. These habits are correlated to the motor significations perceived in the environment and are anticipations and motivations for motor action. Therefore, when a level is forced to shift into another level by changes induced in the sensorimotor loop, the body aims to use its habitual sensorimotor coordination, but is forced to reorganize this coordination considering the new circumstances. However, since it is possible to find similar anchorage points in the emergent sensorimotor dynamics, the habitual form can be transposed into the new level.

The crucial aspect of this description of levels is their open-ended character, which is not only exhibited by the experiments from above, but seems to be a necessary condition for explaining why the interactions between the body and the environment always remain open to continuous readjustments that nonetheless follow predictable paths inherent to the normative frameworks of levels previously enacted (cf. Merleau-Ponty, 2013, p. 76). The description of levels is ultimately a description of an endogenous developmental process of the agent-environment entanglement. Considering this description of levels, as the normative framework of space and places, our last task is to clarify how levels contribute to our understanding of norm-development.

The Development of Enactive-Ecological Norms

The ecological approach of the skilled intentionality framework analyzes the norms of action and perception in terms of what I called normative frameworks (situated normativity) and norm-attunement (skilled intentionality). From this viewpoint, individual agents become attuned to pre-established normative frameworks. The problem with this viewpoint lies in the way it describes normative frameworks as constituted independently of individual agents, and before these agents are engaged in bodily practices.

The enactive approach, by contrast, is capable of a more adequate account of the continuous development of the norms of practices. Norm-enactment, contrary to norm-attunement, involves the active participation of agents in the constitution and development of norms. However, the enactive approach sometimes reduces its account of norms to a relation between

autonomous agents and physical constraints, thereby neglecting the existence of normative frameworks that constrain the enactment of norms.

I argued above that norm-enactment is not simply the projection of meaning to physical reality, nor can such enactment be understood as the emergence of meaning from mere physical constraints. Rather, norm-enactment entails the constant development of norms from previously given normative frameworks, something I called norm-development. The account of sensorimotor norms of the enactive approach points to the description of this phenomenon. Nonetheless, this account is still insufficient, because it ignores the fact that norm-development does not simply involve the development of bodily habits, but also the development of environmental structures that embody the counterparts of bodily habits.

To improve our understanding of this dynamic of norm-development, I appealed to the phenomenological account of perceptual norms found in the writings of Merleau-Ponty, and to his concept of spatial levels. From a phenomenological perspective, norms of perception are moments of equilibrium between the whole ecological context (a situation) and the embodied subjectivity of an agent, instituting what Merleau-Ponty called levels. These levels, however, are in constant development (level shift) because the agent-environment entanglement is a temporal and open-ended structure that is in a constant conflict and movement.

Norm-development, however, is not purely dynamic phenomenon. It also implicates the stability of norms as horizontal normative frameworks. On the side of the agent, this stability is incarnated in bodily habits, while on the side of the environment, stability is expressed as what I described as excorporations. These are anchor points of places that enable and constrain the enactment of more specific aspects of the environment, which we can understand as affordances. Excorporations may relate to the concept of ecological information in the ecological tradition, whereas levels point to the normative frameworks that constrain the enactment of new norms of action and perception.

CONCLUSION

The norms of action and perception are not pre-given sets of lawful relations, nor static frameworks that constrain the behavior of agents until we consciously change them to become adapted to the new worldly circumstances. All bodily practices are highly dynamic, our bodies, the environment, our relations with others, are constantly flowing processes that nonetheless find periodical moments of stability. Stability and change are the two crucial features of life and cognition, either from a dynamical systems theory perspective or from a phenomenological analysis. If we failed to acknowledge one of these aspects, we will fail to describe accurately the dynamics of life and cognition. We must therefore construct an approach to norms of action and perception that acknowledge these two central features of norms.

I proposed an enactive-ecological approach to norms. This approach is based on the process of norm-enactment described

by the enactive approach, but that incorporates an account of normative frameworks. Since these frameworks are not accurately described by the skilled intentionality framework, I appealed to Merleau-Ponty's phenomenology for this task. The notion of spatial levels broadly describes temporally open-ended normative frameworks that constrain bodily practices but also make possible the enactment of new norms for these practices. I named norm-development as the process of norm-enactment that implicates the temporal evolution of normative frameworks. A more detailed descriptions of norm-development is still needed, as well as the way to apply these descriptions to the concrete normative domains of interaction of agent(s)-environment systems.

These conclusions, in favor of an enactive model over an ecological one, must not let us think that ecological approaches, specially the skilled intentionality framework, are not highly valuable for our study of cognition from a radical embodied cognition perspective. Rather, if my arguments are right, this is a call for ecological approaches to become more truly enactive. Many of the concepts of the skilled intentionality framework and the free energy principle that support this theory are already pointing in this direction (Kiverstein and Rietveld, 2018).

Although at a high theoretical level, it is still hard to see a real complementarity between ecological and enactive approaches, their few but crucial discrepancies are currently useful to create

a productive dialogue between these two radical forms of embodied cognition. I hope the reader has found in this work a nice example of it.

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The author confirms being the sole contributor of this work and has approved it for publication.

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How Enaction and Ecological Approaches Can Contribute to Sports and Skill Learning

Carlos Avilés^{1*}, José A. Navia², Luis-Miguel Ruiz-Pérez² and Jorge A. Zapatero-Ayuso¹

¹ Department of Languages, Arts and Physical Education, Faculty of Education, Complutense University of Madrid, Madrid, Spain, ² Departamento de Ciencias Sociales, de la Actividad Física y del Ocio, Facultad de Ciencias de la Actividad Física y del Deporte, Universidad Politécnica de Madrid, Madrid, Spain

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*Correspondence:

Carlos Avilés
caviles@pdi.ucm.es

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The purpose of this paper is to explain learning in sports and physical education (PE) from the perspective of enactive and ecological psychology. The learning process is first presented from the enactive perspective, and some relevant notions such as sense-making and sensorimotor schemes are developed. Then, natural learning environments are described, and their importance in the human development process is explained. This is followed by a section devoted to the learner's experience in which some research methods are explained, such as neurophenomenology, in addition to self-confrontation, interviews aimed at bringing out the meaning, sensations, and emotions that performers experience when they are immersed in their sport or a PE class. The sections on the ecological approach deal with the attunement, calibration, the education of intention, and the importance of representative experimental designs. The last section addresses the main similarities and differences between the two approaches. Finally, we state our theoretical position in favor of a common project that brings together the main elements of both post-cognitive approaches.

Keywords: embodied cognition, acquisition, mastery, expertise, physical education

INTRODUCTION

There has recently been an increase in the number of papers published linking enactivism and ecological psychology. This is evidence of the scientific community's growing interest in these methodological concepts and proposals (e.g., Segundo-Ortín, 2020). This trend encourages us to envisage a confluence between these embodied approaches in today's post-cognitive era (Lobo, 2019). Classical cognitivism and information-processing theory based on a computer-based analogy of the mind, have both been strongly criticized. It currently appears very difficult to accept, given an analysis of the athletes who are active in such a rapidly changing environment as is the sporting world, the explanation that learners use representations of the world, motor programs, and rules to act (Moe, 2005; Breivik, 2007).¹ A revised paradigm of the mind based on this critique arose some years ago wherein mental processes do not occur solely in the head of the performer. The approach corresponds to the "4E" theory on cognition as embodied, embedded, enacted, and extended (Rowlands, 2010).²

¹ This paper mainly uses the terms *learners* and *performers* to refer to the agents and athletes who act in all kinds of situations and who have different levels of mastery and expertise.

² Rowlands (2010) attributed the 4E paradigm of the mind (pp. 3 and 219) to Shaun Gallagher at the Embodied Mind Workshop held at Cardiff University in July 2006 (see Gallagher, 2017, p. 28).

According to Gallagher (2017), these four pillars of post-cognitivism have been redefined over time, and some researchers have added more “Es” (ecological, empathic, experiential) and even an “A” (4E&A, affective) to the original idea (see also Menary, 2010; Dotov, 2016; Higuera-Herbada et al., 2019). Gonzalez-Grandón and Froese (2018) have developed an excellent explanation of the four “Es,” which can be summarized as follows: *embodied* means that bodily structures constitute the learner’s cognition, “the bodily realization of cognitive abilities as constitutive for their achievement” (p. 190); *embedded* means that the learner’s cognition is situated in an environment and within a specific context that offers affordances by which to act; *enacted* means that “cognition and consciousness emerge only through the active embodied interaction, or structural coupling, of an autonomous living system with its environment” (p. 190); and *extended* means that “cognition is extended beyond the boundaries, thus being inherently connected with the respective physical or sociocultural environment” (p. 190).

These post-cognitivist approaches to cognition have significant implications that affect our understanding of the process involved in learning sensorimotor skills (Di Paolo et al., 2017) and in sports education (Chow et al., 2016). Performers bring sensorimotor skills to bear in all kinds of learning contexts: in natural situations, such as when children play with their friends or parents in a park close to home; in more structured learning environments, such as that usually found in a PE class at school; and in individual and group sports training sessions. For Dreyfus and Dreyfus (1986), to achieve proficiency or expertise in a particular task or sport, an apprentice must undergo a long process of practice, trial, and error. The expert level is the maximum expression of learning and optimization. In their enactive proposal, Di Paolo et al. (2017) advocate an open-ended and never-ending learning process. Over time, “mastery is the ongoing process by which the agent continuously adapts to the challenges of a changing world” (p. 107). Footballers, skaters, climbers, tennis, and other sports players, constantly adjust their sensorimotor organization to all kinds of changes. These adaptations occur every second, from 1 min to the next, throughout a training session, or even from 1 week to the next.

In this paper, we focus on enactivism and ecological psychology to explain skill acquisition in radical embodied cognitive science, which adopts elements of the ecological approach, dynamical systems theory, and the key notions of the enactivist movement (Chemero, 2009). This theoretical integration will later help us explain the incorporation of non-linear pedagogy in sports teaching and PE. The primary objective of this paper is to show how these approaches can improve our understanding of some aspects of the performer’s acquisition process in sport, PE, and daily activities. This paper will give a broad outline of general ideas that can guide practitioners, learners, and academics. Despite theoretical discrepancies, we are in favor of a common project that brings together both post-cognitive approaches.

The first section of this paper sets out the main notions associated with enactive learning. The second section then presents the core notions of ecological psychology in skill acquisition. The third and final section addresses a number of divergences and connections between these approaches.

ENACTIVISM IN SKILL ACQUISITION

The enactive approach to cognition was first introduced in 1991 by Varela, Thompson, and Rosch in their seminal book *The Embodied Mind*. For these authors “cognition is no longer seen as problem solving on the basis of representations; instead, cognition in its most encompassing sense consists in the enactment or bringing forth of a world by a viable history of structural coupling [*sic*]” (p. 205). This initial research program and its founding ideas established a roadmap that researchers and thinkers from different fields of study have subsequently followed, and which is currently in full evolution.

The approach has its roots in phenomenological philosophy (Gallagher and Zahavi, 2008; Gallagher, 2017), and is closely linked to the evolutionary changes that occur in humans during ontogeny, hence its relevance in explaining learning (Di Paolo, 2019). Enactivism is a non-representational approach that adopts world-involving explanations: “cognitive activity is co-constituted by agent and world” (Di Paolo et al., 2018, p. 333). Some ideas are closely related and are essential to an understanding of enactivism: autonomy, sense-making, emergence, embodiment, and experience (Di Paolo et al., 2010). An organism, and in the case that concerns us here, a *learner* of a certain sport is an autonomous system. According to Thompson (2007) “a distinctive feature of the enactive approach is the emphasis it gives to autonomy. In brief, an autonomous system is a self-determining system, as distinguished from a system determining from the outside, or a heteronomous system” (p. 37). For Thompson and Stapleton (2009) “the enactive approach starts from the question of how a system must be organized in order to be an autonomous system—one that generates and sustains its own activity and thereby enacts or brings forth its own cognitive domain” (pp. 23–24).

Another crucial notion is sense-making, meaning “creation and appreciation of meaning,” which arises in the agent’s interactions with the world (Di Paolo et al., 2010, p. 39). If we consider an agent playing a sport, “significance and valence do not pre-exist ‘out there,’ but are enacted” (Thompson, 2007, p. 158), or in the words of Gallagher (2017), “the world (meaning, intentionality) is not pre-given or predefined, but is structured by cognition and action” (p. 6). The agent, through an active sensorimotor engagement with his or her activity, transforms the world “into a place of salience, meaning, and value — into an environment (*Umwelt*) in the proper biological sense of the term. This transformation of the world into an environment happens through the organism’s sense-making activity” (Thompson and Stapleton, 2009, p. 25). “Sense-making is the interactional and relational side of autonomy. An autonomous system produces and sustains its own identity in precarious conditions and thereby establishes a perspective from which interactions with the world acquire a normative status” (p. 25). When an athlete is actively committed to his or her activity, some elements or objects become more relevant than others. According to Di Paolo et al. (2017):

Sense-making does not imply sophisticated kinds of cognition, but it is implied in them. It is what is common to basic minds (Hutto and Myin, 2013) and human minds. To be clear, by “sense-making,” then, we refer to the notion that objects or events become

meaningful for an agent if they are involved in the normatively guided regulation of the agent's activity (e.g., by triggering or mediating it). This mode of relating to the world is the active making sense of a situation and the orientation of the agent toward a course of action that is adequate to it. (p. 123).

How We Learn to Act and Perceive

Sensorimotor learning involves changes that occur in the behavior of the agent. These changes are non-linear and are constrained by the interaction of a large number of factors, such as the learner's motivation to acquire a new skill, their sensorimotor coordination during the learning process, the number and variety of opportunities available to them to practice, and even the sociocultural environment in which they grow, develop and learn. The learner needs these possibilities. Adolph et al. (2012) showed that even the most natural or ontogenetic skills such as walking require immense amounts of practice. In a natural environment of free play, toddlers aged between 12 and 19 months of age walk an average of 2,368 steps an hour. The next milestone is to achieve sensorimotor mastery that will allow the toddler to walk very fast or run around without falling. Movements are fundamental since motor actions generate new opportunities for learning or *cascades of development* in domains that go beyond the mere sensorimotor (e.g., intelligence). In response to this, Adolph and Hoch (2019) highlight the embodied, embedded, enculturated, and enabling nature of human movements.

Enactive learning is eminently non-representational, evolutionary, and dynamic. Learners are the product of their history of sensorimotor coupling with the environment, depending on their phylogenesis, ontogenesis, and cultural setting (Varela et al., 1991). To paraphrase Antonio Machado's famous poem, so significant to enactivists, there is no fixed path or pre-given world that guides our way forward (Thompson, 2007, p. 13). Sensorimotor couplings correspond to earlier, ongoing interactions that leave traces or create habits, the path of learning is the product of creative interactions between learners and their environment. For Hutto and Myin (2013), the arguments that explain the changes in the agent can be found in the developmental-explanatory thesis, "which holds that mentality-constituting interactions are grounded in, shaped by, and explained by nothing more, or other, than the history of an organism's previous interactions. Sentience and sapience emerge through repeated processes of organismic engagement with environmental offerings" (p. 8).

From the enactive point of view, the learner's active movements have a relevant role in the emergence of cognitive and learning processes and perceptual learning (Bermejo et al., 2020). Doing and learning by doing is fundamental in couplings between the environment, the brain, and the body of the performer (Gallagher, 2017). Enactivists explain ontogenetic changes and sensorimotor development "as the growth of a network of stable patterns and the relations between them" (Di Paolo et al., 2017, p. 161). Through practice and experience, the performer will expand his or her sensorimotor repertoire and will reach a higher level of dexterity and mastery. Di Paolo et al. (2017) define it as follows: "Mastery is the ongoing process by which an agent continuously adapts to the challenges of a changing world.

In our proposal, mastery consists in the refining and acquiring of new sensorimotor responses and their integration into an existing repertoire" (p. 37).

Di Paolo et al. (2017) explain the process of enactive learning through a dynamical system interpretation of Piaget's theory of equilibration (p. 88). In short, learning involves going through the phases of assimilation, accommodation, and equilibration. According to these authors, the performer acquires sensorimotor schemes with practice. A sensorimotor (SM) scheme is "an organization of SM coordination patterns" (p. 90). In turn, a scheme involves a whole sequence of coordination patterns. If we think of a child who is learning to ride around a circuit on a bicycle with training wheels, the sequence would involve the following patterns: keep the handlebar in the correct position to go straight, pedal at a constant rate, look forward to know when to turn, pedal slower and move the handlebar slightly to the left to turn left, and so on. In this case, for the performer, *assimilation* consists of trying to maintain the stability condition even when variations arise that may affect him or her, such as performing the same circuit just after a rain shower. *Accommodation* is "plastic change that re-establish[es] a scheme" (p. 91), how to perform the same task, but this time without training wheels. Finally, *equilibration* is the last phase of an open, permanent, and endless process of learning. Here, the performer adapts to a variety of practice conditions "aimed at maximizing the stability of each scheme against violations of the transition and stability conditions resulting from environmental perturbations or internal tensions" (p. 91). Practical examples of this last phase are using lighter and heavier bicycles and riding around the same circuit but with steeper and flatter slopes, or on a variety of surfaces, such as dirt, asphalt, tile, etc.

Natural Learning Environments

Not all learning takes place in formal settings with purposeful teaching programs such as those implemented in schools and sports clubs. A great deal occurs naturally. Stewart (2010) emphasizes the importance to the learner's autonomy of action and the learning that takes place in or near the learner's current stage of development, and criticizes the Shanonian notion of information and instructional teaching processes:

"Learning" can only be a modification of the developmental process; this means that what can be "learned" is both enabled and constrained by the epigenetic landscape. Development, and therefore learning, is essentially an endogenously self-generating process; it is, therefore, unnecessary—and impossible—to "instruct" it from the outside. This runs directly counter to the widespread notion that "learning" is a process of "instruction," by which is meant a process of information transfer from teacher to pupil (pp. 8–9).

Gallagher (2017) mentions the importance of *natural pedagogy* in a child's learning. The process of upbringing, non-formal teaching, and interaction with others (i.e., intersubjective education) determines the amount of attention we pay to some objects or events over others. A natural context in which enactive intelligence manifests itself is found among populations who depend on the sea for their livelihood. These groups, called

Sea Nomads, include the Moken and Orant Laut of Malaysia and Indonesia and the Bajau Laut of the Philippines, Malaysia, and Brunei. These villagers spend an average of six or even 10 h a day in the water, and half of this time is spent underwater. The sea is the children's playground, and the adults' workplace (Abrahamson and Schagatay, 2014). Their enactive-aquatic intelligence is embodied and enacts with objects and situations since it allows them to adapt to the problems posed by their aquatic environment. Their coupling is such that their children can see perfectly well underwater without the help of goggles, a finding that was of great interest to researchers (Gislén and Gislén, 2004). This lifestyle has led to major adaptations similar to those found in many marine animals, namely, their diving reflex and their clarity of vision underwater. Gislén et al. (2003, 2006) wondered whether the visual acuity of these groups was genetic or the result of an extensive history of coupling and co-dependence of these children with water. After carrying out different studies, they concluded that the superiority of these Moken or Bajú children with respect to European children was a consequence of a long evolutionary history of co-determinations with the marine environment (Gislén et al., 2003). For these researchers, spending their lives in the water has taught these children to constrict their pupils so that they can see clearly when they are submerged. Thousands of years of structural coupling with water has facilitated the development of the underwater sensorimotor skills they need to survive. When these individuals dive into the water, their intelligence extends beyond their hands and is distributed in the fishing utensils they use, and they demonstrate a refined sensorimotor skill that allows them to move freely in the marine environment, making their aquatic experiences much more than mere acts of sensorimotor coordination.

The Subjective Universe of Learners and Experience

The subjective universe is independent of any external analyzing and quantifying observer. No external observer can see what the learner, practitioner or team sees, feels, and lives from their point of view, with their biological idiosyncrasies, sensorimotor skills, knowledge, psychological characteristics, and their experience during the activity. Agents themselves interpret the usefulness of their actions. It is their subjective world (*Umwelt*) that emerges in these situations (Von Uexköl, 1951) — a world of interactions and co-determination with different levels of analysis and organizational domains, in which the specific motivations and intentions of the agents arise during the action. Von Uexköl proposed the concept of *Umwelt* to highlight the specific relationships between agents and their environments. They always perceive the world from their point of view. As Merleau-Ponty (1985) explains, the individual is not only a body, not only a physical structure but also a being that lives and experiences, that manifests an external and internal dimension when relating to its environment. From an enactivist perspective, learners are beings in a situation where they have an intense relationship with their environment, in which their subjective world is intensely involved, and is absorbed in their actions.

Educational contexts are laden with embodied situations of acquisition and sensorimotor knowledge. Although the school system insists on eliminating the body from education, learners must be present with their body in the world. Learners are thus open to possibilities, operating bodily within, and react to the specific situations in which they find themselves. They enact to obtain the information they need from the environment and make decisions without the need for complex cognitive operations or mental representations (Button et al., 2012; Avilés et al., 2014; Davids et al., 2015). The unit of analysis is no longer the isolated individual, but rather the system made up of that individual *in situ*, in co-dependent and dynamic interaction with the environment in which emerging, self-organization processes occur (Varela et al., 1991). Learners regard themselves as individuals in action and in a situation, in a dialectical relationship with their surroundings and with the objects around them.

One of the crucial challenges and novelties of enactivism at the methodological level is to articulate descriptions of learners' experiences using objective behavioral data. Varela (1996) called this approach neurophenomenology — the way of studying first-person subjective experience and third-person objectification. The key is to create a fruitful circularity between phenomenology and cognitive science. One of the characteristics of this method is that both participants and investigators need to be properly trained to use it correctly. A second person, i.e., an investigator or *empathic resonator*, is sometimes called in to act as mediator or coach. Their role is to be aware of the signs and indicators of the study participant (i.e., the first person) in order to interpret the data they express, such as phrases, body language, and expressions, etc. (Depraz et al., 2003).

The capacity to access learners' consciousness is a fundamental challenge for investigators. The objective is to bring out the significant elements of the experience when practicing or learning a sports activity. There is an important body of literature in which researchers often combine biomechanical data with that obtained from interviews with athletes and learners in PE and sports (Hauw and Durand, 2007; Bourbousson et al., 2012; Sève et al., 2013; Evin et al., 2014; Terré et al., 2016; Rochat et al., 2017, 2019; Hauw, 2018; Récopé et al., 2019). Although each study is unique, the general method has been to reconstruct the *course of action* (Theureau, 2010) to "capture" the performer's experience by verbalizing it in self-confrontation interviews. During the interviews, the researchers present the performers with videos and biomechanical data that allow them to relive the experience and more easily unleash the feelings, emotions, concerns, etc. In their study in rowing, Sève et al. (2013) analyzed athletes' subjective perception of the synchronization of their movements, which are not very noticeable externally. Reconstruction and access to the athletes' *course of action* allowed coaches to identify temporary movement dysfunction. It is important to detect this mismatch to readjust the biomechanics of movements in training.

It is essential to immerse ourselves in or break down the moment of learning from the point of view of the learner in PE, because, as Masciotra et al. (2008) explain, learning occurs from the perspective or optic of the learner, and he or she will have significant access to new skills when this converges

with emotions, feelings, beliefs, previous experiences, etc. that are brought into play in the situated action. This has two very important consequences in PE. On the one hand, it optimizes the diagnostic assessment of the student and the initial knowledge of each student. On the other hand, it establishes a reactive, empathetic, skillful, and recurrent assessment that obtains information from the student's perspective and, simultaneously, gives empathic feedback that enhances the meaningfulness of the activity experienced by the learner in the context of the PE class. The world of teacher-student interaction during PE lessons appears to be mediated by intersubjective perspectives that show that teacher empathy is very relevant to motor learning.

The Role of Practitioners in Developing Skill Mastery

As mentioned above in the context of learning or mastery, enactivism relies on the tools of dynamic systems theory. Like ecological psychology, both approaches view the learner as a complex adaptive system that in turn forms a system with the environment. The self-organization of learner behavior is a crucial element in the autonomy of action. Several years ago, an applied proposal called the Constraints-Led-Approach (CLA) emerged in the field of sports science and PE. This explains the emergence of a new pattern of coordination that involves the interaction between constraints associated with the task, the environment, and the learner (Renshaw et al., 2019). CLA is based on the principle that the learning process does not follow a linear trajectory and therefore results in a non-linear pedagogy (Chow et al., 2016). In this regard, for Davids et al. (2008) non-linear pedagogy is:

A theoretical foundation that views learning systems as non-linear dynamical systems. It advocates that the observed properties of dynamical human movement systems form the basis of a principled pedagogical framework. In particular, non-linear pedagogy advocates the manipulations of key constraints on learners during practice (p. 224).

If we accept that perception, coordination and cognition can be explained through the self-organization of behavior, we must believe that non-linear pedagogy can be related to enactivism. In an enactive pedagogy, the practitioner is always present to promote learning, but the question is, how? Although practitioners might adopt a traditional approach and teaching method, they must above all design learning environments that favor a varied landscape of affordances. In these scenarios, the practitioner's mission is to become a true "environment architect" insofar as sensorimotor exploration and autonomous discovery of solutions will be accompanied by more selective and less frequent use of verbal information (Renshaw et al., 2019). Therefore, teaching sessions involving children from 2 to 6 years of age should invite them to explore and to allow their sensorimotor behaviors to emerge spontaneously (Équipe des Conseillers Pédagogiques en EPS du Bas-Rhin, 2015). Returning to the issue of autonomy of action, a study published by Récopé et al. (2019) found that certain professional volleyball players strayed from the established game system: "It should also contribute to explain why some people (here some players)

have some difficulties to follow the prescription, including the role distribution in a collective organization (here the game system)" (p. 236).

To make it easier for the reader to understand the acquisition process, we will take the example of tennis. There is no doubt that an apprentice aspiring to be a good tennis player will need thousands and thousands of practice shots to reach a good level of play. However, since tennis is not a predefined world, each shot or movement is different. In tennis, one of the most interesting moments of the game is the return of serve, probably due to the receiving player's impressive responses to a ball traveling at more than 200 km/h. One of the movements that tennis players acquire after years of practice is the split-step. This is a hop-jump sequence that the receiver performs by jumping or taking off from the ground just before the server hits the ball. Until recently, tennis players were thought to have directional anticipatory behavior, that is, they were able to anticipate the server's movements and move and jump to the side where the ball would land in order to respond before the server hit the ball. However, recent research has shown that expert tennis players follow a *neutral* jump pattern, i.e., they do not move to either side during the split-step (cf. Avilés et al., 2019).

From the enactive perspective, studying the split-step gives insight into how tennis players with different levels of expertise function. Firstly, beginners and basic level players cannot do the split-step; they must learn it naturally through sensorimotor adaptation during practice. There is no way of knowing exactly when they will learn it or when this movement will first emerge *naturally* during the game. Secondly, non-anticipatory neutral behavior indicates that the expert receiver creates meaning or *sense-making* in each serve and return sequence, and even that considering their intentions, emotions, and movements, a participatory sense-making of the interactions between both players will emerge (Di Paolo et al., 2010). Thirdly, several scholars criticize excessive intellectualism and argue that mental representations are not needed to act competently (Noë, 2009). In fact, in the case of a tennis ace, these images or representations could impair their performance. The body-mind unit evolves, and this is reflected in the mastery the player brings to the sport. As Varela et al. (1991) put it: "As one practices, the connection between intention and act become closer [*sic*], until eventually the feeling of difference between them is almost entirely gone" (p. 29).

For the embodied and enactive approaches, being skilled means acting intelligently in a situation in which the individual is both *situating* and *situated* (Masciotra et al., 2008), and in which he or she establishes a dynamic and adaptable relationship. Acting skillfully means using enactive intelligence, to the extent that it activates the individual's adaptive capacity as a learner, showing control over themselves and the situations around them (Noë, 2004). In this adaptive process, cognition is distributed throughout the body, the learner does not operate outside the world, rather, it is the interaction of the athlete with his or her world that gives meaning to learning and performance. These enactions take place in natural and formal educational contexts.

Returning to enactive ideas, action spaces become a network of relationships, which are embodied between the agent (practitioner and/or learner) and the environment. Training,

according to Stewart et al. (2010), becomes a conscious experience of the experience of acting, where the performers as “cognitive systems are always engaged in contexts of action that require fast selection of relevant information and constant sensorimotor exchange” (p. x). Learning skills means effectively and efficiently changing the knowledge of the acting agent, changing their sensorimotor patterns, their way of acting, the meanings of their actions, and their intentions. It involves creating an enacted and embodied itinerary in which the agents progress from incompetence to expertise.

In enactivism, motor learning involves refining adaptation processes through a history of structural couplings with the environment. A situation is a specific space-time that influences the way individuals act. For enactivists, the practitioner needs to create situations that favor adaptation processes in which athletes co-determine with their environment, and which facilitate the emergence of the appropriate situation-specific motor patterns. As a result of various couplings, motor skills *emerge* more than they are *acquired* (van der Kamp et al., 2019). The Fosbury flop high jump does not exist in itself, it only exists when the athlete enacts with the situation and clears the bar. As Merleau-Ponty (1985) indicates, the individual is inseparable from the environment in which he acts. Sports action exists to the extent that athletes are in a position to act, and is defined, in this case, by their motor coordination and their sensitivity to changes in the physical and material environment in which they act (McGann et al., 2013).

One of the questions posed by researchers is whether mental representations are needed in these intense relationships between athletes and their sports environment — whether it is appropriate to claim the existence of such internal constructs, or whether it is direct experience, the athletes’ direct contact with their environments, that drives the emergence of the sensorimotor patterns of solution. Practitioners face the challenge of designing and promoting situations that favor enaction. Understanding the situations in which learners act in PE classes involves analyzing the interactions and couplings that favor the emergence of significant sensorimotor patterns to solve the problems that arise. It is important to examine these perception-action cycles and the dynamic interactions they elicit between the brain, the body, objects, materials, people, and the context in general. In the field of sports, the questions raised for researchers are: how do athletes interact with their environments? What favors or hinders these co-determinations or couplings with the environment? Or, how do sensorimotor patterns of action emerge in these co-dependence processes?

Furthermore, and along the same lines, it is important for the practitioner to calibrate the degree of variability in daily practice. Renshaw and Chow (2018) maintain that practitioners must take variability into account to promote learning:

The amount of variability designed-in to a session needs to be matched to the learner. For the beginner level player, low task and environmental variability may be beneficial to guide exploration toward one or two functional solutions. In contrast, the more expert performer may be presented with greater variability in individual, task and environmental constraints to promote more adaptable behavior. Knowledge of ‘critical values’ (i.e., the amount

of variability that will lead to instability and the search for new solutions) is important for practitioners and needs careful management and awareness of the implications for placing individuals in these critical (‘red’) zones (p. 12).

SKILL ACQUISITION FROM THE ECOLOGICAL PERSPECTIVE

Ecological psychology was first formulated by the psychologist James J. Gibson (1979/1986) in opposition to the (by then prevailing) cognitivist approach. The ecological approach to visual perception was originally conceived to explain how animals control movement in their environment. Subsequent researchers have made significant contributions to the development of a theory founded on motor control and learning in humans (Michaels and Carello, 1981; Turvey, 1992; Withagen, 2004; Jacobs and Michaels, 2007) and its application in sport (Araújo et al., 2006; van der Kamp et al., 2008; Fajen et al., 2009). In this section, we will try to describe the advances made in the ecological approach to sport expertise and skill acquisition.

The ecological approach championed direct perception, which involves some core considerations (Gibson, 1979/1986). First, that information is rich enough to produce perception, and no computations or inferences (i.e., knowledge stored in the memory) are required to perceive the energy patterns in the ambient array. Second, that the available information specifies environmental properties that in turn offer invitations to act. Affordances can be conceived as the opportunities for action that the athlete perceives from informational variables emerging from the environmental specifications. Third, perception and action are coupled processes that mutually influence each other. How an athlete becomes an expert, or how a learner is capable of acquiring new skills, has been explained by three interconnected stages: education of attention, calibration, and education of intention (Jacobs and Michaels, 2007).

Education of Attention or Attunement

When the perception of a property involves one-to-one mapping with respect to environmental energy patterns (1:1), then that informational variable is *specific* to that property. For instance, the variable tau (τ) under certain circumstances signifies the ratio expansion of an incoming object (e.g., a ball in a penalty kick), which in turn specifies the time-to-contact (Savelsbergh et al., 1991). However, performers detect (and use) some informational variables that may not perfectly correlate with environmental properties but can still be useful. These are the non-specifying variables (Withagen and Chemero, 2009). As one might observe, the usefulness of variables to accurately control movement depends on the reliability of the information (degree of specificity of the variable). For example, during a penalty kick, the goalkeeper may rely on non-specific variables, such as the penalty-taker’s direction of gaze during the run-up (which does not necessarily match the direction of the kick; Wood and Wilson, 2010), or they might base their dive on other, more reliable, variables observed closer to ball contact, such as the orientation of the non-kicking foot (Lopes et al., 2014).

In penalty-saving, informational variables that unequivocally determine the trajectory and the speed of the kick are extracted from the ball's flight.

The education of attention is the convergence from the least to the most (1:1) specifying variables. With practice, performers learn to rely on more useful variables to control a particular action. A recent study applied this theoretical concept to penalty kicks, with promising results (Dicks et al., 2017). Goalkeepers improved their rate of successful saves after on-field training. During training sessions, they were forced to pick up information closer to the point of contact with the ball by placing three potential penalty-takers who simultaneously started the run-up to the ball, but only one kicked the ball. In other words, the goalkeeper learned to become attuned to more specific informational variables during the penalty kick.

Calibration

There is an ample body of research (cf. van Andel et al., 2017) showing that the perception of opportunities for action (affordances) are scaled to the performer's ability, such as their size (e.g., Warren, 1984) and personal capabilities in terms of action (e.g., Dicks et al., 2010b). Fajen's affordance-based control approach establishes that an athlete's action capabilities regulate their own and other's (opponents) affordance perception, creating a boundary between achievable and non-achievable actions (Fajen, 2005; Fajen et al., 2009). In other words, successful control of movement is predicated on the basis of the relationship between the maximum capabilities of action and the space-time constraints of the task.

Continuing with the penalty kick example, one goalkeeper may be attuned to the most specific information about the future location of the ball: the trajectory of the ball during the first moments of flight. However, that information is typically picked up too late, leaving the goalkeeper insufficient time to complete the dive with guarantees (i.e., arrive at the right time). Therefore, if goalkeepers do not calibrate their agility to the expected demands of the situation by waiting for the most reliable information, they will move to the same side as the ball (the right place), but too late to intercept the ball (Navia et al., 2017). Hence, the space-time constraints of the task (speed of the ball, distance traveled) would need to be calibrated for maximum agility (speed of movement) if they are to achieve their objective of stopping the ball (see a detailed model of this in van der Kamp et al., 2018). Studies suggest that goalkeepers scale their timing of the save to their capabilities (Dicks et al., 2010b); more agile goalkeepers start the saving action later (closer to ball contact) and less agile ones dive earlier. Interestingly, more agile goalkeepers were found to save more penalties (Dicks et al., 2010b).

Education of Intention

Education of intention is defined as the selection of affordances that guide behaviors. In other words, it is about decision-making during an action. The selection of action is related to the perception of affordances, which in turn depends on scaling actions (calibration). For example, there are some basic scenarios in which the athlete's decision-making takes into account lateral

movements (e.g., penalty kick, return of tennis serve). In the case of a penalty kick, the control of the action – where to dive and how to time the dive – would be primarily predicated on the affordance-based control of that interacting situation (see van der Kamp et al., 2018). In Dicks et al. (2010b), more agile goalkeepers who initiated the saving action later saved more penalties than their slower counterparts. The authors suggest that waiting longer allowed goalkeepers to pick up more reliable information and control their actions based on more specifying variables (Lopes et al., 2014). Similar findings have been reported in tennis (Triolet et al., 2013) when, under more lenient space-time constraints, players waited longer, which in turn allowed them to base their action on more reliable information (see also Navia et al., 2018).

However, there are multiple situations where different affordances can be used to guide actions (e.g., imagine a football midfielder just after receiving the ball). Here, ecological dynamics provides a theoretical framework for explaining behavior trends (Araújo et al., 2018). On the premise that behavior emerges from the interaction between the athlete's characteristics (abilities) and the space-time constraints of the environment, affordance selection is understood as the shift from action modes (e.g., moving forward with the ball, dribbling, passing to a teammate, etc.). These changes between modes of action fulfill a functional criterion. Athletes follow a particular (and stable) action mode until the instability of emerging agent-environment constraints compels them to shift toward another mode during the action. Underlying agent-environment system factors such as the distance between encounters (Esteves et al., 2011; Vilar et al., 2012) have been found to shape changes of action modes and successful performance in sports such as basketball (Esteves et al., 2011), futsal (Vilar et al., 2012), boxing (Hristovski et al., 2006), etc. With practice, performers learn how to become attuned and calibrated to the landscape of affordances to maximize action selection and transition from one action mode to another (Araújo et al., 2019). In this regard, Rietveld and Kiverstein (2014) argue that an animal in a particular *life form* perceives affordances in relation to motor abilities. With practice and experience, as the performer becomes more skillful his or her landscape of affordances becomes richer and more varied. Therefore, two performers at different sporting levels who share the same sociocultural practice could have more relevant or less relevant affordances. This means that for an athlete, affordances are modified and actualized in accordance with the learning process. In the words of Heras-Escribano (2019a): “the action–perception loop changes and it allows us to open new possibilities that were not present before” (p. 87).

Despite these recent contributions, this aspect is still the least developed area within direct learning (Jacobs and Michaels, 2007). In particular, how information from different sources interacts and is integrated remains unsolved. In this regard, the probabilistic functionalism derived from the Brunswik lens model may provide a promising sports framework to further explore the interaction between imperfect information coming from different time-scales: proximal vs. distal (Pinder et al., 2013). For instance, in the football penalty kick, goalkeepers in experiments modified their behavior (timing and

side success) whenever situational information concerning the kicker's preferences was conveyed (Navia et al., 2013). Similarly, goalkeepers show an unusual tendency to dive to either side, regardless of the kicker's kinematics or record, due to possible negative social judgments if they do not (Bar-Eli et al., 2007).

Representative Experimental Designs

A core concern in ecological psychology has been the degree of fidelity between behavioral agent-environment system properties and the experimental settings used to test expert performance and perceptual (motor) learning. Since Araújo et al. (2007) reintroduced the original Brunswik notion of representative design (Brunswik, 1956), sports scientists have been concerned about the extent to which experimental conditions influence the perception of affordances and the regulation of actions. Accordingly, there has been growing opposition to some methods used to capture the expertise of athletes (e.g., verbal reports, occlusion techniques, video-based training, etc.) that could hamper perception-action coupling at both the basic, neuropsychological (van der Kamp et al., 2008; Mann et al., 2013) level and the applied behavioral level (Travassos et al., 2013).

In other words, if ecological psychologists hold that performed actions change the way the athlete perceives the world, and affordance perception changes the regulation of actions, then separating or altering the natural coupling between perception and action would significantly distort the picture of perceptual attunement, calibration and affordance selection. For example, in the football penalty kick, findings suggest that differences in information pick up among goalkeepers occur as a function of the type of response required (i.e., joystick or verbal vs. actual save) (Dicks et al., 2010a). Therefore, the representativeness of task design in experimental settings should be assessed and ideally be preserved at the highest level to truly recreate the athlete's skill performance in a competitive context (Avilés et al., 2019) or actual learning conditions (Pinder et al., 2011).

DIFFERENCES AND SIMILARITIES BETWEEN APPROACHES

Discussing skill acquisition from an enactive and ecological perspective, this paper will now present some divergent points that make it difficult for these approaches to converge or work together. Heft (2020) recently analyzed the most relevant books and articles in this regard and identifies three main discrepancies between direct realism and enactivism: *sensations*, the *concept of information*, and an *organism's boundaries* (see Heft, 2020 for a review). Cummins (2020), meanwhile, also believes convergence to be difficult, and criticizes ecological psychology, saying: "on the experience side of the account, it has nothing to say about phenomenology, experience, emotions, or feelings" (p. 9). Moreover, Cummins says:

The ecological analysis starts by singling out a "behavior" to be characterized, by fixing the organism/animal/agent and the environment of relevance, and it builds its account from there. In so doing, it frequently has the result that much of the explanatory

load normally consigned to hidden interiorities and brains is reduced, but not removed. (p. 10)

Since the publication of *The embodied mind* in 1991, the founders of enactivism have criticized Gibson's approach. Almost 30 years ago, Varela et al. (1991) explicitly expressed their disagreement, especially with "the act of perceiving being direct" (p. 204). For ecological psychology, information is there for the agent to perceive it directly, and this information affects the perceptual process that guides their actions. For enactivists, these invitations to act (affordances) cannot be captured directly by the agent — they can only be detected or rather *enacted* in a co-determination relationship (Scarinzi, 2011). The concept of functional tonality has many similarities with the previously mentioned *equimentality* of Heidegger (2003) or Gibson's affordance Gibson (1979/1986). Sounds, movements, gestures, objects, people, weather, etc., mean something, establish something that is perceived and *interpreted* by performers and practitioners. Coaches, in their desire to teach and correct skills, situate their subjective universe in relation to the subjective worlds of their athletes. This embodied orientation is reflected in the current understanding of motor learning in school, where the feelings, emotions, and perception of how learners live and feel teaching, has led to the emergence of new 21st century PE teaching methods, focusing on how to teach learners to understand how they learn (Moy et al., 2019) in an environment full of meaning, mediated by a universe of dozens of students.

Another relevant critique of the ecological approach has been the role played by the movement of the perceiver. Enactivists argue that in the Gibsonian approach, agents and performers play a passive role when perceiving, that is, that the act of perceiving was passive rather than active (Varela et al., 1991). We believe that Gibson's founding idea Gibson (1979/1986) has always been the idea of seeing the agent as an active explorer, and we, therefore, disagree with this enactivist critique. In this regard, Gibson (1969) mentioned the following about perceptive learning: "It is not a passive absorption, but an active process, in the sense of exploring and searching, for perception itself is active" (p. 4). Three decades later, Gibson and Pick (2000) added: "Information about properties and especially about what they afford is actively obtained by exploring, and after a few more months by actively using objects. Exploring objects and discovering how they can be used is the way meanings are learned" (p. 86). It is also true that the experimental paradigms used by both approaches can induce certain differences. Specifically, many enactivist studies have used sensory substitution or deprivation, which compels participants to perform many active movements to perceive, and this, logically, leads to a sense-making that demands a true commitment from the learner (see Bermejo et al., 2020). However, if we consider ecological sports studies, where the performer has access to information from all their sensory modalities, perception can be rapid and active without the need for many repeated or constant movements to elicit meaning. For example, in a football penalty kick, the goalkeeper moves but only has a few milliseconds to perceive the direction of the ball.

An important limitation for the convergence of both post-cognitive approaches is the use of different concepts

and vocabulary. This is a problem for researchers who are compelled to use enactive and neo-Gibsonian terms that generate different interpretations. A common language would facilitate understanding among practitioners such as PE teachers and coaches and help them design practice sessions that encourage emergence or self-organization. Heras-Escribano (2019b) argues that some enactivists use the term *affordances* very lightly, with no regard for the ontological and epistemic consequences (p. 207). On the other hand, it is interesting to note how the term *affordances* has different interpretations in ecological psychology (e.g., Chemero, 2009; Withagen et al., 2012; Rietveld and Kiverstein, 2014).

Despite apparently studying the same phenomenon, when we look more closely, we realize that both approaches explain the relationship between the performer and the environment differently. From an ecological point of view, the environment is *more objective*; enactivists, however, give more importance to the history and *lived experience* of the agent. As McGann (2016) points out: “it is also important to note that experience is continually sensitive to its own history” (p. 313). Enactivism explores this subjective dimension of actions, motivations, needs, and impulses that compel performers to commit to their environment (Di Paolo, 2005). Each person perceives this enactive relationship according to their personal characteristics, their goals, and their life experience. And it is in this area of this subjectivity where objects and situations make sense to the performers, where they acquire a purpose and utility, and where they have a functional tonality, defined by what can be done with them, by their usefulness. This is an aspect that ecological approaches based on Gibson’s theories reject, despite the numerous coincidences that exist between the two paradigms, since although ecological approaches sometimes use the term *enaction*, they do so as a way of highlighting the active nature of perception, focusing attention on the environment (Stoffregen et al., 2006). For enactivists, the structural coupling between agents and their environment (couplings) must be regarded as sensorimotor patterns that enable them to carry out actions guided by their perceptions (Scarlinzi, 2011).

This is why analyzing sports performance and experience from a solely third-person perspective only allows us to capture this action dynamic in an equation of movement and modeled behavior but does not allow us to understand how the agent experiences this environment as the one who acts. Hence, the enaction paradigm offers the possibility of articulating the different levels and domains of organization involved in sports action. As Krein and Ilundáin-Agurreza (2017) show, sport highlights the value of enactivism and extend its range of application beyond the simple minds that are usually analyzed by researchers.

Within a broader, conceptual, embodied cognition, Beilock (2008) argues that experience (i.e., practice) in/of a particular action modifies the extent to which cognition is grounded in action. Thus, embodied cognition establishes that our experience in performing a particular action helps us to predict the other’s actions in terms of what and how they will act (a similar concept to social affordances; Fajen et al., 2009). Thus, motor

experience accumulated by a skilled athlete would maximize their ability to predict and accurately assess the other’s actions (Cañal-Bruland et al., 2010). However, the most prolific approach to sport is the embodied perception theory (Proffitt, 2006; Witt, 2017). This embodied viewpoint postulates that perception of the environment (e.g., ball speed) is not (solely) determined by the physical properties of the environment, but rather reflects our ability to interact with objects (Proffitt, 2006). Although this assertion may seem unaligned with the foundations of ecological psychology, embodied perception can be conceived as an extension of the concept of affordance (Gray, 2014). Hence, the properties of the environment are perceived in terms of the agent’s action capabilities (Witt and Riley, 2014; Witt et al., 2016), and within a rational boundary of possible actions to be carried out (Lessard et al., 2009), an idea which has similarities with the aforementioned affordance-based control approach (Fajen et al., 2009).

There is extensive empirical evidence of how specific perception affects the function, the relative difficulty of a task (i.e., skill expertise, concomitant success, objective task difficulty), and its final goal (overviews on Gray, 2014; Witt et al., 2016). For example, the cup was perceived to be larger by golfers who were more skilled, and when putting from nearby (Witt et al., 2008). Similar effects have been found in softball and baseball, where players with a better performance history perceived the ball to be larger (Witt and Proffitt, 2005; Gray, 2013), or when the stroke was more difficult to execute (Gray, 2013). In the same baseball study, the speed of the incoming ball was perceived as being slower by players with a better batting average (Gray, 2013). This action-specific perception of speed is claimed to be supported by an underlying perceptual-motor information process similar to calibration. By way of example, if the absolute value of ball speed is scaled to the individual agility of goalkeepers, then goalkeepers with faster lateral movement would perceive the ball as slower (Gray, 2014). With respect to the objective of the task, findings suggest that different perceptions of ball size are a function of the intended objective of the action. For example, Batters perceived a ball to be larger when the task constraints were aligned with the goal action and vice versa (Gray, 2013). Other authors have observed a correlation between hitting performance and estimated target size, but the effect disappeared when the goal of the action changed from just hitting to hitting and catching the launched ball (Cañal-Bruland and van der Kamp, 2009). Gray (2014) suggests that these differential effects of ball size perception, as a function of the goal of the intended action, may be used to shape affordance selection (e.g., altering the task constraints of the batter’s training – ball size or trajectory– to perfect a specific stroke).

In recent years, researchers have made theoretical attempts to bridge the gap between enactivism and ecological psychology (Chemero, 2009; Stapleton, 2016; Baggs and Chemero, 2018). The rapprochement between these theoretical perceptions is reflected in the transversal use of some concepts, such as affordances and agency. For example, ecological psychologists and enactivists use the term *affordances* to refer to the values or meanings of things (Thompson, 2007). Gibson himself said: “I have coined this word

as a substitute for *values*, a term which carries an old burden of philosophical meaning” Gibson (1966/1968, p. 285). Even in the enactivist framework, the original concept has been changed to a broader notion called *affordance spaces* (Gallagher, 2017, p. 174). According to Travieso et al. (2020), if we are to bring enactivism closer to ecological psychology it is essential to distinguish between *perceiving* and *actualizing* affordances. These authors also comment on the relationship between affordances and sense-making, outlining that this is “because affordances are related to the bringing-forth-the-world concept of enactivism and sense-making” (p. 7).

Higueras-Herbada et al. (2019) claim that direct learning theory should be included among the post-cognitivist theories of learning, as it shares the basic commitments of embodied, embedded, enacted, and extended. According to Heras-Escribano (2019a), enactivism and ecological psychology can be combined in a single post-cognitivist research framework, providing we assume the interaction between the organic agent and the environment on two different levels of understanding. The sub-personal levels involve the neural dynamics of the sensorimotor contingencies and the emergence of *enactive* agency, and the personal level deals with the dynamics that emerge from the organism-environment interaction in *ecological* terms. It seems, then, that sensorimotor abilities and the study of affordances have much more in common than their proponents realize (Chemero, 2009, p. 154). In a more sports-related framework, the enactivism of Krein and Ilundáin-Agurruza maintains that high cognitive non-representational states during a high performance (e.g., climbing without ropes) can be possible through flow and *mushin* (i.e., mindfulness fluid awareness). The athlete is holistically attuned to the environment on multiple levels of engagement: intellectual, emotional, volitional, kinetic, and other capabilities (Krein and Ilundáin-Agurruza, 2017). Climbing is a very comprehensive sport that develops different skills in PE classes. It is interesting because the learner creates an intense relationship through a personal commitment to the wall (Terré et al., 2016). None of the learners will live the same experience. Each student must discover creative solutions that emerge moment by moment, in their constant interaction with the wall. The best hand and foot holds are not prepared in advance, but will rather, be the result of their sensorimotor enactment.

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CONCLUSION

In this article, we have shown the enactive and ecological notions used to explain learning in sport, PE, and daily living activities. Sports and motor skills in general are excellent settings for investigating learner cognition. Reaching a certain level of learning or mastery requires practice, and each learner experiences the learning process in a way that is unique and individual to them. We have seen how for several years, and despite having several ideas in common, enactivists and ecological psychologists have seemed to be working separately, and sometimes these ideas are at odds. However, there are clear signs of the potentials for combining the two approaches. In 2020, the beginning of a new decade, we are curious to see how events will unfold. Enactivists and neo-Gibsonians may one day no longer regard each other with suspicion, and instead join forces in a joint language, forming an *enactive-ecological* program or an *ecological-enactive* approach (cf. Baggs and Chemero, 2018; Heras-Escribano, 2019a). This would certainly allow them to broaden explanations and in our case, to better understand, how human beings function when they learn or perfect a skill. In line with the conclusions of Segundo-Ortín (2020), we believe that enactivism (Di Paolo et al., 2017; Di Paolo, 2019) can make an important contribution to understanding learning and showing how the performer acquires and optimizes his or her sensorimotor skills.

AUTHOR CONTRIBUTIONS

CA, JN, L-MR-P, and JZ-A have equally contributed to the structure, theoretical position, and writing of the manuscript. All authors contributed to manuscript revision, and read and approved the final version.

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An Enactive-Ecological Approach to Information and Uncertainty

Eros Moreira de Carvalho¹ and Giovanni Rolla^{2*}

¹ Department of Philosophy, Institute of Philosophy and Human Sciences, Federal University of Rio Grande do Sul, Porto Alegre, Brazil, ² Department of Philosophy, Faculty of Philosophy and Human Sciences, Federal University of Bahia, Salvador, Brazil

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Marek McGann,
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*Correspondence:

Giovanni Rolla
rollagiovanni@ufba.br;
rollagiovanni@gmail.com

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Information is a central notion for cognitive sciences and neurosciences, but there is no agreement on what it means for a cognitive system to acquire information about its surroundings. In this paper, we approximate three influential views on information: the one at play in ecological psychology, which is sometimes called information for action; the notion of information as covariance as developed by some enactivists, and the idea of information as a minimization of uncertainty as presented by Shannon. Our main thesis is that information for action can be construed as covariant information, and that learning to perceive covariant information is a matter of minimizing uncertainty through skilled performance. We argue that the agent's cognitive system conveys information for acting in an environment by minimizing uncertainty about how to achieve intended goals in that environment. We conclude by reviewing empirical findings that support our view by showing how direct learning, seen as an instance of ecological rationality at work, is how mere possibilities for action are turned into embodied know-how. Finally, we indicate the affinity between direct learning and sense-making activity.

Keywords: Shannon-information, information for action, information as covariance, enactivism, ecological psychology, uncertainty

THE QUARREL ABOUT INFORMATION

Information is the bread and butter of cognitive science and neuroscience (CSN). Talk about information *processing, control, storage, and retrieval* is abundant in explanations of how cognitive systems can perform specific tasks and enable agents to interact intelligently with their environment. Accordingly, one of the defining tasks of CSN is to describe the mechanisms through which information is conveyed, an enterprise that, if successful, allows us to understand, predict, simulate, and intervene upon the cognitive capacities of real agents.

The groundwork of the way information is understood by CSN today was laid by Shannon's (1948) mathematical account of information, which made possible nothing less than digital communication. Simply put, Shannon's theory defines information as entropy, which is the measure of average uncertainty of the selection of an encoded signal. The core idea of what became known as *Shannon-information* is that the less uncertain the selection of the encoded signal is at its receiver, the more information the signal carries from its sender. Noise, on the other hand, permanently corrupts the signal, thus increasing entropy and diminishing information. To summarize, information is a matter of minimization of uncertainty. Thus, CSN requires the

cognitive system to fundamentally receive and process encoded signals in a way that minimizes uncertainty about their source, say, the distal causes that initiate cognitive processing¹.

It might seem straightforward that the converse of Shannon-information is *representational content*—despite Shannon’s advertence that “[the] semantic aspects of communication are irrelevant to the engineering problem” (Shannon, 1948, p. 379). Indeed, proponents of CSN typically—but not necessarily, or so we will argue—take the encoded signals processed by cognitive systems to carry information *about* their source, which implies that the signals display semantic content, i.e., they (non-metaphorically) *tell* the cognitive system something about its environment². Homunculus issues aside—if the signal tells something to the cognitive system, then something within the system is listening after all—a dominant idea behind CSN is that the outcome of information processing is the composition, manipulation, and consumption of representational content. Patterns of neural activity, therefore, supposedly *represent* whatever gave rise to the cognitive acts of which they are a token, because they convey information about their distal sources.

Two parallel research programs in cognitive sciences and psychology, however, challenge the theoretical tenability of the very notion of representational content, or at least the assumption according to which representational content is needed to explain all sorts of cognitive activity. On the one hand, Gibson’s (2015) ecological psychology gave rise to a research program that identifies environmental variables, which are known as *affordances*, as directly (non-representationally) perceived by cognitive agents. According to the ecological view, agents directly perceive possibilities of engagement with their immediate environment according to their specific bodily morphologies. On the other hand, the general outlines of what would later become known as enactivism were first presented by Maturana and Varela (1980) and later expanded by Varela et al. (1991). Enactivists argue that cognition is not a matter of representing the environment, it is instead the active exploration of an environment by an organism, which determines meaningful points of interest for an organism with specific systemic structures—an activity that is known as “sense-making.”

The consolidation of both paradigms characterized the so-called *Pragmatic Turn* in the cognitive sciences (Engel et al., 2013) and, given the shared rejection of pervasive representations in cognition and semantic notions more generally, pragmatically oriented views of cognition typically eschew traditional informational parlance. Gibson straightforwardly rejected that Shannon-information could serve as perceptual information (Gibson, 2015, pp. 231–232), given the communicative character

of information in Shannon’s view. Perceptual information, for Gibson, is not communicative because it is direct, it cannot be a matter of *translating* the messages emitted from a source. A more critical stance toward semantic information has recently been developed by radical enactivists (Hutto and Myin, 2013). They claim that natural structures, such as patterns of neural activity, do not exhibit accuracy conditions, which is the defining trait of representational content—whatever else representations turn out to be. What they call the Hard Problem of Content is the challenge of reducing structures with accuracy conditions to the physical world. Given that the promise of reduction has not been fulfilled, so their argument goes, the assumption that representational content is pervasive of all cognition, turns out to be a matter of theoretical recklessness. They write:

“Anything that deserves to be called content has special properties—e.g., truth, reference, implication—that make it logically distinct from, and not reducible to, mere covariance relations holding between states of affair (Hutto and Myin, 2013”, p. 67).

Covariance is the relation of two or more states of affairs varying reliably or nomically, and if that relation holds, it does not follow that one state of affairs represents the other. It is one thing to say that smoke *indicates* fire, meaning that whenever there is smoke there is fire; it is another thing altogether to say that smoke *says* that there is fire, or *stands for* fire. And it is the former that grounds a scientifically respectful notion of information, one that evades the Hard Problem of Content. Hutto and Myin call it *information as covariance*. So, “if information is nothing but covariance then it is not any kind of content—at least, it is not content defined, even in part, in terms of truth-bearing properties” (Hutto and Myin, 2013, p. 67). Importantly, if two variables co-vary reliably, one can *predict* the value of a variable based on the value of the other (Anderson and Chemero, 2013). This kind of consideration casts a different light on what a deflationary notion of information may look like within the enactive paradigm: cognitive systems co-vary reliably with their environment, in a way that an external observer can observe, for instance, patterns of brain activity and predict their source, given the correct set of assumptions regarding the broader mechanisms that play a role in cognitive activity (bodily morphology and environmental display, for instance). According to this less contentious notion of information, cognitive systems are, to use a Gibsonian metaphor, “attuned” to their medium.

Interestingly, criticism from the radically enactive camp is not directed solely to cognitivism, which is the philosophy underpinning the dominant view on CSN. They argue that Ecological Psychology and what they call Autopoietic Enactivism—Maturana and Varela’s original ideas regarding sense-making and autopoiesis—end up smuggling representational content through semantic information. Despite Gibson’s emphatic rejection of representationalism and Shannon-information (at least for perception), his recurrent phrase “information pickup” puts its view under suspicion of covert representationalism: “no informational content is ‘picked up’ or ‘extracted from’ the world and then ‘supplied’ to the user by sensory means” (Hutto and Myin, 2013, p. 73). For, if

¹Shannon-information has become the cornerstone of the Predictive Coding paradigm (Friston, 2009; Clark, 2012, 2013; Hohwy, 2013, 2016), which is in its tracks to become the dominant one in CSN, given its promise of explanatory unity of a wide range of cognitive phenomena.

²Importantly, Dretske (1981) criticized Shannon’s information theory precisely because it did not account for the semantic content of information in a more general sense. The criticisms from radical enactivism presented below are initially directed against teleosemantic theories of content/information in general, of which Dretske is a prime example—but, given the assumption by some adherents of CSN that encoded signals carry information *about* their source, the same criticisms apply to how information is sometimes conceived in CSN.

there is no informational content, so they might argue, there is nothing to be picked up by the cognitive system. More recently, discussing Tony Chemero's (2009) account, which combines ecological psychology with dynamic systems theory, Hutto and Myin write that:

"Chemero's version of an ecological dynamical approach [...] remains committed to the language, if not the framework, of information processing. Some of Chemero's ways of talking—when he speaks of the "pro-vision," "use," "gathering," and "pickup" of information "about" affordances—are anathema to a non-representational rendering of Gibson (Hutto and Myin, 2017", p. 86).

But as van Dijk et al. (2015) argue, and Hutto and Myin acknowledge (Hutto and Myin, 2017, pp. 86–87), this does not necessarily put radical enactivism at odds with ecological psychology. The key to reconcile both paradigms is to take the Gibsonian notion of information not as carrying content *about* the medium, but as offering possibilities of action *for* an agent, something that becomes clearer if we take Gibson's notion of affordance seriously, as we will do in the following section. Following van Dijk, Withagen, and Bongers, we call this view *information for action*. Moreover, as Segundo-Ortin et al. (2019) argue, *specification* and *meaning*, which are central notions for ecological psychology, are compatible with the principles of radical enactivism. To say that the information in the ambient array specifies the environment amounts to saying that there is a lawful covariation between patterns of the array and the environment—a point we also stress below. Accordingly, the notion of *meaning* is also free from contentful worries in ecological psychology because information is "meaningful" for the organism in the sense that it is acquired through active exploration of its environment, which is a goal-directed activity.

In this paper, we side with pragmatic views of cognition, for we reject pervasive representational content and semantical information as the basis of all cognition. But we part ways on the supposed relation between information as a minimization of uncertainty and representational content—Shannon's idea was precisely that a quantitative account of information is independent of semantic issues. Thus, we offer an account of information as a minimization of uncertainty without representational content. In section "Ecological Information (or Information for Action)" we turn to the notion of information in ecological psychology in order to provide more details of a pragmatically oriented account of information, that is, information for action. We also show how this account of information offers an interesting opportunity to approximate ecological psychology to enactivism. Finally, we indicate that perceptual learning is a process of minimization of uncertainty, a point we will further develop in the last section based on the empirical literature. In section "Skilled Agency and Information" we intend, on the one hand, to capture the idea of reduction of uncertainty that underlies Shannon-information, but without implying representational content and, on the other hand, to be consistent with the idea of information for action. We argue that the agent's cognitive system conveys information for acting in an environment by minimizing uncertainty about how to achieve the

intended goals in that environment through skilled agency. This idea is compatible with enactivism for, as we show, can be cast in terms of information as covariance. We address the challenge of explaining how skilled agency, which is refined and reinforced through past interactions, can be adapted to deal with unforeseen circumstances and successfully minimize uncertainty in new cases. We conclude in section "Direct Learning and Minimization of Uncertainty" by reviewing empirical findings that support our view and by showing how direct learning, seen as an instance of ecological rationality at work, is the core engine by which mere possibilities for action are turned into embodied know-how. Finally, we indicate the affinity between direct learning and sense-making activity.

ECOLOGICAL INFORMATION (OR INFORMATION FOR ACTION)

The notion of ecological information is central to understanding perception and perceptual learning within the ecological approach to perception. This kind of information is non-representational and non-sensorial at the same time, opening up a unique path to ecological psychology in the study of perception that does not resemble traditional empiricist or cognitivist approaches. In order to capture the core features of ecological information, it will be helpful to contrast it with sensory stimulation.

The concept of stimulus is used in different ways in psychology and physiology, and even within psychology there is no agreement about how it should be defined precisely (Gibson, 1960). For instance, "does a stimulus motivate the individual," considered from the first-personal perspective, "or does it merely trigger a response" (Gibson, 1960, p. 695), which could happen only at the subpersonal level? One may also wonder whether a stimulus necessitates a behavioral response or not. Finally, there has also been debate about whether a stimulus activates a sense organ or not, in other words, whether it is effective or just potential (Gibson, 1960, p. 696). It seems that all depends on how far we want to go into the environment to explain changes—physiological, behavioral, or dispositional—in the organism. In perceptual science, it is common to assume that a stimulus is a form of physical energy—optical, acoustical, mechanical, or chemical—that, by exceeding a certain threshold, effectively activates a receptor (Gibson, 2015, p. 46). Sensory stimulation is then that passive process of receptor activation. The *stimulus energy* at issue is proximal, punctate, and momentary, since it is the immediate cause for the activation of a single receptor at a given time (Gibson, 1960, p. 698).

Empiricist and cognitivist approaches to perception share the assumption that sensory stimulation provides the starting point for the study of perception. They differ, however, in how they conceive perception. For the empiricist, perception boils down to the sensations that follow sensory stimulation and their associations, whereas, for the cognitivist, perception is about objects and events in our three-dimensional environment, it produces perceptual states that represent the distal causes of sensory stimulation, as it is typically done in CSN. As the

stimulus energy carries no information about the environment (Gibson, 1960, p. 699), it needs to be processed and enriched for the construction of these perceptual representations (Gibson, 2015, p. 240).

Gibson rejects the assumption above, thereby, rejecting both the empiricist and cognitivist views of perception. In its place, he puts forward the view that, going deeper into the environment, we can find distal, structured, and persisting potential stimulus, which he calls *stimulus information* (Gibson, 1968, p. 29; Gibson, 2015, p. 47). The first thing to notice is that energy can be ordered and structured over time and/or space. Differences of intensity may form a pattern in these two dimensions. For instance, a point of observation in ambient light has structure if the light at that point is different in different directions (Gibson, 2015, p. 45). Structure matters because it can specify the environment, in particular its source. In the case of ambient light, its “structure is locally predictable; that is, physics could, in principle, provide a point by point accounting of reflection and absorption” (Michaels and Carello, 1981, pp. 21–22). Thus, the structure of ambient light specifies surfaces and their properties in that the former is lawfully related to the latter. In a similar way, ambient light structured over time may specify patterns of change, namely, events. Information, in the ecological approach to perception, is just that relation of specification (Gibson, 1960, p. 702; Gibson, 1968, p. 245; Gibson, 2015, p. 231). Accordingly, stimulus information is structured energy to which an organism may be sensitive. Before we characterize in more detail how the organism becomes sensitive to stimulus information, some clarifications are in order.

We mentioned in the last section that Gibson’s talk about information and, as we will soon discuss, the process of picking up information have raised concerns, mainly from radical enactivists (Hutto and Myin, 2017, p. 122), as to whether ecological psychology is radical enough and really uncommitted to representations. We think that these concerns are unfounded. The relation of specification upon which ecological information rests is nothing more than nomic covariation (Gibson, 1968, p. 244; Heras-Escribano, 2019, p. 150), which is a respectable naturalistic notion according to radical enactivists themselves (Hutto and Myin, 2013, p. 71; Hutto and Myin, 2017, p. 67). For Gibson, it is absolutely clear that ecological information is devoid of semantic or contentful information: “The connection between natural stimuli and their sources is not the same as the connection between social stimuli and their sources, for example, the connection between words and their referents. This latter problem, surely, is distinct. Semantics is one thing, ecology is another” (Gibson, 1960, pp. 699–700).

Ecological information is not present in any kind of covariation. First, a structure that specifies its source must be causally related to that source, in that changes in the source are followed by changes in the structure. Accidental or casual covariation is unsafe for grounding organism’s perceptions and actions. Second, that relation of specification might be local, that is, the structure might specify its source only under certain conditions or, more precisely, in the organism’s niche. For instance, a bioelectric field that is “partially modulated in the rhythm of the living thing’s respiratory movements”

(Turvey et al., 1981, p. 276) specifies an edible thing in the environment where sharks live, for “in the niche of the shark ‘an edible thing’ and ‘electric field of, say, type F’ are nomically related” (Turvey et al., 1981, p. 277). Thus, local covariation may be enough for specification. Finally, there has been a debate among ecological psychologists about whether the covariation must be strong enough to support a 1:1 specifying relationship or just a probabilistic specifying relationship (Heras-Escribano and de Pinedo, 2016; Bruineberg et al., 2018). In the latter case the environmental structure does not *uniquely* specify its source because the correlation between them is not exception-free. For instance, the covariation between smoke and fire is less than perfect in that the occurrence of the first makes the occurrence of the latter only likely. Bruineberg, Chemero, and Rietveld distinguish between lawful and general ecological information to capture respectively strict and probabilistic covariation (Bruineberg et al., 2018, pp. 6–7). Of course, the former is just a special case of the latter. What is up for grabs is whether probabilistic covariation is enough to support ecological information. On the one hand, there are plenty of non-strict regularities in the environment, natural or social, that could be useful to guide behavior. Having access to information that some event is likely, is better than having no information whatsoever. On the other hand, general ecological information opens up the possibility of perceptual error. In those occasions in which an environmental structure is present but not its likely source, such as in the case of smoke without fire, an organism may pick up the general optical information about fire when there is no fire around. This would be a case of perceptual error. However, the ecological approach to perception is committed to direct perception, which precludes cases of perceptual error as traditionally conceived (Gibson, 1968, p. 287; Heras-Escribano and de Pinedo, 2016, p. 581; Segundo-Ortín et al., 2019, p. 1016). Cases of misperception in the ecological approach are not cases of picking up information that fails to point to its source but cases of failing to pick up information.

Giving up direct perception is an option, but it would presumably throw us back to empiricist or cognitivist views of perception (Gibson, 2015, p. 159). Besides, it is hard to see how one could account for perceptual error without assuming a suspicious intermediate, maybe representational, between the perceiver and the world. We take a different path. The gap between general and lawful ecological information can be overcome by taking the local aspect of regularities seriously. In general, the occurrence of smoke may indeed make the occurrence of fire only likely, but it may uniquely specify fire in a particular environment. Organisms are not expected to be sensitive to information irrespective of where they find themselves, on the contrary, they might be able to manifest their sensibility to a piece of information only in their niches. As in the example of sharks above, electric field of a certain type locally specifies edible things. As Gibson, and following Raja’s suggestion that a new law-based psychology is Gibson’s most radical idea (Raja, 2019), we reject that cues or mere probable correlations are sufficient to ground and explain perception (Gibson, 1957). To

deal with non-universal correlations, we appeal to Runeson's distinction between complete and incomplete invariants. This is not a distinction between specifying and non-specifying invariants, both kinds of invariant specify some feature of the environment, but the former depends on constraints that hold throughout the relevant environment, whereas the latter depends additionally on further constraints which do not apply throughout the relevant environment (Runeson, 1989, p. 7). Thus, the relevant distinction is not between general and lawful information, but between local and universal lawful information. In this way we preserve ecological information as a 1:1 specifying relationship³.

Ecological information has a dual nature, it is not only, as we have been discussing, information *about* the environment but also information *for* the organism. In fact, an environmental structure is information about something only because it is detectable and usable by an organism, but not because it is semantically laden as assumed in traditional CSN. Thus, ecological information is information in relation to an organism, it specifies both the environment and the organism (Gibson, 2015, p. 132). Let us unpack these claims. The organism needs to be considered in the study of information for three reasons. First, information, as a relevant category in behavioral explanations, cannot fulfill its function to point to something unless it is detectable. So, an energy pattern can be information for an organism only if the organism has sensory registers that are sensible to that kind of energy. Ultraviolet radiation, even if structured, is not information for beings like us, but it can be for honeybees. Second, the detection of energy structured over time and/or space depends on the organism's abilities to explore its environment. Third, and more importantly, for

information to be usable it must be detected in a way that is meaningful or intelligible to the organism. According to Gibson, what an organism perceives when it looks at objects is not their physical qualities but their affordances, what the organism can do with them (Gibson, 2015, p. 126). As perception is direct, ecological information must then specify affordances too (Gibson, 2015, p. 131). This result shouldn't come as a surprise since organisms live not in the environment as such but in a particular niche, "a setting of environmental features that are suitable for an animal" (Gibson, 2015, p. 121). A kind of organism implies a kind of niche and *vice versa*, they are complementary, a niche "complements the variety of actions a species must perform" (Michaels and Carello, 1981, p. 44). Thus, the ecological information specifying those aspects or features of the environment that normally call the organism's attention also specifies their affordances. When we focus on the affordances specified by the ecological information, information is personal, it is information for a species or for an individual⁴.

Take, for instance, the information for optical contact. This information specifies the time at which an object would collide with an observer. When an object is coming toward the observer, it progressively occupies a wider area of the observer's visual field until the limit in which it occupies the whole field, the moment of the collision. According to Gibson and a later study by Lee (1976), the observer does not use information about the absolute speed and distance to calculate the time of contact, as a cognitivist would hypothesize. Rather, they directly pick up the rate of optical expansion of the object. This information is enough to guide the observer's behavior because "the rate of magnification is proportional to the *imminence* of collision" (Gibson, 2015, p. 167). This example is interesting because it shows in a clear way the dual nature of ecological information. The rate of optical expansion of an object specifies a type of event, the *approach-of-something* (Gibson, 2015, p. 167). This is information *about* an event. At the same time, this information is body-scaled, it relates the approaching object to the observer's visual field. Thus, the rate of expansion is also information *for* an organism inasmuch as it specifies possibilities for action, such as receding, deviating, or preparing for collision. As Michaels and Carello put forward:

"As with the example of approaching, the flow of optical texture specifies what is happening (walking toward) and what is about to happen (imminence of collision). Beyond this, the actor requires that the information be in a usable form. This means that it must

³van Dijk and Kiverstein (2020) recently proposed a different strategy, which they called *usage-based account of information*. They want to give up the idea that specifying information is pre-given in the sense that there are lawful correlations between surfaces and ambient energy prior to the agent's unfolding activities. Correlations continue to be necessary for perception in the authors' view, but they are generated by the activity of the agent. Although van Dijk and Kiverstein keep specification as fundamental for information, in agreement with the orthodoxy in ecological psychology, they part ways from this orthodoxy by proposing to think of specification "as a process in which the organism-environment relation forms" (van Dijk and Kiverstein, 2020). Accordingly, "affordances get specified in doing. Specification of affordances is not something lawfully structured energetic arrays can do on their own" (van Dijk and Kiverstein, 2020). Their main point is that generated lawful correlations between surfaces and the ambient energy get their information significance only through the agent's unfolding activities to maintain the organism-environment fit. In this sense, "specification is how the resulting patterns of light, sound and all the rest, are used" (van Dijk and Kiverstein, 2020). We agree in part with van Dijk and Kiverstein. It is true that some relevant correlations are brought forth only by the agent's unfolding activities. We also agree on the importance of how correlations are used, in fact, we acknowledge below that *information for* is the key to *information about*. But we disagree that actual use is what turns correlation into informationally significant. Instead, correlations get their information significance because of what they afford to an agent. For more on this difference between actual use and possible use in the characterization of information for, see Segundo-Ortin et al. (2019, pp. 1015–1016). Finally, in thinking of specification as a process and affordances as getting specified along this process, van Dijk and Kiverstein forgo the relevant distinction between the process of perception and the process of learning to perceive. As we argue below, what is ambiguous, uncertain or indeterminate is not the affordance itself. Instead, given that there are always a great number of affordances available, uncertainty is a matter of which one should be selected by the agent. In learning to perceive the agent learns to select which affordance she should attend to in order to achieve her goals, thus minimizing uncertainty about which affordance she should act upon.

⁴According to the ecological approach, an energy pattern is meaningful only if it specifies a possibility for action in relation to an organism. It may be interesting to note the congruence of this view with MacKay's action-oriented definition of meaning: "the meaning of a message can be defined very simply as its selective function on the range of the recipient's states of conditional readiness for goal-directed activity; so that the meaning of a message to you is its selective function on the range of your states of conditional readiness. Defined in this way, meaning is clearly a relationship between message and recipient rather than a unique property of the message alone" (MacKay, 1969, p. 24), where *message* is to be understood physically, as patterns of energy (MacKay, 1969, p. 20). As in ecological psychology, it is not actual behavior or usage that confers meaning to an energy pattern but a possibility for action, or, in MacKay's terms, a conditional readiness for goal-directed activity.

be specific to the animal (body-scaled) and specific to the animal's particular environment. Perceptual information is specific to the event and compatible with the level of regulation involved in activity (Michaels and Carello, 1981", p. 54).

As said before, there is nothing contentful in the ecological notion of *information about*. We need to keep in mind that, according to the ecological psychology, perception is not a state of the organism considered in isolation from the environment but of the whole organism-environment system (Lombardo, 2017, p. 3; Richardson et al., 2008, p. 170; Raja, 2019, p. 801). An organism perceives only when it is coupled to an environment, living and enacting in its niche. Only those aspects or features of the environment to which the organism is attuned in a practical way, by knowing how to deal with them, constitute the most immediate lived world of the organism, its niche, that region of the environment *about* which the organism can have perceptions. Although we can abstract structured energy from how it is detected by an organism, leaving out what that structured energy affords, the fact is that "for structured energy to qualify as information, an animal not only must have an ability to detect that information, it must also have a way to use it" (Michaels and Carello, 1981, p. 46). Thus, information *for* is the key to information *about*.

Finally, the ecological notion of *information for* and the ecological view of perceptual learning offer an interesting opportunity to approximate ecological psychology to enactivism. Assuming Shannon's idea of information as minimization of uncertainty and the enactivist view of sense-making as the activity by which an autonomous system regulates its coupling with the environment in an adaptive way (Di Paolo, 2015), ecological psychology can bring both ideas together in its explanation of perceptual learning. For Eleanor Gibson and James Gibson, perceptual learning is a discriminative process by which the organism's differential responses to ecological information get richer with practice (Gibson and Gibson, 1955, p. 39). Whenever learning is successful, the organism is "in closer touch with the environment" (Gibson and Gibson, 1955, p. 34) in that it becomes attuned to information that specifies affordances of something in the environment. Understood in this way, perceptual learning is also a process of minimization of uncertainty in that the organism moves from a situation in which its environment is undifferentiated, an indefinite number of possibilities for action are on a par with each other, to a situation in which particular affordances show up to the organism. Becoming attuned to information that specifies affordances is how the organism gets away from uncertainty. As Eleanor Gibson points out, "detecting unity, order, and redundancy are all ways of reducing uncertainty and of achieving specificity and economy" (Gibson and Pick, 2000, p. 157)⁵.

⁵Perceptual learning yields a change in the organism-environment system (Szokolszky et al., 2019, p. 11), at the end of the process the organism and its environment are more coupled to each other than before. The higher the specificity achieved, the lower the uncertainty about which affordances are appropriate to the task at hand, and less effort and exploratory activities are necessary for the organism to satisfy its needs. In sum, "over learning and development, there is

SKILLED AGENCY AND INFORMATION

The ecological notion of information provides the conceptual link between the idea of minimization of uncertainty, which is central to Shannon-information, and nomic variation or reliable covariation, which is the "scientifically reliable notion" endorsed by radical enactivists. So far, we have shown that, with due adjustments, these different views of information can be made to converge without implying representational content or semantically laden information. What is missing from this picture, however, is the role played by skilled agency in minimizing uncertainty.

Since its early days, enactivists have emphasized the role played by agency in cognition. The initial motivation in Maturana and Varela's work (Maturana and Varela, 1980) was to explain the distinctiveness of living organisms, with the additional supposition that whatever makes an organism a living one makes it a cognitive agent as well—which later became known as the strong life-mind continuity thesis (de Jesus, 2016), as endorsed for instance by some enactivists like Thompson (2007). Autopoiesis, the continuous production of the organism's own components and its functional distinction from the outside environment, was thus conceived in order to explain the difference between agency and mere mechanic reaction. An autopoietic organism is constituted by a precarious network of interrelated processes that determine its own viability conditions through self-production, approaching favorable conditions for its existence and avoiding detrimental ones. This, however, is insufficient in explaining agency, given that favorable and detrimental viability conditions can vary in degrees (Di Paolo, 2005). The fuller picture is that a cognitive organism is not only autopoietic but *adaptive*, that is, it improves its viability conditions by selecting more favorable environmental couplings and avoiding more detrimental ones, altering the set of parameters and conditions that affect the dynamic coupling between agent and environment (Di Paolo et al., 2017). We take this modulation of the system-environment coupling to be a matter of conveying information, which can be understood at the personal level as *skilled agency*.

Consider the following scenario: an inexperienced agent finds herself in a situation where she intends to do something. That can be achieved through certain actions that are available to her—however, due to her inexperience, she is uncertain about the outcome of any particular action in that environment. To add more details to that scenario, imagine a child using pointy cutlery for the first time with the intention of eating something on their plate, or a beginner piano student struggling to coordinate their hands while playing a scale. Plausibly, both are cases of intentional action, even though the agents in question may lack the ability to describe their intentions in a fine-grained manner. We recognize, therefore, a goal in their actions, and how well they perform depends on how close they get to achieve their goals. Importantly, their inexperience translates to uncertainty about the outcomes of specific actions *vis-à-vis* their goals, for they

a continual increase in predictability and efficiency of perceiving what is doable" (Adolph and Kretch, 2015, p. 130).

have a plethora of ways of acting and no means of choosing the most efficient or least costly ones. That is, unskilled agents cannot discriminate between more and less favorable environmental couplings for the achievement of specific goals. The child may hold the fork and the knife in a way that may be inefficient to cut the meal and bring it to their mouth, whereas there are many alternative ways to hold the fork and the knife which can be more efficient than the way they have done it—and they presently lack the cognitive resources to make a decision for a better way. Similarly, the piano student may play the scale incorrectly or out of sync due to the way they are placing their fingers on the keys, thus failing to perceive that there is a more efficient way within the set of possible ways to play that scale in a piano with a certain weight to its keys, and so on.

What the examples above show is that an inexperienced agent does not perceive the relevant possible ways of acting as clearly and as well-defined as a more experienced agent would. A skilled agent, on the other hand, has established efficient ways of achieving specific goals in those circumstances (and sufficiently similar ones), which means that they are more certain that a specific way of acting has the desired outcome in those circumstances. Thus, skilled agency minimizes uncertainty, conveying more information for action—how someone should act, given those circumstances (and sufficiently similar ones)—for the best way of doing something varies nomically with the intended outcome. Given that an agent's performance is selected and refined in order to deal with specific circumstances, that is, it is developed through their engagements within their niche, the information conveyed is usually local rather than universal, but in cases of skilled performance it is also uniquely specified in those particular circumstances.

The talk about uncertainty naturally leads to the question of whether we're committed to an objective interpretation of uncertainty, according to which it is inherently probabilistically unmeasurable, or to a subjective interpretation, which intends to treat objective uncertainty as subjective estimations of specific outcomes for specific actions. The latter option would allow for uncertainty to be treated in the way risk sometimes is in economy and decision theory, that is, as a case in which each action leads to specific outcomes whose probabilities are known by the agent, but which are not certain. Naturally, a more suitable approach to the enactive-ecological view of information is the ecological interpretation of uncertainty put forth by Kozyreva and Hertwig (2019), which was inspired by bounded and ecological rationality (Simon, 1956; Todd and Gigerenzer, 2012). Their view is that uncertainty is a function of the systemic coupling between agent and environment, an emergent feature that depends on how the agent engages with her niche. What Kozyreva and Hertwig call "uncertainty as a property of the organism-environment system" is a needed change to the concept of uncertainty for the enactive-ecological approach of information, given that both enactivism and ecological psychology take the system comprised of *agent interacting in an environment* to be the fundamental unit of analysis. Thus, "uncertainty comprises both environmental unpredictability and uncertainties that stem from the mind's boundaries, such as limits in available knowledge

and cognitive capabilities" (Kozyreva and Hertwig, 2019). Our previous discussion shows that we should include *skillfulness* in the class of "cognitive capabilities" that affect uncertainty, for, the more skillful the agent is, the more information they acquire from their surroundings. Moreover, as Kozyreva and Hertwig acknowledge, their view of uncertainty as an emergent feature of the agent-environment system leads to the idea that, in order to understand how the organism deals with uncertainty, it is crucial to understand their evolved cognitive capacities and the strategies they have developed in order to engage with their environment. Conversely, the way the organism explores the information that is available for them depends not only on their skills, but also on their bodily morphology, both from the ontogenetic and the phylogenetic standpoints. Clearly, bodily morphology selects and restricts the set of possible actions an individual can undertake in order to achieve a certain goal, functioning as the most fundamental factor in the minimization of uncertainty.

Aside from bodily morphology and skill, it should be clear due to our emphasis on intentional action that another variable to factor in the minimization of uncertainty is the practical interest, or simply the goals, of the agent in that environment. That the agent's goals matter in information pick up is one of the morals to be drawn from Neisser and Becklen (1975) classic ballgame experiment, where subjects watched two superimposed videos of basketball players passing the ball and, given their task of counting the number of passes between players in one video, they typically didn't notice "odd events"—which included, in replications of that experiment, a lady passing by with an umbrella and the famous gorilla. Experiments of selective attention therefore show that information that is plainly available to the agent is not picked up if it does not affect their goals. Accordingly, individuals with similar bodily morphologies and similar skill levels can still perform widely different actions in the same environment given their goals.

Now, if the skilled agent minimizes uncertainty about the outcomes of their actions, thus having a rich informational pickup going on, due to the limited set of actions they can undertake in order to accomplish a given task; it might look puzzling how the skilled agent is able to deal with unforeseen circumstances. After all, their skillfulness enables them to *limit* the set of possible actions, whereas unforeseen circumstances, at least the ones that don't relate to more familiar ones, may as well call for *new* actions. So, paradoxically, it might seem that the skillful agent would be less apt to deal with new circumstances and environments. This is, in fact, plausible: the reliance upon habits, that is, patterns of engagement we reinforce in order to act more skillfully in familiar settings, may set us back when we face new situations. But that is not to say that the unexperienced performer would be at an advantage, for they also would be greatly uncertain of the outcome of their actions in those circumstances. However, we speculate that in such cases the skilled agent would still be in a favorable position, because their skills enable them to operate at a higher order, perceiving the similarities between familiar environments and new ones, thus adapting previously

selected pairs of actions/outcome to engage in new, more suitable actions.

DIRECT LEARNING AND MINIMIZATION OF UNCERTAINTY

The literature on direct learning (Jacobs et al., 2000, 2001, 2009; Michaels et al., 2008) helps us to bring together and provide empirical support for some claims we made in the last two sections, namely, that agents perceive by picking up ecological information specific to affordances and that skilled agents minimize uncertainty about the outcomes of their actions. As we pointed out in section “Ecological Information (or Information for Action),” energy patterns may correlate with their respective sources in different degrees. However, according to the ecological approach, only a 1:1 specifying relationship supports direct perception. If this assumption about direct perception is correct, one can predict that learning to perceive “involves moving across the information manifold to a locus that permits better performance in the task” (Michaels et al., 2008, p. 944), in other words, through perceptual learning one is expected to change from relying on local specifying variables to universal specifying variables when these are available and more useful to the task at hand. This should not come as a surprise, since skilled performance seems to require successful perception in a variety of circumstances. We will discuss one study which obtained this result, namely, convergence to use universal specifying variables after practice.

The study in question tracked the variable to pick up the relative mass of colliding balls (Jacobs et al., 2009). Based on a prior study (Runeson, 1983), in which it was shown that the kinematics of linear collisions contain unambiguous information about kinetic properties, such as weight ratio, Jacobs et al. proposed a set of experiments to test whether novice and expert observers would differ in the kinematic information they use to perceive the relative mass of colliding balls (Jacobs et al., 2009, p. 1019). At least three types of kinematic information about colliding balls are correlated with their relative masses. As pointed out by Runeson, the mass ratio of colliding balls is specified by the amount of velocity change, according to the following formula: $m1/m2 = |v1 - u1| / |v2 - u2|$, where $m1$ and $m2$ are the masses of the balls, $u1$ and $u2$ are the velocities of the balls before the collision, and $v1$ and $v2$ are the velocities of the balls after the collision. The amount of velocity change is a very useful variable because it highly correlates with mass ratio across different environments. Another two kinematic variables that *might* be highly correlated with mass ratios are the difference in exit speeds—the speeds of the balls after the impact—and the difference in scatter angles—the angles between a ball’s velocity before and after collision (Jacobs et al., 2001, p. 1019). These are local non-specifying variables in that they highly correlate with mass ratios only in some specific conditions. In Jacobs et al.’s experiments, collisions between balls were simulated by a computer and displayed in a screen to observers who were then instructed to estimate the relative mass of the colliding balls. The experiments were designed to track learning, they consisted of

three sets of trials: an initial 64-trial pretest without feedback, followed by two 74-trial blocks of training with feedback—observers were informed about the correct mass ratios of the balls—and a final 64-trial posttest without feedback. By tweaking the simulation, it was possible to set up a set of trials in which mass ratios were highly correlated with all three variables above. Thus, in one experiment they were able to test whether observers would change the variable they rely on if it correlates highly with mass ratios. In this case, they did not, even those who started relying on local variables (Jacobs et al., 2001, p. 1023). In another experiment, with a different set of trials, where only the universal specifying variable correlated highly with mass ratios, the observers did change the variables they used and converged on the universal specifying one (Jacobs et al., 2001, p. 1032). A higher level of skilled performance was also observed in this case, as remarked by the authors: “Those observers who discover a specifying variable improve dramatically and reach high levels of performance” (Jacobs et al., 2001, p. 1033)⁶.

These results back some claims we made in the last two sections up. We said that the distinction between general and lawful information could be overcome by taking into consideration local constraints. As we mentioned in section “Ecological Information (or Information for Action),” both local and universal lawful information allow accurate performance in a task ecology⁷. In the first experiment, the observers kept using the same local specifying variable they started with, the exit speeds, because in the simulated condition that variable was highly correlated with mass ratios and, therefore, was very useful for the task at hand. At the same time, as shown by the second experiment, observers converged to a more useful variable when it was available and the variables they started with were poorly correlated with mass ratios. Change of variable happens when the observer is not already attuned to their task. Thus, the general conclusion is that “observers merely search for variables that are useful in the ecology encountered in practice” (Jacobs et al., 2001, p. 1035), what can be achieved by relying on local or universal information insofar as that information, given universal or local constraints, is useful for the task at hand.

Jacobs et al. finish their paper by advising that “great care must be taken in the selection of a stimulus set; otherwise, what may appear to be global cognitive principles can, in fact, be local solutions to local problems” (Jacobs et al., 2001, p. 1035). However, one may draw a different moral from their results,

⁶For another very interesting study with similar results, see Michaels et al. (2008). In this study the aim is to track variables for perceiving the length of unseen rods through dynamic touch (Gibson, 1962). For instance, when wielding and hefting a rod one may become attuned to variables that correlate with rod length such as the first and the third principal moments of inertia, or a higher order variable that is a combination of the first two (Michaels et al., 2008, p. 946). As in Jacobs et al.’s study, Michaels et al. (2008, p. 952) also concluded that “perceptual learning is guided by convergence information.”

⁷These considerations about the role of local and universal constraints also handle the objection that progressive perceptual learning seems to be incompatible with direct perception, which is a matter of all or nothing. At each stage of learning, the agent is attuned to a different variable, changing from local to more universal ones inasmuch as becoming more skillful in dealing with a task requires accurate performance in a wider range of circumstances. Perceptual learning is a matter of discovering more useful information (Runeson, 1983, p. 8). See also Michaels et al. (2008, pp. 946–947) discussion on information space.

namely and in resonance with our discussion in the last section, that cognition and rationality should be understood ecologically, as bounded by the environment, the task at hand, and the skills of the agent; as Kozyreva and Hertwig point out, “the essence of rational behavior consists in how an organism can adapt to achieve its goals under the constraints of its environment and its own cognitive limitations” (Kozyreva and Hertwig, 2019). Learning a perceptual skill is a process of adaptation to a discriminatory task, ecologically situated, whereby the agent becomes attuned to ecological information and minimizes the uncertainty about how to act in their environment. Skilled action optimizes the agent-environment coupling, which means that specific actions for the skilled agent have less uncertain outcomes. As we incorporate a skill to our network of skills, our body prepares itself for a set of possible states in the neighborhood of the states we are in as we act. We know what the consequences of our actions will be, not because we have an internal model, but because we are sensitive to these consequences insofar as we are prepared for them and know how to deal with them. Thus, to be sensitive to an affordance is to be less uncertain about the consequences of our actions, and this is the minimization of uncertainty provided by learning to perceive ecological information. As we have already pointed out in sections “Ecological Information (or Information for Action)” and “Skilled Agency and Information,” the range of possibilities for actions that can be successfully performed to achieve a goal or solve a task is determined and specified through perceptual learning. Uncertainty, as unpredictability due to a lack of knowledge, even probabilistic knowledge (Gigerenzer, 2019), is thus minimized by turning, through practice, some hitherto mere possibilities for action, whose consequences were also unknown, into embodied know-how. The skillful agent who knows how to ϕ enacts a world where the consequences of their ϕ -ing are under their control and are felt as such.

By approaching direct learning as an instance of ecological rationality at work, we also make it easier to see this process as close to sense-making activity, as we have already indicated in section “Ecological Information (or Information for Action).” Both are adaptive processes enacted by an agent. Gibson also characterizes direct learning as a process of *education of attention* (Gibson, 1968, p. 51; Gibson, 2015, p. 235) by which the agent *selects* only information that is needed for accomplishing their goals (Gibson, 1968, p. 286) and whose outcome is the agent getting “in closer touch with the environment” (Gibson and Gibson, 1955, p. 34). This is not so far away from the sense-making activity or “the capacity of an autonomous system to adaptively regulate its operation and its relation to the environment depending on the virtual consequences for its own viability as a form of life” (Di Paolo et al., 2018, p. 33), where adaptivity is understood as an agent’s ability to distinguish and select what is good and what is bad for the preservation of their own identity over time. We submit that enactive approaches could benefit from adopting the framework of ecological information; direct learning can be a helpful way to frame and explain, at least in part, the capacity behind sense-making activity, and at the same time, we acknowledge that ecological psychology can improve its understanding of the

organism-environment systems by encompassing the enactivist emphasis on agency (Stapleton, 2016, p. 326) and the role of the asymmetry between organism and environment, which lies on the side of the former, in explaining how an enacted world is brought forth, as we did in section “Skilled Agency and Information.”

Could this enactive-ecological approach to information and uncertainty scale up and explain how information is conveyed in offline cognitive acts, such as planning, remembering, inferring, hypothesis formulation, and language use? The question assumes that all cognitive performances could be explained within the same framework. While this is a possible position, we do not need to commit to it. It could be the case, for instance, that perception shares more similarities with planning and remembering than it does with inferring and language use, and it could be the case that at least some higher cognitive performances are currently better explained by appealing to more traditional views of information processing⁸. We do, however, believe that the discussion above shows that perceiving and planning do have a lot in common: while the former is a matter of online cognition, the latter is usually taken to be an offline performance, whereby the agent does not need to be in direct contact with their environment. But given that skilled performance involves an embodied readiness to deal with the outcome of our actions, it turns out that perceiving is already a matter of being able to engage in and to deal with possibilities that have not yet been actualized through our actions, what Kiverstein and Rietveld (2018) call “sensitivity to virtual conditions”⁹. Thus, planning could in principle be approximated to perception in this framework. Similarly, recent discussions on procedural memory—that is, the ability to remember how to do something—shows its approximation with perceptual abilities (Hutto and Myin, 2017). Moreover, Michaelian and Sant’Anna, 2019 have convincingly argued that a dispositional conception of memory traces, as favored by post-causal theories of memory; entails that episodic memory functions by strengthening the connection among nodes in a network, not by storing content. This again shows that episodic memory, and not only procedural memory, can be understood in a similar manner as perception is in the enactive-ecological framework. It follows that contentful information is not as central to the explanation of episodic memory as traditional CSN would have it, and it opens up the possibility of approximating the way information is conveyed in memory to the way it is in perception. It remains to be seen what other *prima facie* offline cognitive performances could be explained in a similar fashion, but we remain cautiously neutral on whether an enactive-ecological approach is sufficient to do so.

⁸Alternatively, Di Paolo et al. (2018) offer a distinct unified explanation of cognition, which consists not in scaling up basic levels of cognition, but instead in *scaling down* what is usually called higher-cognition. As De Jaegher points out in another paper, “nothing in enactive theory restricts it to this so-called ‘low level’” (De Jaegher, 2019) in that the very understanding of higher-order cognitive phenomena is transformed when it is reconceived by enactive resources. For instance, a correct understanding of embodiment allows us to see how our linguistic bodies and language emerge from a certain kind of participatory sense-making activity without having to appeal to semantic concepts (Di Paolo et al., 2018, p. 215).

⁹Although they do subscribe to a strict continuity between lower and higher cognition, a thesis we remain neutral about

CONCLUDING REMARKS

We have argued that information, stripped of any semantic or contentful significance, can also be the bread and butter of the enactive-ecological research program. Shannon-information as minimization of uncertainty is well placed to work out a bridge between ecological psychology and enactivism. First, we have put forward the ecological view of information as a relation of specification based on covariation. Because of its dual nature, ecological information specifies its source and affordances for an organism. Ecological information is mainly *for* action. Then, based on the enactivist view of agency, we explained minimization of uncertainty as resulting from the skillful activity of an agent while pursuing their intended goals in a particular environment. This is compatible with the ecological view of information because, in fact, what the agent is doing is reducing the full range of available affordances to those that are effective for achieving their goals. New and unknown situations offer new opportunities for an agent to minimize uncertainty, which they face with the help of their already acquired skills. We backed this view of minimization of uncertainty up by appealing to empirical literature on direct learning. Agents converge to use more useful and specifying variables, thus minimizing uncertainty, when their perceptual skills are improved by practice. We also indicated how closely related direct learning and sense-making activity are. Finally, we submit that enactivists should welcome ecological talk about information, since such talk enlightens the non-representational transactions between the organism and environment; and ecological psychologists

should forget Gibson's qualms about Shannon's view of information, as direct learning can be seen as a process of minimization of uncertainty.

AUTHOR CONTRIBUTIONS

EC is the main contributor responsible for sections "Ecological Information (or Information *for* Action)" and "Direct Learning and Minimization of Uncertainty," whereas GR is the main contributor responsible for sections "The Quarrel About Information" and "Skilled Agency and Information." Both have made contributions to all sections. Both authors contributed to manuscript revision, read, and approved the submitted version.

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Dynamic Touch as Common Ground for Enactivism and Ecological Psychology

David Travieso¹, Lorena Lobo^{2,3}, Carlos de Paz¹, Thijme E. Langelaar⁴, Jorge Ibáñez-Gijón^{1*} and David M. Jacobs¹

¹ Facultad de Psicología, Universidad Autónoma de Madrid, Madrid, Spain, ² Facultad de Ciencias de la Salud y de la Educación, Universidad a Distancia de Madrid, Villalba, Spain, ³ Embodied Cognitive Science Unit, Okinawa Institute of Science and Technology, Okinawa, Japan, ⁴ Faculty of Medical Sciences, University of Groningen, Groningen, Netherlands

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Fernando Bermejo,
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Argentina
Carlos Avilés,
Complutense University of Madrid,
Spain

*Correspondence:

Jorge Ibáñez-Gijón
jorge.ibanez@uam.es

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The main purpose of this article is to show that enactivism and ecological psychology share more aspects than is often recognized. Rather than debating about differences, commonalities between the approaches are illustrated with the example of dynamic touch. Dynamic touch is a form of touch that implies muscles and tendons and that allows the perception of hand-held objects that are wielded but not seen. Given that perceivers perform the wielding movements with effort, dynamic touch necessarily implies active exploration. The strength of dynamic touch as an example lies in the fact that it has been formalized and analyzed in detail at the level of the laws that govern the organism-environment system. The example provides empirically supported instantiations of sensorimotor contingencies, in enactivist terms, and of intentional exploration and information detection, in ecological terms. Moreover, dynamic touch is a practical example of the enactivist concepts of bringing-forth the world and sense-making. As a second purpose, we use the example of dynamic touch to clarify key concepts of the ecological approach. Specifically, we analyze the concepts of invariance and affordance, indicating the crucial difference between perceiving and actualizing affordances, and highlighting the importance of these concepts for the dialogue between enactivism and ecological psychology.

Keywords: ecological psychology, dynamic touch, enactivism, intentionality, postcognitivism

ENACTIVISM AND ECOLOGICAL PSYCHOLOGY SHOULD BRIDGE THE UNCANNY VALLEY

The enactive and ecological approaches are two disciplines concerned with understanding cognitive systems using a perspective that avoids scientific constructs such as internal representations or mental states, focusing instead on the interaction between the agent and its environment. Despite these strong commonalities, confrontation between enactive and ecological approaches has been the norm since the early days of enactivism. In the introduction of their book, *Sensorimotor Life*, Di Paolo et al. (2017) consider the relation between the enactive approach to cognition and the ecological approach to perception and action. In their words:

The relation between the schools of thought is one of strange familiarity, as if their respective practitioners were staring at each other across an uncanny valley. It is true that both approaches overlap in their rejection of representationalism, but this does not mean they are necessarily rejecting the same thing. As we will discuss further in this chapter and demonstrate in the following ones, the enactive perspective rejects a functionalist general approach to cognition, whereas ecological psychology rejects the assumption of the poverty of environmental information. These are not the same thing. For Gibsonians, perception is still about information pickup, but not for enactivists, who conceive of perception as an aspect of sense-making, a concept that is explicitly grounded in the notion of autonomous agency. (Footnote 3, p. 18)

In this article, we unfold the concepts that, according to Di Paolo et al. (2017), divide the traditions. We consider what information pick-up is for ecological psychology and whether it is compatible with the ideas of sense-making and autonomous agency from the enactivist approach.

As discussed in our previous work (Higueras-Herbada et al., 2019), the so-called 4E approaches (Gonzalez-Grandon and Froese, 2018; cf. Calvo and Gomila, 2008) – which include enactivism – only turn an eye to the much older ecological approach occasionally. As do the 4E approaches, the ecological approach has criticized the cognitivist approach from its very beginning (see Fultot et al., 2016, and the commentaries on that article; see also Lobo et al., 2018, for a historical overview of the ecological approach). The different origins and foci of enactivism and ecological psychology, however, have at times prevented that the commonalities between the approaches are appropriately reflected in the writings of scholars of the respective approaches (cf. Baggs, 2018). As Di Paolo et al. (2017) state:

This is one of the reasons for the admittedly rather quick dismissal of ecological psychology by Varela et al. (1991), who saw it only capable of providing a theory of cognition on the side of the environment. In later years, there have been many attempts at bringing the two traditions closer to each other. (Footnote 3, p. 18)

As indicated in the previous quote, recently there have been a number of attempts to relate enactivism and ecological psychology, giving room to at least three main positions (Higueras-Herbada et al., 2019). The first position considers the approaches irreconcilable (Cariani, 2016) or with substantial differences (Mossio and Taraborelli, 2008). The second position considers the approaches complementary, focusing on different levels of analysis. Thus, whereas the ecological theory of perception focuses on the ecological level of analysis, enactivism focuses on autonomous agency or on a subpersonal level of analysis (Heras-Escribano, 2016, 2019a,b; McGann, 2016). A third position, as formulated by Stapleton (2016) in her commentary on Fultot et al. (2016), holds that there are already examples that joint crucial concepts of the considered approaches:

It seems to me that much of the research developed in the ecological psychology approach, and the conceptual tools used,

are valuably incorporated by enactivists to flesh out a full framework of life and mind. Likewise, ecological psychology can benefit from the depth of the enactivist enterprise. (p. 327)

We believe that theoretical papers concerning the enactive and ecological approaches should be understood as being engaged in dialogical discussions (Voloshinov and Bakhtin, 1986). In such discussions, main concepts are treated as *dialogemes*, which is to say, as voices where the content of the terms has to be colonized by a tradition. In such a process, differences between approaches are often stressed, even subtle ones, concealing strong commonalities. In order to avoid such detrimental drift, the present article takes the opposite direction and aims to stress commonalities.

Just above the quote that opened this article, Di Paolo et al. (2017) state:

As proof of how close the approaches can be in concrete cases, we make use throughout this book of work originating in the Gibsonian tradition (Gibson, 1979/1986). This tradition usually supplies some of the clearest examples of how dynamical engagements and bodily synergies can be explanatorily powerful. (Footnote 3, p.18)

In this article, we focus on what we consider the best example to indicate points of coincidence of the approaches, and to describe classic ecological concepts such as affordance, invariant, and information pick-up through intentional (goal-driven) exploration. This example is the one of dynamic touch.

WHAT IS DYNAMIC TOUCH?

As far as we are aware, the study of dynamic touch can be traced back to Gibson's article *Observations on Active Touch* (Gibson, 1962) and his seminal book *The Senses Considered as Perceptual Systems* (Gibson, 1966). In the article, Gibson questioned the everyday relevance of touch as conceived as a passive sensory channel. Instead, he highlighted the active nature of touch and the prominent role of exploration. He did so by comparing passive and active conditions of haptic perception in a series of experiments. In his words:

Active touch refers to what is ordinarily called *touching*. This ought to be distinguished from passive touch, or *being touched*. In one case the impression on the skin is brought about by the perceiver himself and in the other case by some outside agency Active touch is an exploratory rather than a merely receptive sense. When a person touches something with his fingers he produces the stimulation as it were. More exactly, variations in skin stimulation are caused by variation in his motor activity. . . . Such movements are not the ordinary kind usually thought of as responses. They do not modify the environment but only the stimuli coming from the environment. (Gibson, 1962, p. 477)

Gibson referred for the first time to dynamic touch (dynamic touching in the original) in the two chapters about haptics in his 1966 book (Gibson, 1966). In these chapters, Gibson recognized that part of the kinesthetic system allows a muscle-based perception of properties of external objects (Gibson, 1966,

p.109). This is why dynamic touch, on occasions, is referred to as muscle-based perception.

In a practical sense, dynamic touch concerns the everyday haptic perception of natural and manufactured objects that we hold in our hands. Just to name a few examples, this includes the perception of how far we can throw objects through hefting (Bingham et al., 1989; Zhu and Bingham, 2008, 2010), if objects can be used for hammering (Wagman and Carello, 2001), the perception of shape (Burton et al., 1990), tool use (Michaels et al., 2007), the perception of heaviness (Shockley et al., 2001), and even an explanation of the size-weight illusion (Amazeen and Turvey, 1996).

Manipulating objects, such as a tennis racket, produces perceptions that cannot be explained appealing exclusively to the stimulation of the skin. In Gibson's (1966) words:

The passive skin can be stimulated by an object resting on it, the amount of pressure (that is, skin deformation) being proportional to the weight of the object, but in this case discrimination is rather poor. It is much better when the object is lifted. (p. 127)

The different amounts of stretching and contracting of muscles, as well as the forces exerted by and on the muscles and on the tendons, change depending on the movements that are performed and on the form, size, and mass distribution of the object. Those variations form the main sensory basis of dynamic touch (Carello and Turvey, 2015, 2017).

The pivotal elements of the ecological conception of dynamic touch are the laws that connect motor components (forces exerted by muscles) and sensory components (in muscles and tendons). In this regard, the ecological portrayal of dynamic touch shows remarkable similarities with key concepts of the enactive tradition. Consider the example of the softness of a sponge that figures importantly in the writings of enactive scholars. According to O'Regan et al. (2005):

Having the sensation of softness consists in being aware that one can exercise certain practical skills with respect to the sponge: one can, for example, press it, and it will yield under the pressure. The experience of softness of the sponge is characterized by a variety of such possible patterns of interaction with the sponge, and the laws that describe these sensorimotor interactions we call, following MacKay (1962), laws of sensorimotor contingency (O'Regan and Noë, 2001). (p. 56)

In this regard it is curious to note that, when Gibson developed his intuitions about the functioning of dynamic touch, he cited several studies on the perception of softness, much in line with the writings of enactivist scholars. In Gibson's (1966) words:

The firmness or softness of a material substance is a property of the substance that is registered when forces are exerted on it by the hand. Scott-Blair and Coppen (Harper, 1952) investigated the perception of the firmness-softness of industrial substances (rubber, bitumen) by having the observer squeeze a cylindrical sample of the material to be graded. The "feel" of the material was quite clear at the end of this dynamic action. They concluded that the perception "had the nature of a Gestalt," but I would suggest instead that an invariant was isolated. (p. 128)

Gibson (1966) further suggested that the invariant involved in the perception of softness relates to the ratio of the force exerted and the amount of depression of the surface (cf. Harper and Stevens, 1964). In the case of dynamic touch, the relevant invariants relate forces to movements. Let us now introduce the physics of these invariants.

THE LAWS THAT GOVERN THE ORGANISM-ENVIRONMENT INTERACTION IN DYNAMIC TOUCH

Early research on dynamic touch analyzed the mechanical properties that govern the perception of the length of hand-held rods. In their pioneering study, Solomon and Turvey (1988) reported a linear relation between actual and perceived length and they argued that the observed pattern of results was consistent with the claim that the length judgments were based on the mechanical property that is referred to as *first principal moment of inertia* (cf. Kreifeldt and Chuang, 1979). Although this claim has been supported by later studies (e.g., Fitzpatrick et al., 1994), it has also been questioned (e.g., Kingma et al., 2004). Kingma et al. demonstrated the importance of a different mechanical property, referred to as *static moment* (cf. van de Langenberg et al., 2006). In the present section, we define such mechanical properties and provide intuitions about how these properties determine the relations between exerted forces and resulting movements.

Consider a rod that is loosely attached to a support at one of its ends so that the force of gravity orients the rod with its longitudinal axis toward the ground. Measuring the force exerted by the rod is one of the ways that allows the detection of the mechanical property *mass*. To facilitate the presentation of less well-known properties later in this section, it may be helpful to note that the mass (M) of an object can be approximated by:

$$M = \sum_{i=1}^N m_i, \quad (1)$$

in which the m_i s represent the point-masses of the object at N different points (integral-form versions of this equation and of Eqs 2 and 3 can be found in Jacobs et al., 2009). As captured by Newton's second law of motion (*force = mass × acceleration*), mass can also be defined as the resistance of the object to linear accelerations. This means that moving a rod in a direction that is aligned with its longitudinal axis may reveal mass as the invariant that relates force and acceleration.

The equation that defines mass does not include a term that relates to the length of the object. This means that one cannot differentiate rods with equal mass and different lengths with linear movements along the longitudinal axis. Analogously, an object can be attached to ropes of different lengths and if one holds the rope vertically, one can detect mass, but not the length of the rope. If, however, all the rods that one encounters are of the same material and diameter (for instance in a laboratory situation), then length and mass co-vary perfectly. This means

that, for such a particular set of rods, exploratory movements that allow the detection of mass also allow the detection of length.

Now consider a rod that is held by its end and maintained with its longitudinal axis horizontal to the ground. The rotational force that is exerted by the rod at the point of rotation corresponds to the mechanical property called static moment. Extending Equation 1, static moment (SM) can be defined as:

$$SM = \sum_{i=1}^N m_i d_i, \quad (2)$$

in which each d_i is the distance of the corresponding point-mass m_i to the axis of rotation. For rods with the same mass, homogeneously distributed over the length of the rod, the static moment is higher for longer rods. Therefore, under certain laboratory circumstances, statically maintaining a rod as described above may allow one to differentiate the lengths of objects with the same mass.

As a next step to introduce the mechanical properties and laws that are most relevant to dynamic touch, we illustrate how rods can be modified without changing their mass or static moment. Consider **Figure 1**. The rods have the same mass. They also have the same static moment, and thus exert the same rotational force when held still horizontally. However, if one actively rotates the rods, the lower one offers more resistance. This is so because the resistance to rotation offered by mass is a squared function of distance; hence, whereas moving M_2 away from the axis of rotation is compensated by moving M_1 nearer for static moment, this is not the case for the resistance against rotation. More precisely, for one-dimensional rotations, the moment of inertia (I) can be defined as:

$$I = \sum_{i=1}^N m_i d_i^2. \quad (3)$$

In analogy to Newton's second law for linear motion, the moment of inertia determines the acceleration that is obtained with a rotational force (i.e., $\tau = I \times \alpha$), meaning that the moment of inertia can be measured as the invariant relation between rotational acceleration, α , and force, τ .

As a final step in our introduction to the relevant mechanical properties and laws, one should note that, so far, we have only considered one-dimensional rotations. Even if one considers a single point of rotation, however, objects can be rotated around

different axes, leading to different amounts of resistance. A full description of the 3-dimensional resistance to rotation that is offered by an object is provided by the inertia tensor, which is a symmetric 3×3 matrix with nine inertial components. The inertia tensor, \mathbf{I} , relates three-dimensional forces to three-dimensional accelerations according to the formula: $\boldsymbol{\tau} = \mathbf{I} \times \boldsymbol{\alpha}$, in which the use of boldface indicates the fact that the symbols stand for vector and matrix properties. If one diagonalizes the inertia tensor, the eigenvalues that one obtains are the mechanical properties referred to as the first, second, and third principal moments of inertia (I_1 to I_3). These moments can also be described as the resistance against rotation around three orthogonal axes that are ordered from the highest amount of resistance to rotation to the lowest amount of resistance. For a symmetric rod, I_1 and I_2 are identical and correspond to rotation around axes that are orthogonal to the longitudinal axis of the rod, and I_3 corresponds to rotation around the longitudinal axis.

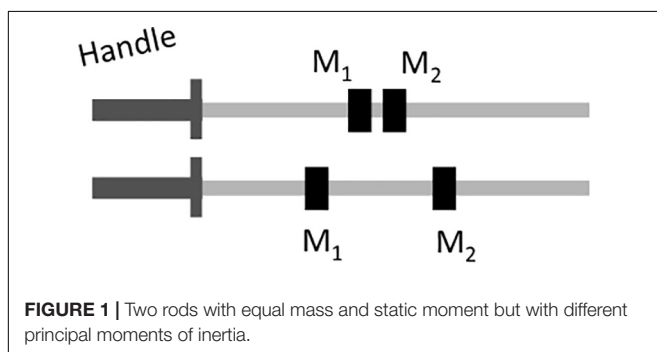
It is easy to intuitively experiment with some of these mechanical properties and laws. To do so, we ask you to hold a small rod between the thumb and index finger (for instance a wooden ruler or any other elongated object). The rod will move until aligned longitudinally with gravity. Move it up and down, so that you can feel its mass. But, what about its length? Then, keep it in a horizontal position. Does the effort change? What about mass and length perception? Finally, grip the object from the center and rotate it like a seesaw, and do the same while holding it by the end (rotations with low and high I_1 , respectively). This small experiment provides an intuitive demonstration that the relation between self-produced forces and resulting accelerations allows us to detect properties of wielded objects.

To summarize this section, during wielding, different types of forces stand in different invariant relations to the resulting accelerations. An enactivist may call these relations *sensorimotor laws*. Being sensitive to these relations, or sensorimotor laws, allows the perceiver to detect the mechanical properties that underlie, or determine, the invariant relations. The starting point of perceiving through dynamic touch, however, is not formed by the mechanical properties that underlie the agent-environment interactions. Instead, the starting point is formed by the exploratory movements exerted by an intentional agent. The next section, therefore, analyzes the exploratory movements and the role of intention as modifier of these movements.

INTENTIONAL EXPLORATION: BRINGING-FORTH THE WORLD THROUGH DYNAMIC TOUCH

The concept of bringing-forth the world may be attributed to Varela et al. (1991), who write: "Cognition in its most encompassing sense consists in the enactment or a *bringing forth of a world* [emphasis added] by a viable history of structural coupling." (p. 205). Elaborating on the concept, Proulx (2008) states:

It is my structure that allows me to "see" or perceive things in the physical world, and so my structure allows me to give



meaning to the attributes of the physical world. I – my structure – allow the physical world to be brought forth. If these attributes of the physical world are outside of my structure, outside of my capacity to make sense of them, I cannot distinguish them and cannot perceive them. In other words, they cannot “trigger” anything in me. Hence, I bring forth the physical world’s attributes when I give/create meaning to it – I acknowledge their physical “presence” by bringing them forth. If I do not bring them forth, the physical world’s attributes will still be “there,” but they will remain unnoticed, not made sense of and kept “in the dark.” It is in this sense that the physical attributes themselves are brought forth by my interaction with them (if I perceive them). In some sense, I make the physical world emerge. (p. 21–22)

In our effort to stress commonalities between the enactivist and ecological approaches, we should note the similarities between the intentional exploration in dynamic touch and the enactivist concept of bringing-forth the world. The mechanical properties defined in the previous section (mass, static moment, inertia tensor) are intrinsic properties that can be detected only by acting upon them. Although the inertia tensor of an object can physically be described independently of a perceiver, in order to detect or measure the property, perceivers apply forces on the object and identify relational aspects of the emerging interaction.

The fact that, in dynamic touch, the perceiver chooses which mechanical properties to act upon, or bring forth, brings us to the concept of intentionality. A common portrayal of the ecological approach from enactive scholars considers that action is reduced to mere movement, thus leaving intentionality out of the explanations. For example, Di Paolo (2016) states:

In addition to a deep understanding of the environment, we need a theory that pays attention to the perceiver as an active agent and her capacity to engage her world meaningfully. “Active” here does not mean simply “moving” (this is well-covered in ecological psychology). It means engaged in a regulated coupling with the environment, generating goals and pursuing them, moving in ways that alter the constraints that link the agent and the environment as coupled systems. (p. 327)

The example of dynamic touch, however, shows the central role of actions and intentions in the ecological approach to perception. In the ecological portrayal of dynamic touch, it is particularly clear that exploratory movements are performed *because* the perceiver intentionally, or purposefully, aims to reveal certain mechanical properties of the object while ignoring others. This notion of the role of action and intention in perception is shared with enactivists researchers. A prominent example can be found in the book *Action in Perception* (Noë, 2004):

Think of a blind person tip-tapping his or her way around a cluttered space, perceiving that space by touch, not all at once, but through time, by skillful probing and movement. This is, or at least ought to be, our paradigm of what perceiving is. The world makes itself available to the perceiver through physical movement and interaction. (p. 1)

The concept of intentionality was, in fact, one of the key concepts in the pioneering research on dynamic touch by Solomon and Turvey (1988), and thereby one of the foundational

concepts for the body of research on dynamic touch. In their words:

With a haptic subsystem, intentionality identifies the goal to be attained. On the basis of the intention of the subject/performer, the parts of the haptic perceptual system are assembled into a special-purpose machine capable of attaining the desired goal when the muscles and other tissues are assembled into a subsystem, a functional unit, the behavior of the subsystem is conjugate to the properties of the object under exploration. (Solomon and Turvey, 1988, p. 405)

Later in this section we describe empirical research that demonstrates how different intentions lead to different exploratory movements. First, however, we describe empirical research that indicates how different exploratory movements determine the mechanical properties that are detected.

Burton and Turvey (1990) performed experiments on the perception of length through dynamic touch with unrestricted movements as well as with the instruction not to move the rod. With instructional restrictions on the movements, static moment predicted the length judgments better than the first principal moment of inertia, whereas this was the other way around for unrestricted movements. Relatedly, in their study on length perception through dynamic touch, Lobo and Travieso (2012) systematically restricted the exploratory movements in six movement conditions with different amplitudes and frequencies. With faster movements, more accurate judgments were obtained, supporting the idea that, in unrestricted conditions, length perception relies on the first principal moment of inertia.

Similar conclusions concerning the importance of exploratory movements were obtained by Harrison et al. (2011). These authors also showed that the intention to detect different affordances (e.g., holdability, rotatability) affected length perception. Their results “revealed perception to be constrained by (a) the moments of mass distribution of the hand-tool system, (b) the qualities of exploratory wielding movements, and (c) the intention to perceive each specific property” (Harrison et al., 2011, p. 193). A further example of how intentions affect the detected mechanical properties as well as the exploratory movements can be found in Arzamarski et al. (2010; cf. Riley et al., 2002). These authors manipulated the intention of participants by asking them to report either the length or the width of hand-held objects. When participants intended to perceive length, the exploratory movements showed relatively more rotation around the anterior-posterior axis (as defined in **Figure 2**), and the judgments were more closely related to I_1 than to I_3 . On the contrary, when the intention was to perceive width, participants performed relatively more rotations around the twist axis and estimations were more closely related to I_3 than to I_1 .

Rather than thinking about relatively simple exploratory movements such as pure rotations or twists, one may prefer to think about more complex ones. It is interesting to indicate in this regard that Stephen et al. (2010) argue that fractal fluctuations in exploration reveal the detection of information at many time-scales:

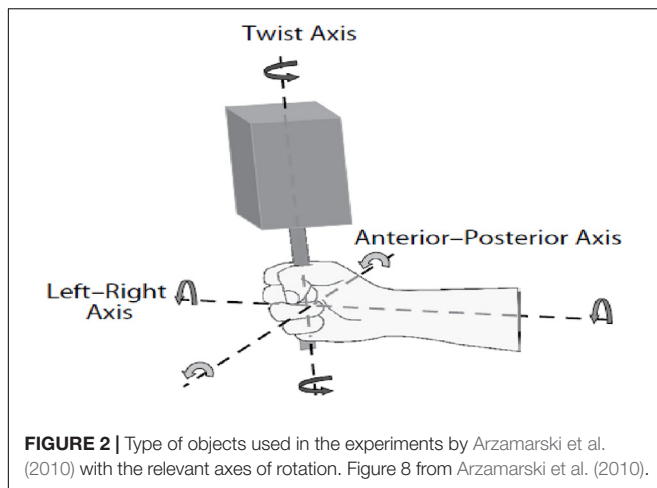


FIGURE 2 | Type of objects used in the experiments by Arzamarski et al. (2010) with the relevant axes of rotation. Figure 8 from Arzamarski et al. (2010).

Indeed, even the miniscule musculoskeletal fluctuations incident to static holding have been claimed to inform haptic judgments (Burton and Turvey, 1990). Whereas static holding is simply the maintenance of balance among muscular and gravitational forces, wielding signifies a strongly intentional excursion from balance that is meant to produce new or richer information about the inertial properties of the object. Of course, active forces in wielding movements will still interact with reactive forces: The inertial properties of the object still exert effects on the trajectory of the limb that are not explicitly prescribed by the muscle forces exerted during wielding. (p. 2)

As an aside, the idea of multi-scale behavior is reminiscent to an ecological theory of learning, referred to as *direct learning* (Jacobs and Michaels, 2007), which holds that phenomena at the time-scale of learning can be explained with the ecological principles developed for the time-scale of perceiving and acting. The above-mentioned study of Arzamarski et al. (2010) is related to this theory, as well as other learning studies in the field of dynamic touch (Michaels et al., 2008; Jacobs et al., 2009; Withagen and van Wermeskerken, 2009). We refer the reader to Higuera-Herbada et al. (2019) for a description of that theory and its relevance to the dialogue between the enactive and ecological approaches.

To summarize the gist of this section, the type of exploratory movements that are performed determine which mechanical properties become determinants of the agent-environment interaction and which mechanical properties are irrelevant for that interaction (e.g., twisting movements are affected by I_3 but not by I_1). The ecological portrayal of dynamic touch, therefore, starts with the intention to perceive some property. This intention leads to exploratory behavior that is determined by, and hence reveals in the interaction, those mechanical properties that relate to the property that the agent intends to perceive. This portrayal is aligned with the writing of many enactivists, who may say that the purposeful, autonomous agent *brings forth* those mechanical properties that are relevant to her goals, leaving in the dark other properties.

AFFORDANCES AND INVARIANTS IN DYNAMIC TOUCH

Our next goal is to illustrate and hopefully clarify two key concepts from the ecological approach: affordances and invariants. Instead of providing canonical definitions of these terms, we consider them using the example of dynamic touch. With respect to affordances, we focus on the distinction between perceiving and actualizing, which, we believe, is often under-emphasized or misunderstood in the writings of scholars that compare enactivism and ecological psychology.

When Gibson (1966) introduced the concept of invariant in dynamic touch, he stated the following:

The mass of an object can be judged, in fact, by wielding it in any of a variety of ways, such as tossing and catching, or shaking it from side to side. One can only conclude that the judgment is based on information, not on the sensations. The stimulus information from wielding can only be an invariant of the changing flux of stimulation in the muscles and tendons, an exterospecific invariant in this play of forces. Whatever specifies the mass of the object presumably can be isolated from the change, and the wielding of the object has the function of separating off the permanent component from the changes. The merely propriospecific information can thus be filtered out, as it were, leaving pure information about the object. This process takes time, for an invariant can only emerge from a series of transformations over time. (p. 127)

When we wield a tennis racket, for example, rotational hand and arm forces lead to different movements. Those movements depend on the original position of the hand-arm system and the racket, and on the dynamics of the whole system in inertial terms. The invariants that reside in the flux of change of forces and movements are specific to intrinsic properties of the wielded objects. However, in contrast to the interpretation of ecological psychology as a physicalist approach, the information that is used for perception through dynamic touch is not the specification of such mechanical properties in discrete stimuli that are internalized, or values that perceivers infer from stimulation that is imposed on them. Quite the opposite, the invariants exist because of the laws that govern the organism-environment system only when these laws are combined with the intentional exploration that creates the necessary change for the invariants to come into existence. Perceiving, then, is the detection of the invariants in the organism-environment interaction that specify possibilities of action. As ecological psychologists would say: we detect invariants and we perceive affordances.

As Carello and Turvey (2017) remind us, Gibson (1966) first introduced the ideas behind the concept of affordance in his reflections on dynamic touch:

Although he did not develop his notion of affordance until his 1979/1986 book it is, in fact, mentioned in Gibson (1966) in one of the chapters on the haptic system. In arguing against the tradition of imposing discrete stimuli on passive participants who were to report “awareness of the impression, not the object making it” (p. 98), he recommended that an active observer obtaining patterns of stimulation should be “allowed to report what he perceives,

including what it affords or might be used for” (p. 99). (Carello and Turvey, 2017, p. 97)

For rods, examples of affordances may be throwability, holdability, rotatability, whether other objects can be reached with the rods, or whether the rods are suitable for certain hitting actions. In contrast to other properties (e.g., the length or shape of rods), affordances are defined with respect to the organism’s purposeful actions. This means taking the organism-environment system as the unit of explanation. Thus, when wielding an object and producing rotations, perceivers detect the relation between exerted forces and resulting movements, perceiving affordances that allow them to prospectively control further movements (e.g., Bongers et al., 2004).

We believe that it is crucial for the dialogue between enactivism and ecological psychology to clarify that perceiving an affordance is not the same as actualizing an affordance (i.e., performing the action that is afforded; Michaels et al., 2001). For instance, perceiving that a stone affords throwing (Bingham et al., 1989) is not the same as throwing the stone, or perceiving that a ball can be caught is not the same as actually catching the ball (Jacobs and Michaels, 2006). Consider a further example. During the night, a person wakes up and wants to go to the bathroom without turning the lights on. Instead, she uses the light of her phone to illuminate her peripersonal space (the space immediately close to her). With this light, she sees one slipper under the bed, but, unfortunately, a bit far, so she cannot reach it with her arm. She stares at the slipper as she taps nearby objects in an attempt to find something that allows her to reach the slipper. She grabs an object and wields it, but rapidly discards it, as it is too short. Then she grabs another object, does the same quick wielding, and finally uses it, knowing that it will be long enough to reach the slipper. Using the ecological vocabulary, one may say that the sequence of actions started with the intention to get the missing slipper. Using dynamic touch, in the first try with an object she did not perceive the affordance of reaching the slipper. In the second try, she did perceive the affordance. After perceiving the affordance, she actualized the affordance by actually reaching toward the slipper.

When actualizing an affordance, then, such as throwing a stone, catching a ball, or reaching for a slipper, information is used that allows the actor to control the relevant forces. The action itself emerges from the information-action couplings and the dynamics of the agent-environment system. This means that, for the actualization of affordances, one does not need environmental information that specifies the affordance. Hence, in line with what is often claimed by enactivists (e.g., Varela et al., 1991), for a theory of perceptually-guided action (i.e., a theory about actualizing affordances), one does not need environmental information that specifies affordances.

In order to veridically perceive an affordance, however, often done before actualizing the affordance, a relation of specificity must be maintained between the agent and the environment (Jacobs and Michaels, 2002). In the case of dynamic touch, this implies a lawful chain of specificity that goes from the intention to perceive the affordance, to invariants

in the flux of forces and movements that is created during the exploration, via the mechanical properties of the wielded object, to the actual affordance, as well as vice versa. If an affordance is not specified in detectable information, it cannot be perceived. Ecological psychologists are interested in the perception of affordances, for which the specification of affordances is indispensable, as well as in the actualization of affordances, which may be analyzed with less concern about what is specified by the information that guides the movement (cf. Michaels et al., 2001).

Varela et al. (1991), in their treatment of the ecological approach, had in mind the actualization of affordances when they describe their own position. This is clear, for example, when they write: “The overall concern of an enactive approach to perception is ... to determine the common principles or lawful linkages between sensory and motor systems that explain how action can be perceptually guided” (p. 173). In this regard, the enactive approach is more closely related to the part of the ecological approach about the actualization of affordances than to the part about the perception of affordances. Rather than noting existing commonalities with ecological research about the actualization of affordances, however, Varela et al. (1991) distanciate themselves from the ecological approach by referring to ecological ideas concerning the perception of affordances: “In Gibson’s view ... perceptually guided action consists in ‘picking up’ or ‘attending to’ invariances in the ambient light that directly specify their environmental source” (p. 203). This quote seems to concern the actualization of affordances (“perceptually guided action”) in its first part but changes its emphasis toward the perception of affordances (“invariants that specify their source”) in the latter part. To summarize, rather than searching for commonalities with theoretical and empirical research from the ecological tradition about the actualization of affordances, enactivist scholars often choose to stress differences by focusing on parts of the ecological approach that concern the perception of affordances – an issue that, one way or another, any approach has to address.

Apart from the confusion concerning perception and actualization, the concept of affordance is often claimed to be well suited to the enactivist approach (Varela et al., 1991) and is mentioned ubiquitously by enactivists (e.g., Noë, 2004; Di Paolo et al., 2017; Gallagher, 2017). This is so because affordances are related to the bringing-forth the world concept of enactivism and to sense-making. We briefly address the concept of sense-making before our concluding section.

SENSE-MAKING AGENCY IN DYNAMIC TOUCH

Sense-making agency refers to a conception of agency by which the organism builds up its agency through meaningful interactions with the environment. In this context, perception is not a blind contact with the environment that imprints its effect on the sensory surfaces, which is afterward processed searching for regularities. Using the words of Thompson and Stapleton (2009):

Even the simplest organisms regulate their interactions with the world in such a way that they transform the world into a place of salience, meaning, and value – into an environment (Umwelt) in the proper biological sense of the term. This transformation of the world into an environment happens through the organism's sense-making activity. (p. 25)

The concept of sense-making refers to the particular behavior of the autonomous organism that is determined by its structure (for example, only animals with eyes can see), which makes available certain properties of the physical world that constitute the environment for her. Moreover, enactivists remain skeptical of those animal-environment relations in which specification does not imply an intentional action on the part of the organism. A clear example is the detection of time-to-contact (Lee, 1976). Despite the fact that the original analysis concerned the active control of movement by the perceiver (i.e., the control of braking by a driver), the optical specification of time-to-contact can be demonstrated for the case where the perceiver actively approaches a static object as well as for the case where an object approaches a static perceiver. Thus, Di Paolo (2016) states that for enactivists:

Meaning is not just something that pops up in the relation between organism and environment. It necessitates a particular kind of activity on the part of the agent to emerge, i.e., sense-making. (p. 328)

In the paradigmatic case of dynamic touch, the history of interaction with the object consists of the exploratory wielding, where forces exerted by the agent produce changes in the position of the objects. The objects that are wielded during dynamic touch, and the mechanical properties that we described earlier in this article, therefore form part of the meaningful environment of the perceiving agent. An enactivist may claim that dynamic touch is the sense-making activity that makes that the rods and the relevant mechanical properties form part of the meaningful environment of the agent. The ecological example of dynamic touch, therefore, as well as the concept of affordance, can easily be related to enactivist concerns about sense-making. For further debate about the notion of sense-making we refer the reader to Fultot et al. (2016).

From our perspective, at the same time that the sense-making activity determines the ecological niche for the organism – only animals with eyes can see – the environment exerts selective pressure on the organisms, establishing constraints on the structure of the organism – eyes are adaptive only in an environment with light that obeys the laws of optics. Therefore, we can consider that the sense-making activity is determined by the structure of the organism, and the laws governing the sensorimotor activity are those describing the physical world in which they are embedded. The strength of the dynamic touch example is that, together with the sense-making activity, we have a detailed description of the laws governing the physical interaction. Borrowing, again, the words of Di Paolo (2016):

Despite the accent on agency as always situated in an environment, it is correct that there is a dearth of enactive

theorizing about the environment, as noted by McGann (2014). Does this mean that such theorizing is unwanted or that it could not fit well with other enactive ideas? I do not think so. It is more a case that it has not been done yet, and what better encouragement to do this than to engage in ongoing dialogues with ecological psychologists. (p. 329)

CONCLUSION

In this article we have aimed to reveal commonalities rather than emphasizing differences between enactivism and ecological psychology, using dynamic touch as example. We have argued that more similarities can be identified than is often indicated in the literature. In this sense, we have shown how dynamic touch can provide an excellent test bed for enactivist ideas concerning sensorimotor laws, bringing forth the world, goal-directed agency, and sense-making activity. In particular, the active and intentional information detection put forward by ecological psychologists implies that ecological information is not instructive, meaning that the information does not determine what is perceived or acted upon.

Given that not all perceptual tasks reveal such an obvious intentional exploration as dynamic touch, however, one may wonder whether dynamic touch can be considered a generalizable example. That is, would the enactivist and ecological approaches show as much similarity if analyzed with another example? In this regard, it is interesting to note that both enactivists and ecological psychologists tend to indicate similarities between vision and touch. To illustrate this for ecological psychology, consider two quotes from Gibson's (1962) seminal article on active touch. Concerning passive touch and vision, he states:

In passive touch the individual makes no voluntary movements. Similarly, in passive vision he makes no eye movements, which means that he must voluntarily fixate his eyes on a point specified by the experimenter. Neither state is natural to an individual. (Gibson, 1962, p. 489)

Concerning active touch and vision, in contrast, he states:

The foregoing survey suggests that vision and touch have nothing in common only when they are conceived as channels for pure and meaningless sensory data. When they are conceived instead as channels for information-pickup, having active and exploratory sense organs, they have much in common. (Gibson, 1962, p. 490)

To illustrate that similarities between vision and touch are also indicated in the work of enactive scholars, reflecting a notion of perception in which the enactive and ecological approaches can meet, we conclude with a quote from a prominent predecessor of the enactive approach, Maurice Merleau-Ponty: "Vision is a palpation with the look" (cited in Noë, 2004, p. 35).

AUTHOR CONTRIBUTIONS

DT wrote the initial draft of the manuscript. All authors contributed to the planification, writing, and correction of the manuscript.

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Where Is the Action in Perception? An Exploratory Study With a Haptic Sensory Substitution Device

Tom Froese^{1*} and Guillermo U. Ortiz-Garin²

¹ Embodied Cognitive Science Unit, Okinawa Institute of Science and Technology Graduate University, Okinawa, Japan,

² Laboratory 25, Department of Experimental Psychology, Faculty of Psychology, National Autonomous University of Mexico, Mexico City, Mexico

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United States

Dobromir G. Dotov,
University of Montpellier 1, France

*Correspondence:

Tom Froese
tom.froese@oist.jp

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Enactive cognitive science (ECS) and ecological psychology (EP) agree that active movement is important for perception, but they remain ambiguous regarding the precise role of agency. EP has focused on the notion of sensorimotor invariants, according to which bodily movements play an instrumental role in perception. ECS has focused on the notion of sensorimotor contingencies, which goes beyond an instrumental role because skillfully regulated movements are claimed to play a constitutive role. We refer to these two hypotheses as *instrumental agency* and *constitutive agency*, respectively. Evidence comes from a variety of fields, including neural, behavioral, and phenomenological research, but so far with confounds that prevent an experimental distinction between these hypotheses. Here we advance the debate by proposing a novel double-participant setup that aims to isolate agency as the key variable that distinguishes bodily movement in active and passive conditions of perception. We pilot this setup with a psychological study of width discrimination using the Enactive Torch, a haptic sensory substitution device. There was no evidence favoring the stronger hypothesis of constitutive agency over instrumental agency. However, we caution that during debriefing several participants reported using cognitive strategies that did not rely on spatial perception. We conclude that this approach is a viable direction for future research, but that greater care is required to establish and confirm the desired modality of first-person experience.

Keywords: active perception, embodied cognition, agency, perceptual discrimination, enactive perception, Enactive Torch, volition, active touch

INTRODUCTION

The fields of enactive cognitive science (ECS) and ecological psychology (EP) are two prominent alternatives to orthodox cognitive science, and which are in agreement about the need for a relational account of mind situated at the personal level (Chemero, 2009). They also share a commitment to the claim that perception is a dynamic process, and hence that movement is essential for perception, yet they also disagree on a number of points regarding the nature of perception (Varela et al., 2017; Heras-Escribano, 2019). It is still unclear whether these

disagreements are signs of deeper conceptual differences, or are merely differences in emphasis, which highlights the need of establishing a closer dialog (Lobo, 2019). One major point of contention is the precise role of agency in the perceptual process. More specifically, it is still an open debate to what extent action makes a difference to perception and perceptual learning, i.e., whether it matters if bodily movements are self-initiated, actively regulated, and/or intentionally guided, or merely accidentally caused by the agent's body, or even completely environmentally driven.

Ecological psychology started as a non-representational account of perception (Gibson, 1979), but has since developed into a more comprehensive non-representational psychology. As such, it also has a strong interest in agency and active exploration (Heras-Escribano, 2019). Yet, arguably, it has most famously focused on the experimental study of *perceptual invariants* (Mossio and Taraborelli, 2008), which are arguably independent of the source of perceptual change. In fact, some do not require any bodily movement at all. For example, when EP uses optic flow to derive time-to-contact it does not matter whether perceptual flow is brought about by bodily movements actively performed by the perceiver, or if flow is just passively undergone due to changes in the perceiver's environment (i.e., produced "by object *R* as it moves toward the eye," Chemero, 2009, p. 124). More generally, EP does not distinguish between: (1) optical changes due to intentional self-movement, e.g., human locomotion, (2) optical changes due to accidental self-movement, e.g., being hurled towards a collision, and (3) optical changes due to environmental movement, e.g., an approaching ball to be intercepted; all of these changes can be captured by the same invariant of optic flow because it is mathematically defined independently of agency, namely as the rate of acceleration of optical expansion (Lobo et al., 2018). Research into active, dynamic or effortful touch may seem to be provide a counterexample, but even here a key hypothesis is that the perceptual capabilities are defined in terms of detection of invariance in the patterns of tissue deformation (Carello and Turvey, 2015); the source of the deformation is irrelevant for the shape of the patterns. We will consider active touch in more detail below.

To be fair, following Gibson, most classical, and contemporary research in EP strongly emphasizes the importance of action and agency for perception and human experience (e.g., Gibson, 1979; Reed, 1982; Käufer and Chemero, 2015). Nevertheless, it is also fair to say that the focus of interest has been on the other direction of influence, namely on the claim that actions can be controlled by perception of affordances, like catching an approaching baseball. It is sufficient for our argument that both kinds of claims tend to be compatible with an instrumental interpretation of the role of active movement in perception. Thus, bodily movement is an important, but not exclusive, manner of generating optic flow and detecting time to contact. The upshot of this instrumental role, whereby e.g., the explanatory weight is placed directly on the rate of optical expansion, is that EP – its many claims to the contrary notwithstanding – is still partially aligned with the orthodox "input-output picture" (Hurley, 1998). At this stage, it remains unclear how perception would differ

when its invariants are instantiated for reasons other than self-movement. We refer to this compatibility with an instrumental role of self-movement as the hypothesis of *instrumental agency*. This leads to the experimental prediction that perception should be unaffected by whether the perceiver is actively exploring an object or undergoing the same changes passively.

Enactive cognitive science, on the other hand, has famously focused on the role of action in perception (Noë, 2004; O'Regan et al., 2005; Myin, 2016; Di Paolo et al., 2017; Froese and González-Grandón, 2019), which foregrounds the role of the perceiver's skillful capacity for regulating movement in the constitution of perceptual experience. One key concept here is that meaningful perception depends on the perceiver's exercise of their mastery of *sensorimotor contingencies* (O'Regan and Noë, 2001), i.e., of the regular ways in which sensations would change as a consequence of bodily movements. The major approaches to ECS differ in the details of how this dependence on the exercise of mastery should be conceived (Bishop and Martin, 2014), e.g., in terms of metacognition, intentional directedness, or adaptive regulation, but they share a common hypothesis of *constitutive agency*. Although it is not exactly clear how perception during active vs. passive movement conditions would differ, the prediction is that the perceptual experience will be affected in some way. For example, we might expect there to be a difference in the qualitative feel of the experience (O'Regan, 2011), there might be an attenuation in its felt significance (Di Paolo et al., 2017), or an impaired sense of object presence (Noë, 2012). As such, ECS goes beyond just EP's instrumental role of bodily movement and forms an important part of the broader class of *action-based* theories of perception (Briscoe and Grush, 2017).

Proponents of EP often make claims that also favor the stronger hypothesis of constitutive agency, and it would be interesting if EP developed those intuitions in a more explicit manner. We hope that the kind of psychological study we will propose can facilitate this process.

PREVIOUS WORK

Experimental evidence often cited by EP and ECS in support of the importance of self-movement typically comes from two major classic sources on perceptual learning and more recent versions:

- (1) the "kitten carousel" studies initiated by Held and Hein (1963), which concluded that passive exposure to optic flow is not sufficient for the ontogenetic development of normal visual perception, and
- (2) the "sensory substitution" studies initiated by Bach-y-Rita et al. (1969), which concluded that exposure to prerecorded time series of sensory stimuli is not sufficient for the lifetime learning of normal visual perception.

A key issue with source (1) is that it is problematic to derive strong claims about the quality of perceptual experience based on an animal behavioral result. According to Prinz (2006), it is equally conceivable that the kittens from active and passive conditions had exactly the same visual experiences, but that

the kittens from the passive condition had not yet had the opportunity to acquire an adequate mapping of that visual experience to motor commands. In other words, it is still possible to formulate an interpretation of the results that is consistent with the orthodox input-out picture.

Held and Hein's study was replicated and extended by Walk et al. (1988). They added two new passive conditions: one in which the kittens' attention to visual stimuli was enhanced by being able to control the automated movement of their own cart, and another in which the kitten's cart remained immobile but was placed in front of a more dynamic environmental spectacle involving moving toy cars. Even though these kittens were unable to use their legs to self-locomote, their legs responded appropriately to the visual cliff test. The authors explained these results in terms of EP and argued that what is important is attention to perceptual variation, but not whether locomotion is self-initiated. Nevertheless, kittens in all conditions were still capable of self-initiating movements of their heads and eyes, and hence they could in fact actively explore sensorimotor contingencies in this restricted visuomotor domain. In other words, it is equally conceivable that the kittens were sufficiently motivated to acquire mastery of these available visuomotor contingencies.

Advances in technology have permitted much more sophisticated versions of this paradigm. For example, a recent study placed pairs of mice in a virtual reality setup akin to the kitten carousel (Attinger et al., 2017). Each mouse was placed on a large trackball in front of a screen with the head fixed in position. Whenever the active mouse walked its display would change accordingly, while the other mouse's trackball and display would change identically, forcing it to undergo a similar visuomotor loop but without being able to actively influence the visual stimulation. The authors analyzed recordings of neural activity from primary visual cortex (V1) and found that coupling between motor output and visual feedback is necessary for the functional development of visual processing. This result seems to favor constitutive agency. However, even though the trackballs rotated identically, mice in the uncoupled condition were able to move differently, and hence were exposed to highly irregular sensorimotor invariances and sensorimotor contingencies. It is therefore not surprising that their perceptual skills developed poorly. Finally, although differences in development of neural activity in V1 are suggestive, it is not clear in general how such neural differences are related to visual experience (Hurley and Noë, 2003).

Two common problems with these animal studies are that it is difficult to isolate agency, and also to derive claims about perceptual experience from behavioral and/or neural data.¹ A more promising approach for the scientific study of the role of active movement in perceptual experience are psychological studies involving participants that can give reports about how changes in conditions affect their first-person experience (Froese et al., 2012b). This brings us to second classic source.

In particular, the use of sensory substitution interfaces provides a useful experimental technique for simplifying and controlling human sensorimotor loops (Bach-y-Rita and Kercel, 2003; Lenay et al., 2003; Froese et al., 2012a). Such studies consistently find that performance on perceptual tasks is improved when the changes in participant's sensations are contingent on their own movements (e.g., Bach-y-Rita, 2002; Auvray et al., 2005; Díaz et al., 2012). However, none of these sensory substitution studies has been able to address the confound that was also an issue for the mouse virtual reality study by Attinger et al. (2017): uncoupling sensory stimulation from passive participants' movements makes it impossible for self-initiated movement to influence sensation, but at the same time it scrambles the regularities inherent in sensorimotor invariances and sensorimotor contingencies more generally. It is therefore unclear whether it is the lack of sensorimotor regularity or the lack of agency which causes the impaired performance.

In summary, so far these lines of research have been unable to arbitrate between the two hypotheses with respect to the role of agency. What is needed is an experimental approach that ensures that both active and passive participants undergo identical sensorimotor loops, involving the same sensations and movements, but in such a way that only the active participant can freely regulate the movements. This is necessary so that any difference in performance can then be attributed to the difference in participant's active involvement in movement (Richardson et al., 2000). It also remains to be seen if any differences seen during perceptual learning would also still apply to mature perception.

A fitting starting point is touch because it is one of the most active modalities, although experimental results are not always consistent with this impression (Symmons et al., 2004). This ambiguity is likely related to the fact that control conditions are often not strict enough. For instance, a study of discrimination of arm movement distances found that active movement is associated with greater precision (van Beek et al., 2014). However, the passive condition induced constant arm movement rather than replicating actual movement patterns, and hence the authors' conclusion that taking away agency from tool operators would deteriorate precision is not necessarily warranted.

Another study removed this confound by replicating patterns of sensorimotor flow: an active participant manipulated a haptic stylus (a Phantom device) to categorize one of four different kinds of 3D geometric shapes, while at the same time a passive participant held onto another Phantom device that underwent the same movements and generated the same feedback (Symmons et al., 2005). In this way, even the perception of the location and movement of body parts, known as proprioception or kinesthesia, is also largely kept the same across participants. It was found that active participants tended to be more accurate, but there was no statistically significant difference. This result could be related to the fact that passive participants were still relatively active: although they did not control the direction of movement, they still had to actively grasp the stylus and follow its trajectory in a compliant manner. To increase passivity, it would be better if the passive condition involved no effort of movement at all.

¹These problems are also shared by agent-based simulation models that are inspired by the hypothesis of constitutive agency (e.g., Suzuki et al., 2005; Buhrmann et al., 2013). It is unclear whether synthetic approaches can capture the relevant aspects of agency and experience (Froese and Taguchi, 2019).

In this brief research report, we describe a novel version of this kind of double-participant setup that satisfies this stricter control condition of passivity for the first time. We also present the results of an exploratory study of width discrimination using this setup.

MATERIALS AND METHODS

The double-participant setup was implemented with a custom-made experimental box consisting of mechanical and electronic components (see **Figures 1, 2** for details). Pairs of participants were seated at opposite sides and could undergo the same movements (albeit in a mirrored direction) and changes in vibrotactile sensations at the same time. The sensations were mediated by a hand-held sensory substitution device called the *Enactive Torch* (**Figure 3**; Froese et al., 2012a), which translates infrared-based measures of distance to nearby objects into intensity of vibrotactile feedback in the user's hand. Like a cane for blind people, this device permits people to learn to perceive passages through objects in space (Favela et al., 2018), and user's walking trajectories coincide with those of visually-guided locomotion (Lobo et al., 2019).

The crucial methodological advantage of working with the *Enactive Torch* is that, by mediating object perception through a fixed sensory substitution device, we could more easily ensure that both participants underwent exactly the same sensorimotor loop. Minor differences in proprioception cannot be ruled out

because it encompasses a complex of sensations that includes muscle force and effort (Taylor, 2009), which will necessarily differ across active and passive participants.

The task was inspired by a recent study in EP on width discrimination that involved the *Enactive Torch* (Favela et al., 2018). In our study, participants had to discriminate between the widths of two objects, and then to indicate which one was the wider one and to indicate if this was a confident discrimination. The two objects were 5 cm and 8 cm wide, which resulted in roughly 70% correct responses after data normalization. This level of discrimination difficulty was chosen as a value between chance level (50%) and potential ceiling effects (100%).

Participants

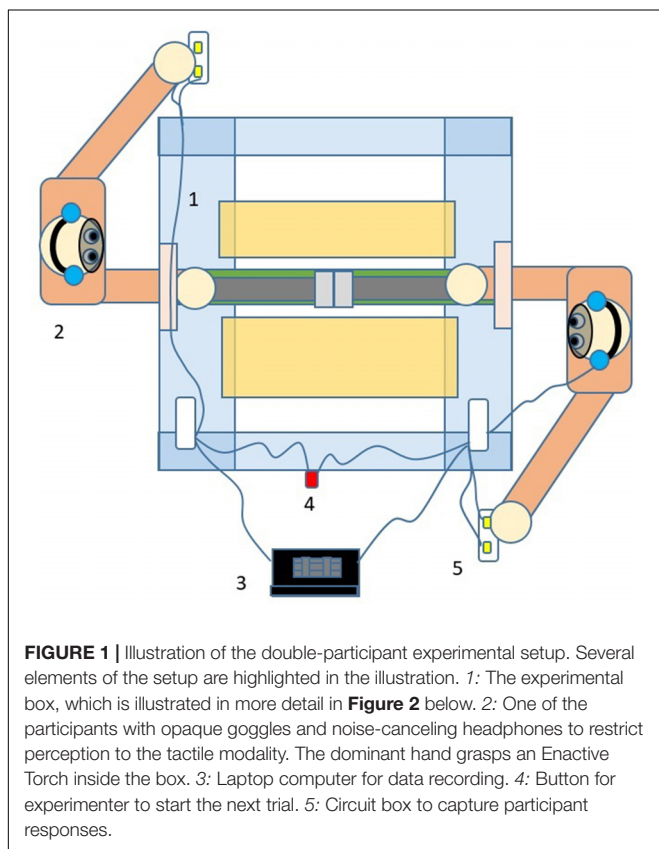
In total, we tested 70 participants (32 men and 38 women; mean age = 21.48, SD = 2.59) combined into 35 pairs. All participants were recruited from our research group and students' networks of contacts at the National Autonomous University of Mexico (UNAM). They volunteered to participate without financial reward and signed informed consent forms. All participants were right-handed, and all reported no psychiatric or motor disorders.

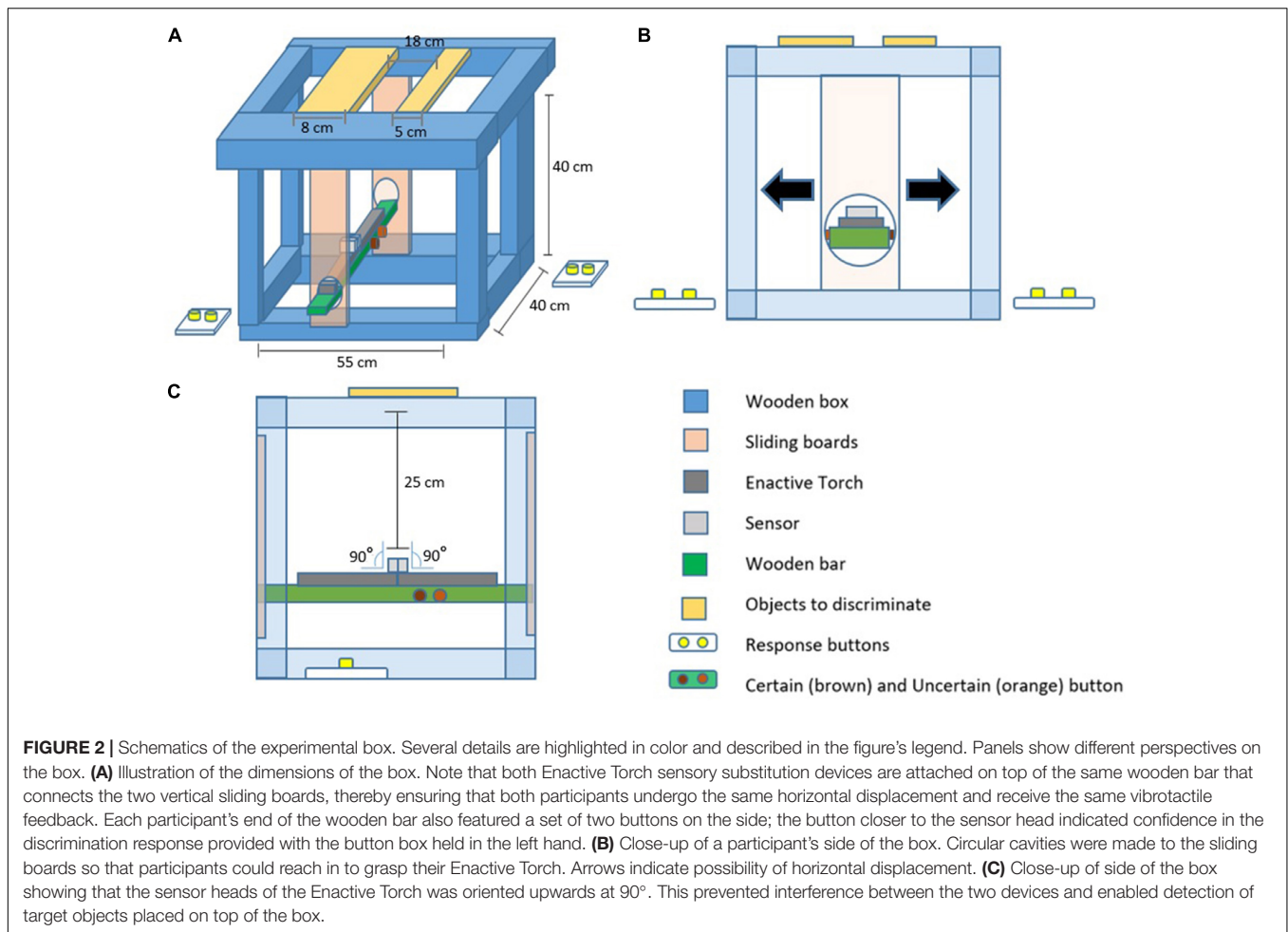
Procedure

Each participant of a test pair was randomly assigned to one of two groups: passive or active. They were unaware of this assignment, and while they could guess that another person was being tested in the same room, they remained unaware of the fact that they were connected in a pair. Participants were blindfolded and then one-by-one guided into the experimental room, where they were seated on a chair, on one side of the wooden box. The side was randomly assigned. They wore headphones that played noise in the background to avoid distraction of sounds; we chose brown over white noise because participants prefer lower frequencies of sound masking (Hongisto et al., 2015). Then the participants underwent a brief training procedure, which consisted in the following steps:

1. One participant removed their headphones.
2. They were then guided to grasp their respective *Enactive Torch*. They were also familiarized with the two sets of buttons to indicate the wider object and their level of confidence.
3. All the instructions were given. A similar but subtly different instruction was given depending on the group, as explained below.
4. Two test trials were run, involving two objects with 3 cm difference in width.
5. The participant was given an opportunity to ask questions.
6. The participant puts on their headphones again.

Then the other participant underwent the same training steps. Regarding the specific instructions, for the active group, the instructions were to grasp the *Enactive Torch* with their dominant hand and to move it horizontally (right to left or vice-versa) at a constant speed for a particular period to sense the width of the two objects. The duration of each trial was 5 s. Participants were to start moving when they heard a beep,





and when they heard the beep again, they were to stop and click to indicate which of the two objects was the wider one. They also clicked on one of the other two buttons next to the Enactive Torch to indicate their level of confidence. They then returned the Enactive Torch to the starting point before the next trial could begin.

For the passive group, the instructions were to rest their dominant hand on the Enactive Torch, and to avoid any resistance to the movements that were going to be produced after the beep. They were also told that when the same tone rang again, the device was going to come to rest, and they should perform the required button clicks. Then the bar would return to its starting point.

No feedback was provided during the experiment. In total, 120 trials were run per pair of participants. However, for the current research question, only the first 60 trials were analyzed given that the second set of 60 trials involved a different condition. At the end of every experiment, we individually asked the participants about the strategies they used to solve the task.

Data Analysis

Statistical analysis of task performance was carried out using the software *R* released by the R Core Team (2019). We first

obtained the proportion of correct answers for every participant, and then obtained the descriptive statistics of the proportions for each group. We ran a two-tailed paired *t*-test analysis to compare the proportions of correct answers for both groups. The null hypothesis was that there are no differences between the average percentages of correct responses between groups.

RESULTS

The responses recorded for all trials can be found in **Supplementary Datasheet S1**. The descriptive statistics of the proportion of correct answers is summarized in **Table 1**.

No statistically significant differences were found among the active and passive groups in terms of the proportions of correct responses [$t(34) = -0.74734, p = 0.46$], nor of confident responses [$t(34) = -1.4639, p = 0.1524$]. Therefore, actively initiated and regulated sensorimotor loops and passively undergone sensorimotor loops led to the same proportion of correct answers.

Informal debriefing interviews after each experiment revealed that some participants had used a counting strategy to solve the width discrimination task. For example, several reported that they would start counting at the start of the first phase of



FIGURE 3 | Photo of the Enactive Torch Research Tool (ETRT). We made use of ETRT v1.0. Note that for this study we turned the sensor head upwards at a 90° C angle so that subjects were given vibrotactile sensations corresponding to the objects placed on top of the experimental box, as illustrated in **Figures 2, 3**. The photo also shows the data cable and a cable with a small actuator and its extension cable for external vibrotactile output. For this study we transferred data to the laptop computer via Bluetooth and employed the vibrating actuator built into the ETRT itself.

TABLE 1 | Summary of descriptive statistics.

	Group	Mean	Median	Std. dev.	Min.	Max.
Correct responses (correct vs. incorrect)	Active	0.708	0.717	0.102	0.500	0.917
	Passive	0.721	0.721	0.081	0.517	0.867
Confident responses (certain vs. uncertain)	Active	0.680	0.7	0.126	0.433	1
	Passive	0.731	0.733	0.149	0.383	0.983

The active and passive groups were compared in terms of the proportion of correct answers to the width discrimination task.

vibrotactile feedback until the end of that phase, do the same for the second phase of feedback, and then compared the counts to determine which object took longer to be traversed. This strategy was aided by the fact that many active participants chose to move slowly within the 5 s limit of a trial. In other words, for these participants width discrimination performance was not based on tactile space perception.

DISCUSSION

The null result is more in line with the more conservative hypothesis of instrumental agency, rather than with the stronger hypothesis of constitutive agency. However, in hindsight the experimental setup still needs to be improved in several respects.

- **Attentional load.** Poorer performance during the active condition could have resulted from interfering effects of increased attentional and cognitive load, which have been attributed to decisions about how to move (Richardson et al., 1981). Conversely, reduction of cognitive load in active conditions has been associated with

a relative increase in haptic discrimination performance (Richardson et al., 2006).

- **Cognitive strategies.** Several participants reported a cognitive (counting and comparing) strategy, which implies that they did not actually perceive width. If so, then the passive group was not necessarily disadvantaged; to the contrary, being moved enabled them to focus their attention on the cognitive strategy. It is possible that the training was not sufficient for perceptual learning, thereby forcing participants to rely on a cognitive strategy.
- **Potential movement.** The ECS theory of sensorimotor contingencies only requires *overt* movement for the learning or acquisition of mastery, but not for the subsequent exercise of that mastery, which also works with *potential* movement (Myin, 2016). Future work should record muscle and/or neural activity in order to try to detect the implicit exercise of mastery of sensorimotor contingencies (Froese and González-Grandón, 2019). Alternatively, the passive condition could involve a mechanical device that fixes the participant's arm and forces it to reproduce exactly the same movement pattern as the active condition, but this is more difficult to implement than the double-participant setup.
- **Degrees of freedom.** The active group might have been overly constrained, which leveled the playing field with the passive condition. This was done to ensure that all trials were comparable across participants. Future work in this direction will have to learn to embrace the possibilities of open-ended exploration and the individual variability that this will generate. In particular, it may be necessary to consider tasks that permit the spontaneous transition between several possible stable patterns of behavior (Dotov et al., 2019).
- **From ends to means.** Normally perception is a means to an end, but in our task perception was the end itself. Again, this may have invited more cognitive strategies. It would therefore be preferable to turn perceptual discrimination into a function at the service of a higher-level action goal (Favela et al., 2018).

More generally, future work in this direction needs to pay greater attention to whether participants are learning to solve the task by incorporating the sensorimotor mediation afforded by the sensory substitution device into a genuinely perceptual experience (Schumann and O'Regan, 2017). This points to a crucial methodological problem: how to better assess participants' experience of using a sensory substitution interface (Kalwak et al., 2018). As revealed in this study, good performance on a perceptual task is not sufficient to discriminate between perceptual and cognitive strategies. And while simple subjective reports can aid in making coarse-grained categorizations, it remains to be seen how we can obtain more fine-grained distinctions. For instance, it is conceivable that ECS and EP will come to agree that, after learning, sensorimotor invariants are sufficient for objectively discriminating *what* is perceived – e.g., time-to-contact (instrumental agency), and that active self-movement then only makes a difference for the subjective

experience of *how* it is perceived – e.g., the conscious feel of vision (constitutive agency), for example with respect to the richness of its presence. However, the details still need to be worked out and operationalized. Moreover, tracking differences in “what it is like” is precisely the problem of consciousness and calls for specialized first-person methods (Petitmengin et al., 2019). Accordingly, despite repeated claims that active movement is essential, there is still more theoretical and experimental work to be done to determine precisely where is the action in perception.

DATA AVAILABILITY STATEMENT

The complete datasets for this study are available in the **Supplementary Material**.

ETHICS STATEMENT

All participants read and signed a consent form. The experimental protocol was approved by the Department of Experimental Psychology of the Faculty of Psychology at the National Autonomous University of Mexico – UNAM.

AUTHOR CONTRIBUTIONS

TF conceived of the general idea to test the role of action in perception with a double-participant setup using the Enactive Torch sensory substitution interface, and he wrote this manuscript. GO-G conceived of and piloted the experimental

protocol, designed and built the experimental box, recruited the participants, conducted the experiment, and analyzed the results. TF and GO-G finalized the manuscript together.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2020.00809/full#supplementary-material>

DATA SHEET S1 | Task performance – participants' responses for all trials analyzed in this article.

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Rediscovering Richard Held: Activity and Passivity in Perceptual Learning

Fernando Bermejo^{1,2,3}, Mercedes X. Hüg^{1,2,3} and Ezequiel A. Di Paolo^{4,5,6*}

¹ Centro de Investigación y Transferencia en Acústica, Universidad Tecnológica Nacional – Facultad Regional Córdoba, CONICET, Córdoba, Argentina, ² Facultad de Psicología, Universidad Nacional de Córdoba, Córdoba, Argentina, ³ Consejo Nacional de Investigaciones Científicas y Tecnológicas, Buenos Aires, Argentina, ⁴ Ikerbasque, Basque Foundation for Science, Bilbao, Spain, ⁵ IAS Research Center for Life, Mind and Society, University of the Basque Country, San Sebastián, Spain, ⁶ Centre for Computational Neuroscience and Robotics, University of Sussex, Brighton, United Kingdom

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*Correspondence:

Ezequiel A. Di Paolo
ezequiel.dipaolo@ehu.es

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Understanding the role of self-generated movements in perceptual learning is central to action-based theories of perception. Pioneering work on sensory adaptation by Richard M. Held during the 1950s and 1960s can still shed light on this question. In a variety of rich experiments Held and his team demonstrated the need for self-generated movements in sensory adaptation and perceptual learning. This body of work received different critical interpretations, was then forgotten for some time, and saw a surge of revived interest within embodied cognitive science. Through a brief review of Held's work and reactions to it, we seek to contribute to discussions on the role of activity and passivity in perceptual learning. We classify different positions according to whether this role is considered to be contextual (facilitatory, but not necessary), enabling (causally necessary), or constitutive (an inextricable part of the learning process itself). We also offer a critique of the notions of activity and passivity and how they are operationalized in experimental studies. The active-passive distinction is not a binary but involves a series of dimensions and relative degrees that can make it difficult to interpret and replicate experimental results. We introduce three of these dimensions drawing on work on the sense of agency: action initiation, control, and monitoring. These refinements in terms of causal relations and dimensions of activity-passivity should help illuminate open questions concerning the role of activity in perception and perceptual learning and clarify the convergences and differences between enaction and ecological psychology.

Keywords: Richard M. Held, sensory adaptation, perceptual learning, self-generated movements, activity, passivity, enaction, ecological psychology

INTRODUCTION

Action-based accounts of perception maintain that there are functional and conceptual links between action and perception (e.g., O'Regan and Noë, 2001; Noë, 2004; Pulvermüller and Fadiga, 2010). These perspectives are advocated both by enactivists and ecological psychologists (e.g., Varela et al., 1991; Reed, 1996; Chemero, 2009; Di Paolo et al., 2017) and can serve to highlight the convergences and the differences between these approaches. In the extensive literature on the subject one experiment has become iconic. In a study conducted in 1963, Richard Held and Alan Hein tested the development of visually guided behavior in kittens reared in the dark who were

placed in pairs in an illuminated carousel. One of the kittens was “passive” and could not self-locomote. The other was “active” and was free to move by itself while pulling the passive kitten through a transmission mechanism that produced an equivalent visual stimulation. The kittens experienced this condition for 3 h a day for a period of 8 weeks. They were then tested on the visual cliff. Unlike active kittens, passive kittens did not show evidence of differentiating the shallow edge of the cliff from the apparent drop. From this, Held and Hein concluded that self-generated movements are crucial for the development of visual perceptual skills. The experiment is often mentioned in the enactivist and ecological psychology literature (e.g., Gibson, 1969; Varela et al., 1991; Noë, 2004; Heras-Escribano, 2019).

This was not an isolated study. It was part of an extensive research program led by Richard Marx Held (1922–2016) during the 1950s and 1960s. We think that the hypotheses, the innovative experimental designs, and the discussions provoked by these studies are still relevant today. Through a brief review of Held’s work, we seek to contribute to discussions about the role of self-generated movements in perceptual learning. Is the self-generation of movements, or “active movements,” a necessary condition for acquiring new perceptual abilities? Or is it possible to learn to perceive without moving actively, i.e., or through “passive,” externally controlled movements?

Our main conclusion will be that many of the terms in these seemingly clear questions require clarification. In particular, we qualify the terms “active” and “passive” because the discussion will lead us to examine how these notions have been used in experimental psychology and neuroscience. We suggest that what is typically taken as a binary distinction is in fact a spectrum of possibilities with various degrees and different dimensions of activity and passivity. This may be one reason why it is sometimes difficult to replicate experimental results and reach widely accepted conclusions regarding the role of action in perception. We will draw on recent work on the sense of agency to refine the active-passive distinction. We will also offer three distinct meanings for claims concerning the role of activity in perceptual learning.

HELD’S STUDIES ON SENSORY ADAPTATION

Participants in sensory adaptation experiments use interfaces that induce perceptual changes. For example, combinations of special lenses, prisms, and mirrors. The sensory disruption puts in evidence relations between action and perception that otherwise remain hidden. In order to learn to behave and perceive correctly again (in the cases when adaptation occurs), participants must modify their repertoire of sensorimotor schemes. Hermann von Helmholtz and George Stratton performed pioneering studies in visual sensory adaptation in the nineteenth century (Welch, 1974). A few decades later Ewert (1930); Peterson and Peterson (1938) carried out further studies involving long-term exposure and adaptation. The period ranging from the late 1950s to the early 1970s was particularly fruitful with researchers like John G. Taylor, Irving Rock, Hans Wallach

making important contributions (Welch, 1974, 1978). According to Welch, the increase in interest may be traced to two sources: the publication by Kohler (1964) of the extensive investigations that he and Theodor Erismann had carried out at the University of Innsbruck, and the work by Held and collaborators. At that time, the team led by Held was setting the pace of the investigation. This period covers his time at Brandeis University (1953–1962) and his first stage at MIT (1962–1971).

During the period in question Held was devoted to the study of adaptation to spatially inverted, reversed, and displaced perception. In most cases he used a technique called *rearrangement*, which consisted in presenting participants with a deliberate distortion of visual or auditory signals through special sensory interfaces. Contemporary studies in sensory adaptation continue to use variations of this method (e.g., Pfordresher and Kulpa, 2011; Bermejo et al., 2020). In typical experiments, Held exposed participants to rearrangement in pretest-posttest designs. To evaluate the effect of self-movement, participants generally underwent an active condition, in which they could move by themselves, and a passive condition, where an experimenter produced in the participant movements equivalent to the active condition. Results, replicated over a series of studies, showed that participants almost invariably compensated for the errors induced by rearrangement only or much more reliably in the active condition (e.g., Held and Hein, 1958; Held and Bossom, 1961; Held and Rekosh, 1963; Held and Mikaelian, 1964).

It is worth taking a brief look at some of these experiments. In one of his first studies, Held (1955) evaluated the effect of experiencing spatially distorted sound cues on sound localization. He used a “pseudophone” that modified the sound streams arriving at the ears causing perceived sounds to be displaced to the left or right. Participants had to orient toward a sound source before and after having practiced with the pseudophone in conditions of self-locomotion. Results showed shifts of auditory localization responses that evidenced a correction of the error induced by the device. Held suggested that adaptation happened because participants were able to associate new interaural patterns with their own movements toward the source. This early formulation of his hypothesis led him to include a passive group in subsequent designs.

In an experiment looking at visual rearrangement, Held and Hein (1958) asked participants to mark with a pencil the apparent location of the corners of a square. They could see their own hands through a prism that produced a lateral visual displacement under different conditions: self-produced hand movement, passive hand movement guided by an experimenter, and no hand movement. The only condition in which the participants were able to compensate for visual displacement was when they could move actively. Held and Bossom (1961) extended the prism rearrangement situation to locomotion. They found that an equivalent correction effect in visual direction-finding occurred when participants performed active self-locomotion. They did not compensate if they were transported by an experimenter in a wheelchair. In a follow-up experiment, Held and Mikaelian (1964) evaluated whether the lack of adaptation in the passive condition could be attributed only to the passivity involved in not being able to initiate movements or in the lack of

specificity between movement and contingent stimulation. They replicated Held and Bossom's (1961) study with the difference that they allowed participants to control the movement of the wheelchair. Adaptation occurred when participants walked by themselves but not when they used the wheelchair. The authors concluded that motor-sensory feedback must correspond to the specific behavior undergoing adaptation, i.e., walking for visual egocentric localization.

These and other studies pointed to similar conclusions¹, which Held (1965) explained in terms of the active regulation of the plasticity of sensorimotor systems. Situations of rearrangement degrade established patterns of sensorimotor coordination. Under typical conditions, the relation between self-produced movements and stable parts of the environment is univocal and lawful. Each movement has its unique train of sensory stimulations and the perceiver is adapted to this lawful relation. A rearrangement situation alters this relation, confounding participants. A given familiar movement will have unexpected sensory consequences, and expected sensory consequences can only be obtained by the performance of unfamiliar movements. New lawful sensorimotor relations may exist in the rearranged situation but these are not yet obvious to the perceiver. This leads to an increase in performance variability and a decrease in accuracy. As the perceiver explores and practices movements in the rearranged situation, progressive shifts in coordination compensate for the errors induced by the atypical conditions. Gradually, as the new sensorimotor regularities are learned, performance becomes more robust and accurate. This same logic also explains the presence of aftereffects: returning to the original condition after prolonged exposure to the rearranged situation gives rise to errors similar, but in the opposite direction, to those initially induced by rearrangement.

Held consistently finds that self-produced movements are key to adaptation. When movements are passive, the condition of a degraded lawful relation between action and perception does not manifest in the same manner, and consequently adaptation does not occur reliably (Held and Freedman, 1963). "Only an organism that can take account of the output signals to its own musculature is in a position to detect and factor out the rearrangement effects of both moving objects and externally imposed body movement" (Held, 1965, p. 92).

In this context, a key concept is that of re-afferent signals, i.e., stimulation caused by self-produced movements. Exafference, in contrast, is the stimulation that is not induced by the agent's own movements. Both of these terms are taken from the "efference copy" formulation by von Holst and Mittelstaedt (1950), an influential model explaining the possible mechanisms involved in perceiving the stable attributes of space.

Another key concept is correlation, which is used to describe the relationship between self-produced movements and re-afference. Because in a stable environment there is a unique feedback signal for any particular movement, it is expected that as time passes, the cumulatively experienced efferent and re-afferent signals will show high correlation. The quasi-constant

relationships in correlations give rise to the idea of a motor-sensory feedback loop. Sensorimotor coordination of perceptual systems is grounded in the information entailed in these loops (Held and Freedman, 1963).

Held and Freedman (1963) considered these adaptive mechanisms to underlie perceptual learning at any stage of life. At this point, the proposal became a "general theory of the plastic sensorimotor systems" (Held and Freedman, 1963, p. 455) in which the same sensorimotor coordination mechanism is involved in three processes: "(1) the development of normal sensory-motor control in the young, (2) the maintenance of that control once it has developed and (3) the adaptation to changes or apparent changes in the data reported by the senses of sight and hearing" (Held, 1965, p. 84).

Held and colleagues tested this theory by looking at sensorimotor development in young animals. The already mentioned kittens study by Held and Hein (1963) was one in this experimental series. In follow-up studies, Hein et al. (1970) evaluated three hypotheses derived from the carousel experiment. First, they investigated whether the deficit of the passive kittens in the acquisition of visually controlled behavior was due to a facilitating effect of self-locomotion or whether it was impeded by passive transport. To test this, they implemented a similar set-up, with the difference that after being exposed to the passive condition, kittens were allowed to experience the active role for a few hours a day over several days. The results showed that previous exposure to passive transport led to a significant delay in the number of hours needed to acquire a simple visuo-motor capacity (limb extension towards an approaching broad surface) with respect to the group that could always self-locomote.

The authors conducted a second study to determine if passive kittens failed in the visual cliff due to a generalized inhibition of locomotion behavior in response to visual stimuli. In this case, they exposed each eye under a different condition: "periods when visual stimulation of one eye accompanied self-produced movement alternated with periods when visual stimulation was provided to the other eye during passive transport" (Hein et al., 1970, p. 184). As predicted, when kittens could use the eye exposed in the active condition, they were successful both in extension response tests and in the visual cliff. When the same kittens had to use the other eye, they failed in both tasks.

A third experiment extended a study by Hein and Held (1967). When kittens who are prevented from seeing their paws during rearing are carried down toward the edge of a horizontal surface, they show fragmented visual control of their forelimbs (extension but not accurate guidance). Failure to develop guided reaching did not affect the use of the limbs for visually guided locomotion, suggesting that reaching is a separate kind of visuo-motor coordination. In the new experiment, Hein et al. (1970) tested whether visually guided reaching might be acquired independently by each eye. The results showed that when the kittens used the eye that had not received visual input from their own limbs, they failed in visually guided reaching and succeeded when using the other eye. Visually guided reaching did not transfer interocularly.

These follow-up studies support and refine Held's proposal concerning the enabling role of active movements in perceptual

¹ According to the SCOPUS database, Held with his team published 34 articles related to this topic between 1955 and 1974.

learning, showing that the control of visually guided behavior can be acquired independently for each eye and that an unsystematic correlation between self-movement and visual stimulation produces disruptive effects.

Prior to the kittens experiments, Held made an attempt to adapt his theoretical perspective to von Holst and Mittelstaedt's (1950) "efference copy" model. Briefly, this model proposes that at the time of motor preparation, copies of the efferent motor information are used to calculate the sensory changes expected as a consequence of its execution. After the effective execution, a real proprioceptive feedback is generated, which will balance the predicted sensory feedback at the level of a so-called "Comparator." In the case of not finding differences between the two signals, the changes in the afferences would be due to the re-afferences. Otherwise, the changes would be the result of the exafferences. Held (1961) proposed to supplement this model with mechanisms that account for the possibility of adapting to rearrangement situations. To do this, he conceived of an instance before the Comparator stage, which he called Correlation Storage. This module would be responsible for retaining combinations of concurrent efferent and re-afferent signals. The selection of a determinate efferent signal activates a combination that then passes on to the Comparator. In cases of adaptation, correlations of signals must be permanently updated. If the combinations are systematically changed it may happen that the same efferent signal can activate different combinations. This ambiguity will be gradually eliminated as more recent combinations gain more weight.

Evidently this model distances Held's proposal from perspectives such as ecological psychology and enactivism due to its reliance on internalist explanations. However, Held himself did not make much explicit use of this model. To understand his proposal more fully, it is necessary to take into account that:

- (a) In the 1950s and 1960s models such as the "efference copy" were in full swing. Simultaneously, von Holst and Mittelstaedt (1950) and Sperry (1950) had proposed equivalent models and researchers such as Hans-Lukas Teuber, who was head of Held's department at MIT, were working on these theories. It is likely that this context encouraged Held to reformulate his ideas in terms of comparator models.
- (b) The model was only described in his first theoretical work (Held, 1961). In future articles, he did not return to it. Since then his explanations were formulated in terms of self-produced movements, reafference, and the correlation between them, without any mention of instances such as Correlation Storage.
- (c) Held clearly rejected internalist interpretations. Immediately after describing the model in the 1961 paper, he remarked that his view of perception does not fit with the idea of the information processor:

"The proposed system neither selects nor filters the incoming signals it receives on the basis of special functional relations or orderings (other than temporal) between the efferent and afferent signals. We can hope that the model

forestalls assertions that the nervous system actively seeks a special kind of order which it may store for future reference. Such statements seem to me to beg the issue by assuming an internal "intelligence" to accomplish precisely what requires explanation. (...) If models of the sort proposed convincingly account for adaptive, as well as non-adaptive, psychological processes, we need have recourse neither to a mysterious internal "intelligence" that somewhat knows how to recognize and select useful sensory information nor to the equally mysterious external "intelligence" that manages to reinforce just those responses to sensory stimuli that will prove useful to the organism" (Held, 1961, pp. 31–32).

We may summarize Held's proposal for explaining sensory adaptation by these claims:

- Self-produced movements are necessary for developing a perceptual ability.
- The stable perception of the environment relies on the consistent coordination of sensorimotor loops.
- Sensory adaptation involves, at first, the disruption of previously established sensorimotor coordination. This is followed by the active gradual reconstruction of new stable sensorimotor patterns.
- The structure of reconstructed sensorimotor loops is constrained by bodily and environmental features and depends on the particular patterns of active practice.
- These principles are not restricted to the visual system, but form part of a general model of perceptual learning.

SOME REACTIONS TO HELD'S PROPOSAL

Given the interest raised by Held's experiments, many contemporary and later studies attempted to replicate their results. Some of them had difficulty doing so. Some found no significant differences in the adaptation achieved between the conditions of passive and active movements (Weinstein et al., 1964; Pick and Hay, 1965; Singer and Day, 1966; Fishkin, 1969; Foley and Maynes, 1969; Baily, 1972; Gyr et al., 1979). There were even studies that showed the possibility of adaptation without movements at all (Howard et al., 1965; Kravitz and Wallach, 1966). The kittens study was particularly difficult to replicate. Walk et al. (1988) wondered if passive kittens paid less attention than active ones to the environment through which they were transported. They repeated the experiment with kittens that either were given something interesting to watch (toy cars racing on a track) or were allowed to move through the environment by lifting their heads to close a microswitch that operated a go-cart. Kittens that paid greater attention to the environment discriminated depth on the visual cliff, whereas those reared with similar light exposure conditions but without the increased attention did not discriminate. The results confirmed the authors' hypothesis, passive kittens paid less attention than active kittens to the environment and probably this, and not the absence of self-generated movements, enables the learning of spatial skills. It is worth clarifying that kittens were "passive" in the sense used

by Held, since they could not walk, but they were “active” in the sense that they paid attention to relevant/interesting events in the environment, being able to move their head or move according to their control. We will return to this point later.

Another point of confrontation with Held’s work concerned rearrangement experiments that involved adapting hand-eye coordination, for example, marking with a pencil the position of a cross that was seen through prisms. Several studies indicated that the perceived discrepancy between the optical image and the postural sensation of the hand was an important cue not taken into account in Held’s explanation of adaptation (Kravitz and Wallach, 1966; Wallach, 1968; Lackner, 1974). According to these studies, the discrepancy is constant and independent whether the hand is moved passively or actively. Therefore, there is no need to re-correlate motor information. The problem is actually one of detecting the constant discrepancy between the true and the seen position of the limb. Adaptation consists in resolving these visual-spatial conflicts. This process involves a great range of factors and subsumes elements like attention, that affect the accuracy of registering the mentioned discrepancies (Lackner, 1981).

Other action-based perspectives at that time, such as incipient work in ecological psychology, also showed a distancing from Held’s proposal. James Gibson’s early empirical work on sensory adaptation was not equivalent to Held’s. It was more focused on what he called phenomenal adaptation. He had developed diverse experiments on adaptation to negative aftereffects (Gibson, 1933, 1937; Gibson and Radner, 1937). These were simple effects showing that during prolonged looking, adaptation can occur in the perceived curvature and tilt of static lines, the curves tending to become straighter and the tilts tending to become either more vertical or horizontal. These perceptual adaptations, according to Gibson, were a sort of phenomenal normalization to the usual conditions of the physical environment. Beyond these experiments, Gibson’s theoretical developments are closely related to “behavioral” adaptations, as he called them. In particular, he did not think that there were important differences in the perceptual information that could be obtained with self-generated movements and passive movements. While he argued that to perceive it is necessary to establish sensorimotor invariants (Gibson, 1979), it seems that the movements activating those invariants could also be passive. The concept of information flow, understood as the pattern of change sensed by the perceiver (Gibson, 1950), for instance, offers the possibility of explaining sensory adaptation processes through passive movements. According to Gibson, in relation to the sensory adaptation experiments:

“Head-movements would be necessary for isolating these new invariants; perhaps voluntary head movements would help in directing attention to them but passive movements should be sufficient. [...] In short, according to this formula there is a way of “finding out” about the environment without necessarily behaving in the sense of performing or executing actions.” (Gibson, 1967/1997, §. 9).

Gibson’s position can also be understood by his considerations on proprioception and exteroception, which he did not consider as two fundamentally different and separate channels of

information. The exteroceptors, such as the retina, are sensitive both to changes in the direction of objects that move in the environment and to the flow of patterns produced by the movement of the head. Meanwhile, proprioceptors can account for both externally imposed passive movements and self-generated ones. Gibson abandons the notion of independent and purely exteroceptive or proprioceptive fields, and the main problem becomes one of exhaustively defining the entire array of stimulation, irrespective of the particular receptors involved (Cohen, 1981).

“Proprioception considered as the obtaining of information about one’s own action does not necessarily depend on proprioceptors, and exteroception considered as the obtaining of information about extrinsic events does not necessarily depend on exteroceptors.” (Gibson, 1966, p. 34).

Attentive to Gibson’s work on phenomenal adaptation (in curved and tilted lines), Held and colleagues expanded the study of these effects by exploring the possibility they may be enabled by a motor component as well. In two similar studies, they assessed adaptation to tilt (Mikaelian and Held, 1964) and curvature (Held and Reikosh, 1963) under active and passive conditions using specific prisms that modify these properties. Both studies were very ingenious; participants had to estimate the state of lines before and after exploring a scene with a random array of small spots. This has the effect of removing from the visual environment any lines or curves that could provide normalizing visual cues for straightness or vertical/horizontal orientation. In the active condition, participants could self-locomote with the goggles, while in the passive one they were transported by an experimenter on a wheelchair or a cart along the same route. Both studies confirmed Held’s proposal, only self-generated movements under the transformed condition induced by the goggles make participants compensate for the errors due to the prism. On removing the goggles, they experience an aftereffect of the same magnitude, but in the opposite direction as the prismatic distortion. In the passive conditions the after-effect is much smaller. These findings imply that even processes classified as purely visual or phenomenal, such as adaptation due to normalization effects, can also involve motor factors.

Discussions at the time seem to arrive at the consensus that self-generated movements were not essential to achieve sensory adaptation although their presence could facilitate the adaptive process (Welch, 1978). Irving Rock summarized the state of affairs: “[self-generated] movement is important only because it allows for certain kinds of information to be registered, not because movement *per se* is necessary” (Rock, 1966, p. 42). From the 1970s onward Richard Held abandoned the study of sensory adaptation, as he describes in his autobiography (Held, 2008).

LATER REPERCUSSIONS OF HELD’S WORK

After a period of relative quiet, today Held’s proposal resonates with contemporary action-based theories of perception. The idea has a strong affinity with the enactive approach according to which perception relies on the mastery of lawful sensorimotor

regularities, with self-generated movements being an enabling (and possibly constitutive) condition for developing these sensorimotor schemes or contingencies (O'Regan and Noë, 2001; Noë, 2004; Di Paolo et al., 2017). Varela et al. (1991) brought the kittens experiment to the attention of a younger generation: "This beautiful study supports the enactive view that objects are not seen by the visual extraction of features but rather by the visual guidance of action" (pp. 174–175). This view was inspirational for the field of evolutionary robotics during the 1990s and 2000s, where the role of self-generated activity could easily be appreciated in concrete examples (Nolfi and Floreano, 2000; Harvey et al., 2005; Vargas et al., 2014) particularly in models where perceptual information is generated by a robot's own activity as in the case of a wheeled robot that uses its own angular velocity while circling objects to discriminate their size (Pfeifer and Scheier, 1999). Self-generated activity was explicitly investigated in developmental robotics, as in a replication of the kittens experiment using real mobile robots (Suzuki et al., 2005).

The fit of Held's ideas with the contemporary ecological perspective is less clear. Mention of Held's work is cursory or absent from many important books in this tradition (e.g., Lombardo, 1987; Reed, 1996; Heft, 2001; Chemero, 2009; Turvey, 2019), although it enjoyed some recognition in ecological theories of development (see below). While it is still argued that in order to perceive it is necessary to establish sensorimotor invariant rules (Lobo et al., 2018), it is difficult to find similar pronouncements on the explanatory status of self-generated movements.

Mossio and Taraborelli (2008) have discussed these differences between the two schools. Ecological theories conceive of sensorimotor invariants as a specific transformation of information linked to the perceiver's motion, but their presence and structure do not rely on the voluntary execution of specific motor schemes. By contrast, for the enactive approach motor schemes are intrinsic constituents of perceptual invariants, and schemes are themselves always constituted by bodily and environmental processes. Perception involves the activation of a network of actual and virtual powers and sensitivities, which by definition cannot be entirely passive, and in the case of honing perceptual skills adaptation processes cannot be divorced from activity of *some kind* (Di Paolo et al., 2017). Ecological psychologists focus on the transformation in the ambient array, while enactivists on the changes produced by active sensorimotor schemes. It is a simplification, but it may be helpful to understand this difference to think that for ecological psychologists the paradigmatic case from which perception in general is explained is vision, e.g., appreciating the affordances of a complex scene, while for enactivists it is touch, e.g., perceiving the softness of a sponge by squeezing it.

This crude characterization serves as a first step in differentiating the enactive and ecological positions. Experimental evidence, however, belies this simple picture. For example, parallax and depth perception in cases of ambiguous optic flows are robustly dependent on voluntary movements by the observer (Wexler and van Boxtel, 2005). Wexler (2003) studied the perception of ambiguous optic flows under voluntary (self-produced head movement), involuntary (movement controlled by an experimenter), and mismatch displacement

conditions (the participant moves a wheelchair with her hands). These conditions help disentangle motor signals for action initiation (assumed to be available only in voluntary motion) and proprioceptive and vestibular information. The same optic flow information leads to different perceptions in voluntary vs. mismatch and vs. passive conditions. Wexler observes that the difference cannot be due to external flows or to proprioception alone but depends on the motor command. However, "it is not the mere presence of a corollary discharge, but the details of the motor command that are crucial to spatial vision" (p. 344). Wexler concludes that not only can we not disregard self-motion in spatial vision, but "the observer's active role in initiating and producing that motion is [also] crucial" (p. 344). This evidence, that could be taken to support an enactive interpretation, could also be interpreted ecologically if the sources of integrated information are extended to include motor commands and other somatosensory signals.

Studies like these show that it is difficult to attribute empirical results as supporting either the simplified versions of the enactive or ecological positions. The evidence used often arises from perceptual situations where sensorimotor schemes are already consolidated. One way to force a contrast between the two perspectives is to analyze the development of sensorimotor invariants or contingencies. Trying to answer how sensorimotor invariants achieve a stable structure can shed light on the role of self-generated movements.

To clarify the discussion, we use the terminology introduced by De Jaegher et al. (2010) to describe different kinds of causal relations giving rise to a phenomenon. A *contextual* factor is one whose alteration changes the manifestation of a phenomenon, but not whether it is manifested or not, an *enabling* factor is causally necessary for a phenomenon to occur, and a *constitutive* factor is an inextricable part of what makes the phenomenon what it is. Accordingly, for ecological perspectives self-generated motion has a *contextual* or at most an *enabling* or instrumental role in the specification of invariants, while for the enactive perspective it has an *enabling* or even *constitutive* role in the consolidation of sensorimotor schemes.

From an enactive perspective, perception is constituted by the skillful use of regularities that govern the ongoing coupling between motor and sensory activity, i.e., sensorimotor contingencies (Noë, 2004). Sensorimotor disruptions present the perceiver with radical obstacles and lacunae. Her established sensorimotor skills suddenly cease to make sense. Perceptual adaptation consists in the re-equilibration of sensorimotor schemes guided by engagement in a particular *activity* and the norms it defines, e.g., whether or not the intended object is reached successfully, quickly, efficiently, and so on. While the changes involved are more radical, the processes themselves are, as in Held's proposal, continuous with those of ongoing equilibration involved in minor adjustments and recalibration (Di Paolo et al., 2014, 2017). A key element of adaptation and perceptual learning is the need for self-generated activity by the agent. New sensorimotor schemes cannot be learned unless the agent engages the world actively and confronts various breakdowns and tries to recover from them, all within the normative context of the activity itself. The degree and speed of

adaptation will depend on whether the new normative situation is radically novel or a modification of established habits. This may explain why adaptation is not observed in conditions of mismatched voluntary movement in experiments by Held and Mikaelian (1964) where participants able to walk normally are asked to move themselves in a wheelchair. The time for adapting to a task with a very different normativity (stipulating the appropriate energy, reach, duration, and coordination of movements) can be expected to be significantly longer. Other things being equal, the enactive approach predicts that adaptation will eventually occur even in such cases (and that people with experience controlling wheelchairs will adapt faster).

Sensory adaptation experiments, either following the rearrangement paradigm or in cases of sensory substitution, are frequently cited in support of the enactive account (Varela et al., 1991; Myin and Degenaar, 2014). Situations of rearrangement make apparent the established relation between sensorimotor schemes and perception by distorting it. In order to perceive correctly again this relation must be re-established. The perceiver must modify her sensorimotor schemes. Action and perception are constituted as an *internal* relation between two terms: the perceiver's repertoire of skills and sensitivities, and the environment. (By internal relation we mean a relation on which the related terms depend and through which they change together, as opposed to an external relation between already defined and fixed entities.) This relation is enacted in concrete form in each particular situation involving current and historical environmental constraints and opportunities, goals, motivations, and so on. Changing either term induces a breakdown in the organization of this relation. This breakdown cannot be recovered exclusively from the agent's side or from the environment's side because a new meaningful coherence must be found between two terms in dynamic flux. For this reason, perceptual adaptation is neither the construction of new correlations that internally rearrange environmental data nor the discovery of pre-given invariants in the environment. Rather, it is the result of re-organizing the internal relation between these terms by simultaneously engaging agents and the world. It is eminently a practical, rather than an intellectual, process.

Perceptual learning demands active engagement by the agent with the environment on two related counts: (1) as the process through which new regularities can be explored and equilibrated, and (2) for establishing situated norms that regulate equilibration (otherwise there is no way *for the agent* to know what counts as success or failure and no way to produce new coherent, task-dependent, sensorimotor relations). For each of these reasons, one causal, the other specifying of what to learn, self-generated activity is both *enabling* and *constitutive* of perceptual learning. This activity will in general take the form of combined voluntary overt motor actions such as locomotion, and covert activity such as modulating the focus of attention. It may even take place largely through non-overt activity, as in the case of patients with locked-in syndrome learning to use a brain-computer interface (Kyselo and Di Paolo, 2015).

Ecological psychology studies on recalibration have discussed the role of activity in terms of its relation with environmental flow. For example, Rieser et al. (1995) induced discrepancies

between a participant's walking speed on a treadmill and the rate of optic flow as the treadmill is dragged by a tractor. After these experiences, they showed evidence of perceptual recalibration that cannot be explained by considering motor activity or environmental flow separately. Instead, it is the product of the participant's sensitivity to the covariance between the two. The authors state that it is difficult to disentangle the precise influence of each variable and that "much work remains to specify the biomechanical information. For example, is efference important?... Is reafference important...?" (p. 496).

Self-generated activity has been more explicitly recognized in ecological approaches to development. Eleanor Gibson seems to have been more sympathetic to the implications of Held's work than her husband for whom, as we have seen, self-generated movements could be helpful in perception, but not necessary as such. Eleanor Gibson's approach to perceptual learning and development is indeed compatible with James Gibson's ideas, but puts more emphasis on the importance of the organism's active role in exploring the environment (Adolph and Kretch, 2015). Animal and environment are considered as an interactive reciprocal system in which self-produced movement provides dynamic simultaneous information about oneself and environmental events (Gibson and Pick, 2000; Szokolszky et al., 2019). Eleanor Gibson considered locomotion as one of the major organizing behavioral systems in infancy, which allows the learning of many affordances. According to her view, perceptual development implies learning to detect new affordances as action capabilities change due to changes in the body (Gibson, 1992). In a mutual relation that unfolds developmentally, efficient visually controlled locomotion involves perceiving what a given surface affords, and detecting the information that specifies this affordance requires experience in guiding the body. This experience plays a critical role in perceiving the affordance of a surface for locomotion (Gibson and Pick, 2000). Eleanor Gibson was overall more receptive to discussing and accepting the implications of Held's work (e.g., Gibson, 1969). She mentions the kittens study in support of her own views:

"Self-produced movement, while guiding locomotion visually, emerged as a critical factor in research with kittens by Held and Hein (1963) [...] This finding strengthens the notion that guided action combining visual and kinesthetic information from the action systems involved is essential for the kind of affordance that is being learned" (Gibson and Pick, 2000, p. 113).

Along similar lines, Karen Adolph's studies on infant locomotion led her to the view that a period of self-produced experience is needed to learn to perceive affordances and avoid the visual cliff (Adolph, 2000; Kretch and Adolph, 2013). The learning experience gained with attaining a given posture (e.g., avoiding risky staircases when crawling) is not automatically transferred when a new motor ability is acquired (e.g., walking). It is necessary to learn to perceive the affordances involved in each case, since the perceptual consequences of moving while crawling or walking are very different. To say that self-produced activity is needed, crucial, or essential for perceptual development amounts to assigning it an explanatory role that is not merely *contextual*,

but also *enabling*, i.e., without this activity, perceptual learning would not occur.

More recently, Jacobs and Michaels (2007) have proposed a direct learning approach whereby adaptive changes in perception occur without mediating inferential processing. The theory formally describes the information for learning as a vector field covering the space of all the perception-action couplings that can be used to perform an action. Each point in this space corresponds to a specific coupling. Changes during learning are represented as paths. Perceptual learning in this model involves three processes: the education of intention, the education of attention, and calibration. Through the education of intention agents in a situation with multiple alternatives can improve “in choosing which of the possible perceptions and actions they intend to actualize” (p. 326). The education of attention, a term taken from Gibson (1979), is the process of learning to detect the most useful informational variable, even if intention does not change. Calibration consists of changes in the way the informational variable that is operative at a particular moment is used in perception or action. This model is meant to explain a wide range of phenomena in ecologically relevant and informationally rich situations as well as in simpler experimental situations. Although it does not explicitly address the issue of self-generated movements, it makes a clear reference to the active role of the agent. A recent reading of this work suggests that there is an equivalence between the model and the enactive proposal described by Di Paolo et al. (2017). The similarities include, among others, the point that direct learning requires the active role of the perceiver through the perception-action coupling (Higueras-Herbada et al., 2019).

Why do we find different positions within the ecological perspective in relation to Held’s proposal? We believe that this is because theories of perceptual learning (Gibson, 1969; Gibson and Pick, 2000; Jacobs and Michaels, 2007) make use of a concept of agency that is not emphasized in more orthodox ecological positions (beyond the recognition that the determinants of behavior are not exclusively environmental, see Withagen et al., 2012). This concept has emerged more explicitly in recent decades and is part of ongoing discussions within ecological psychology. In a keynote address on the future of psychology published in 1994, Eleanor Gibson referred to agency as one of the hallmarks of human behavior. She uses the term to describe the case when an organism manifests at least some autonomy and control (Gibson, 1994). Agency, according to her, is manifested in human behavior together with three other fundamental hallmarks: prospectivity, retrospectivity, and flexibility. Prospectivity and retrospectivity help define a particular animal’s region of controllable agency. Prospectivity directs action and attention toward the emerging features of situations. Retrospectivity enables agents to coordinate past experiences with present control. Flexibility in action control refers to the interchangeability of means to achieve the ends of action. From these elements Edward Reed (1996) points out that the actions of agents are not the effects of just any previous cause. “Their actions are part of a stream of regulatory activities that are typically self-initiated and modified and regulated by both internal and external factors.” (Reed, 1996, p. 19). Such ideas

are consistent with Chemero’s (2009) proposal that we should not think of affordances as dispositional properties. We should understand them in relational terms instead. Chemero believes that perception and action should always be considered in the context of the agent-environment system. To understand the relationship that an agent establishes with her environment, it is not enough to simply focus on the constraints and regularities that may exist, it is also necessary to focus on how the agent is able to selectively be sensitive to or be invited by some affordances and not others (Bruineberg et al., 2019). In making agency an important concept as well as a topic for further research, this ecological strand finds much in common with the enactive approach, for which the idea of agency is central (e.g., Di Paolo, 2005; Barandiaran et al., 2009; Di Paolo et al., 2017).

The discussion today, as it was in the 1960s and thereafter, is fraught with difficulties that arise from the use of apparently straightforward formulations in the context of very complex phenomena. Held proposed that self-generated movements are necessary for achieving sensory adaptation, for perceptual learning and, in general terms, for perceiving in a stable manner. To this we have seen a range of responses that go from the flat denial that self-generated movements (or movement at all) play a role in perceptual learning, to James Gibson’s interpretation that they may facilitate attention but are not really necessary, to Eleanor Gibson and colleagues suggesting they are indeed necessary as part of a mutual developmental influence between action and perception, and to the enactive view, for which an agent’s activity is not only necessary but is itself an inseparable part of the processes of perceptual learning. We have interpreted these different views in terms of contextual, enabling, and constitutive relations. **Table 1** summarizes the possible positions on the causal status of self-generated movements in perceptual learning.

We will not attempt to settle the debate here, in part because we must still critically examine the notions of activity and passivity that have been used above. As with other ideas in these discussions, this distinction is anything but simple.

IS THERE EVER A PURELY PASSIVE OR PURELY ACTIVE CONDITION?

Several attempts to replicate Held’s rearrangement studies were unsuccessful. There is an intrinsic difficulty in determining what counts as active and passive conditions in experimental situations. Simple operational definitions can be deceiving. It may be possible to restrict some body movements (e.g., locomotion, movements of the arm) but minor movements (e.g., head or eye movements) are more difficult to control. For instance, in the Held and Hein (1963) experiment all kittens could move their limbs, the difference was that for the passive group there was no correspondence between limb movement and displacement. Active processes that potentially influence perceptual learning can occur in situations of passivity. Indeed, several of Held’s studies show a marked individual variability in the passive condition. Although most of the passive subjects failed to adapt, some did so partially or even

TABLE 1 | Summary of the different responses to Held's proposal concerning the causal status of self-generated movements (SGM) for sensory adaptation and perceptual learning.

Explanatory status	Interpretation	Proponents
Contextual	SGM may facilitate perceptual learning, but learning can occur without them	J. J. Gibson, Rock, Welch, Lackner
Enabling	SGM are necessary for perceptual learning and development through reciprocal loops between action and perception. Perceptual learning is not possible without them	E. J. Gibson, Adolph, Noë, O'Regan
Constitutive	SGM, or self-generated activity in general, are an integral part of the processes of equilibration, stability, and formation of new schemes that define perceptual learning	Noë, Di Paolo et al.

The names mentioned as proponents for each case serve only as examples and are based on specific items of literature (not a whole oeuvre). In some cases, (e.g., Alva Noë) the position may be ambiguous between more than one possibility.

fully (e.g., see Held and Hein, 1958; Held and Bossom, 1961; Hein et al., 1970).

Even in cases where participants are completely immobile or are moved by an external force, it is very hard to account for what they are attending to. In the replication of the kittens study by Walk et al. (1988), animals in the passive condition that were watching the toy cars could not locomote but could freely move their head. The authors downplay the role of these movements and attribute spatial learning to the visual scene that captures the kittens' attention. These movements, however, were very frequent and enabled kittens to discover "a world in depth" (Walk et al., 1988, p. 251). So, even if they could not perform active locomotion, these subtle exploratory actions elicited by the kittens' interest in the experimental situation could have contributed to learning. It can be hard to determine whether it was one or the other, head and eye movements or visual attention, that gave rise to learning. It may even be a confounded effect between these factors as presumably attention would have faded quickly if the animals could not explore the scene with head and eye movements.

Similar ambiguities arise when defining what counts as an active condition. There can be important differences in the repertoires of actions that participants can perform, from very rich to extremely poor patterns, from attentive and energetic to distracted and lethargic attitudes. As with attention, it is not always easy to ascertain the level of motivation or fatigue with which participants actively perform a task.

An anecdote from an ongoing experiment by two of the authors serves as an example for the point in question. We have performed a study to compare the effect of active and passive exploration on a task where participants, blindfolded and seated, had to reach toward a sound source located in front of them at different distances (similar task as in Hüg et al., 2019). In the active condition, during a training session participants freely explored the arrangement until reaching and touching the sound source. In the passive condition their arm was moved with a sling by the experimenter until the hand made contact with the source. In the posttest the "active" group showed a more precise performance. The "passive" group showed great variability; some participants improved their performance, others did not and others exhibited strange response patterns. At the end of the experiment, passive participants reported very different experiences. For example, one said that she

was practically asleep. Another commented that he was extremely attentive to how his arm was being moved. In general, we could not determine these differences from mere observation.

These ambiguities are also manifested in neuroimaging studies. Passive conditions can differ significantly depending on the protocol, motivation, or attention. If passive movements are mechanically administered by a robot, the brain regions that become activated differ from those involved when an experimenter moves the body of the participant. Van de Winckel et al. (2013) suggest that this occurs because the movements performed by the experimenter are never exactly the same, which stimulates in the participant an awareness and sensory monitoring of the moved body. It is not clear if self-generated and passive movements involve the same brain regions. Some studies show that both common and different areas are activated (Sahyoun et al., 2004; Ciccarelli et al., 2005; Van de Winckel et al., 2013). Others do not find any significant difference (Weiller et al., 1996; Guzzetta et al., 2007).

What may look like a reasonable experimental operationalization can fail to capture relevant aspects of a participant's activity. Activity does not fully stop simply because participants are instructed not to move by themselves. There is, to an extent, always an active element even in the most passive of conditions provided the participant is indeed awake and capable of regulating attention, emotion, effort, inner speech, etc. Participants in typical passive conditions accept an external control source for their movements. But this can involve active elements such as inhibiting a habitual resistance to such external interventions and remaining vigilant that movements do not become too uncomfortable. There is, in contrast, an inherently passive element in every experimental situation, no matter how freely participants may move, in that they accept and comply with the instructions they are given and do not intervene by altering the experimental set-up.

To confound matters further, attributing responsibility for action can be difficult due to social factors, not only in situations of explicit social interaction (De Jaegher et al., 2010), but in general as experimental instructions, clarifications, unintended suggestions, attitudes toward experimenters, social norms, differences in culture and personality, and so on, all form part of a joint participatory construction of sense (De Jaegher and Di Paolo, 2007). Allowing the intervention of another person over the initiation and regulation of

our sensorimotor schemes, as in most experimental passive conditions, is a form of interaction that demands an active kind of acceptance and monitoring (see Di Paolo et al., 2018, pp. 148–149). What a participant does or does not do in active or passive conditions is shaped by the social, linguistic, cultural, material, and technical factors at play in the experiment.

Activity and passivity should not in general be understood as forming a binary distinction. This is the case even in apparently well-defined scenarios where the distinction is applied to a restricted domain, such as whether a movement is self-generated or not. With this, we do not intend to imply that the distinction is useless and should be abandoned. Rather, we think it should be refined. We believe there are different degrees and different dimensions of activity and passivity and that articulating these differences has important theoretical and experimental implications.

A first correction that can bring some clarification is to acknowledge that the distinction is in general only a relative one. Given a series of constraints (instructions, set-up, protocol) it may be perfectly valid to describe a condition as active if it allows a significantly higher degree of choice, control, and engagement by the participant than the passive condition, and vice versa (i.e., “more/less active than ...”). If constraints remain fixed, the relative difference between the conditions is expected to be maintained. However, since activity and passivity are defined relative to each other, this makes comparison between different experiments risky because of the difficulty of comparing in detail what counts as active or passive in different labs, set-ups, etc.

A more principled approach to refining the active-passive distinction results from considerations concerning the sense of agency, i.e., the aspects of lived experience that continually tell us whether we are the agents of our actions (see e.g., Synofzik et al., 2008; Gallagher, 2012). The sense of agency is illuminating not only because it involves the experienced aspects of the active-passive spectrum but also because the conceptual complexity is similar. The sense of agency is not an either-or aspect of experience, contrary to what we may think by contrasting clear-cut cases such as moving an arm or having somebody else move it for us. It is a sense with many facets not always easy to disentangle. Some aspects of the sense of agency, particularly the feeling of being involved in an action, are pre-reflective and phenomenologically recessive, that is, in normal circumstances primary awareness is with the action not with

who is performing it. In cases of breakdown, interruptions, etc., however, we become more presently aware that it was the action that we ourselves have been performing (“something stopped me in my tracks”). Other aspects of the sense of agency, such as the judgment of agency can be reflective, i.e., when we take an introspective stance in the planning of an action or when monitoring its performance. These aspects can take the form of retrospective conceptual attributions (“I did that”) or ongoing deliberate regulations (“Now I must move this cursor just a bit more to the right”).

Similar differences apply to the active-passive distinction. We can expect both pre-reflective and reflective aspects to be in place, as well as differences to do with the prospective/retroactive and ongoing aspects of the action being performed. Buhrmann and Di Paolo (2017) propose a map of these differences (further elaborated in Di Paolo et al., 2017) and connect the phenomenological aspects with microgenetic processes involving the selection, initiation, control, and equilibration of sensorimotor schemes. The same distinctions can be applied to elucidate the active-passive distinction.

One dimension concerns action initiation. This can involve prospective intentional aspects such as an anticipatory awareness of being in a flow of activity and that a particular action needs to be executed next. At the sensorimotor level action initiation correlates with impulses to start an action as well as a sense of urge or preparation. The dimension of action initiation is to be contrasted with ongoing monitoring and control, where the relevant sense is one of progressing toward the achievement of a goal, adapting to deviations or compensating for unforeseen events and obstacles. Imaging studies confirm that different functional brain regions activate during preparation (before active movement), anticipation (prior to passive movement guided by the experimenter), and execution of movement (Sahyoun et al., 2004).

In an experimental situation, it may be relatively easy to control for action initiation in distinguishing between active and passive conditions although some processes, such as preparatory neural motor potentials corresponding to the intention to move, may be active even if the ensuing movement is passive. These processes can make a difference in perception, e.g., preparation to act has been shown to affect visual discrimination (Craighero et al., 1999; Fagioli et al., 2007). It may be less easy to establish a clear-cut difference between activity and passivity in the dimension of monitoring and control. Movement control can be effectively “handed over” to an external agent but this can

TABLE 2 | Dimensions of the active-passive distinction discussed in the text (there may be more).

Dimensions of activity-passivity in SGM	Description
Action/movement initiation	Prospective intentions, urge to act, reflective or pre-reflective awareness about what to do next. Preparatory motor potentials, attention to new goals.
Action/movement control	Pre-reflective sense of smooth control or obstacles and breakdowns. Adaptive equilibration via existing or newly learned schemes. Regulation via spinal circuits, etc.
Action/movement monitoring	Attention, whether focused or peripheral, to actions being performed. Ongoing (pre-reflective or reflective) verification of adequacy to intended goals.

Along each dimension different aspects of an action or movement can make it relatively more or less active. SGM, Self-generated movements.

be an unstable situation precisely because it is unusual and may demand actively trying not to resist the imposed movement, or trying to accompany it, or attempting to predict what the next stage is going to be. In the case of repetitive movements, the participant may fall into a regular pattern where it is unclear who is in control of the movement. Or indeed, in a fully compliant manner, the participant could be doing none of these things.

Controlling experimentally for monitoring is probably not entirely possible (adding distractions or cognitive loads may help if the point is to minimize attention but depending on the hypothesis being tested this may not be desirable). Participants' monitoring in a passive condition may range from close scrutiny of what is going on to a total lack of attention. Again, if the task is repetitive, participants' monitoring in the active condition may recede almost entirely as movements become automatic.

These dimensions of the active-passive distinction—initiation, control, monitoring, (Table 2)—and perhaps others too, should be explicitly considered in terms of experimental design and for explicating which aspects of self-generated activity are theoretically most relevant.

CONCLUSION

The studies on sensory adaptation carried out by Richard Held and collaborators in the 1950s and 1960s provide us with a rich material for querying the relations between action and perception and, in particular, the role of self-generated activity in perceptual learning. The focus of heated debates at the time, this work is much less discussed today but clearly still very relevant for modern enactive and ecological psychology perspectives, and for clarifying their convergences and differences.

Many of the questions investigated by Held remain unanswered. This is partly due to the connected difficulties in clarifying the meaning of his proposal and in its empirical testing. We have introduced two refinements that throw light on the situation: one for elucidating the kinds of causal relations that may be at play, another for explicating the active-passive distinction.

To say that active, and not passive, participants demonstrate sensory adaptation in cases of rearrangement can mean different things. Self-generated activity may facilitate learning without it being strictly necessary, or it may be required for learning to occur, or it may itself be an inextricable part of the learning process. We have discussed examples of these different interpretations and proposed that they should be, respectively, categorized into contextual, enabling, and constitutive positions (Table 1).

To say that a participant is active, and not passive, can also mean different things. It generally means that they are allowed to move by themselves in contrast to being moved by others. But this difference is relative and dependent on the experimental conditions. Distinct dimensions of activity can be at play in either active or passive conditions. Active movements are externally constrained by social situations,

experimental instructions, and set-ups. Self-initiated activity does not necessarily stop when participants allow themselves to be moved. We have appealed to considerations regarding the sense of agency to refine the active-passive distinction and proposed that at least the following three dimensions be differentiated: action initiation, action control, and action monitoring (Table 2). These are strictly dimensions and not binaries in the sense that different aspects and different degrees of intensity can be at play in each.

These considerations can help us understand apparently contradictory empirical evidence and propose more precise hypotheses. Combining the refinements summarized in Tables 1 and 2 yields 9 possible ways of interpreting the claim that active participants adapt better to sensory rearrangement. We do not suggest that this list is exhaustive but it may be enough to help elaborate more precise ways of articulating the convergences and differences both within and between the enactive and the ecological positions.

Clarifying the active-passive distinction goes beyond the study of perception. It has implications, for instance, in areas such as motor rehabilitation. It is well established that active movement improves the recovery of motor function, but the therapeutic role of applying movements passively is still controversial (Lindberg et al., 2004; Zeng et al., 2018; Noble et al., 2019). Some evidence indicates that proprioceptive input caused by passive movements (controlled by a therapist or assisted by a robot) can contribute to improving motor function through the reorganization of the cortical areas involved in sensory integration (Carel et al., 2000). Others, however, state that passive movement is insufficient and active participation by the patient is required (Hogan et al., 2006). Breaking down activity into the dimensions of action initiation, control, and monitoring could help make sense of these differences and knowing which aspects of activity are therapeutically important could lead to improvements in rehabilitation practices.

We conclude by highlighting again the historical and current importance of Richard Held's rearrangement studies. His experimental designs were original and imaginative, his theoretical interpretations very innovative for the time. Either by affinity or contrast, current action-based theories of perception owe much to Held's work. In future work, it would be beneficial to examine other theoretical proposals on adaptation and perceptual learning (such as those by Harris, 1965; Rock, 1966; Wallach, 1987), and the role of memory in such processes (e.g., Glenberg, 1997), as well as related work in computational neuroscience in the light of the classifications introduced here. The dialog between enactivists and ecological psychologists, we believe, can only benefit from the common ground that Held's studies provide and from understanding his ideas more thoroughly.

AUTHOR CONTRIBUTIONS

All authors conceived, designed, and wrote the sections of the manuscript and contributed to manuscript revision, read, and approved the submitted version.

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Scale Matters: Temporality in the Perception of Affordances

Melina Gastelum^{*†}

Faculty of Philosophy and Literature (FFYL), National Autonomous University of Mexico (UNAM), Mexico City, Mexico

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Maria Brincker,
University of Massachusetts Boston,
United States

*Correspondence:

Melina Gastelum
melinagastelum@filos.unam.mx;
megava@gmail.com

†ORCID:

Melina Gastelum
orcid.org/0000-0002-6632-170X

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In this paper I seek to unify enactive and ecological approaches to cognitive science by emphasizing the fact that both approaches view cognitive processes as being inherently temporally extended. My hypothesis is that characterizing the temporal scales in which perception of affordances occur, they can serve different purposes of explanation within the theories. Specifically, the paper brings together, on the one hand, Chemero's (2009) dynamicist understanding of affordances, which he called affordances 2.0, with, on the other hand, a distinction originally made by Varela (1999), and later taken up by Shaun Gallagher (2011, 2017b), between three different timescales for understanding cognition: the elementary, the integrative, and the narrative. Varela's three-fold distinction was originally intended as a way of identifying phenomenological events as being causally coupled to specific cellular events happening within the nervous system. The central claim of the present paper is that affordances, likewise, should be understood in terms of these three different timescales. I show that these temporal scales can be a useful toolkit for explaining the perception and learning of affordances and at the same time unifying enactivism and ecological psychology claiming that affordances serve a different explanatory role depending on which time scale you consider them at. If you are interested in explaining the embodied assemblies that form the always changing sensorimotor contingencies, then you see the elementary scale. If you're interested in explaining perception at the integrative scale, then affordances are solicitations that get actualized and bear an *umwelt* at that same scale. The perception of affordances as such is constituted by the integration of these first two scales, and the experience of it can be characterized by the husserlian structure of experience with its intrinsic temporality. Finally, if you are interested in explaining change in the animal-environment system over developmental time, that is, learning, then affordances are roughly what Chemero proposed and they operate at the narrative scale. But it is important to say that the three scales are always intertwined because learning and perception are ongoing processes that in many senses are impossible to separate. Finally, I discuss the importance of scales from the macro to micro levels for understanding behavior through affordances, considering them as synergies, where abilities and aspects of the environment are understood as constraints on the potential trajectories of such systems.

Keywords: temporality, affordances, ecological psychology, enactivism, temporal scales, synergies

INTRODUCTION

Embodied and situated approaches to cognition have gained terrain within cognitive science in the last decades. They have put forward questions that were traditionally neglected, such as the role of the body in cognition, and have opened a field of research alternative to representational approaches to the mind that is philosophically and operationally solid in its own right. Enactivism and ecological psychology have been without any doubt the most prominent and crucial approaches to this development. However, there has been a historical lack of compatibility between them. Although they share essential tenets about cognition and mind, their respective early formulations were explicitly critical to one another which has led them to emphasize different aspects of the mind in their specific terms: while enactivism focuses on the cognitive agent and its subjectivity, ecological psychology focuses on the environment and the relation that animals establish with it (Baggs and Chemero, 2018). In the last decade, it has been recognized that these approaches are not so distant after all, and even more, that bringing them together could be greatly fruitful for a solid radically embodied approach to cognition. In this paper I join this claim by analyzing the temporally extended character of the perception of affordances for both the approaches.

There are at least three points of agreement between enactivism and ecological psychology. First, they share a conception of perception that makes it continuous with action: for enactivists, perception is understood “as something we do” (Nöe, 2004; Heras-Escribano, 2019) in order to preserve our form of life (Di Paolo et al., 2017), while for ecological psychology, perception occurs in terms of invitations to act and it is “an achievement of the individual, not an appearance in the theater of his consciousness” (Gibson, 1979, p. 228).

Second, for both approaches the environment is constitutive of cognition: for enactivists, the environment is a constitutive element of adaptive interactions which are essential to sense-making (Di Paolo, 2005) and to maintain a central tension that gives autonomy to a living system. This autonomy emerges from a “primordial tension,” which refers to those dynamics by which the identity of an organism requires to persist while opening itself to the environment and making sense of it at the same time. Meanwhile, ecological psychology takes the organism-environment system as the unit of analysis of cognition as a whole, in other words, ecological psychology explains the way in which agents perceive information about affordances and relates to them. For both approaches, cognition doesn’t happen inside the head but in the interaction of an organism with its environment.

Third, both the enactive and the ecological psychology definitions of environment coincide in that the surroundings are primarily meaningful for the agent in an embodied, non-semantic, non-representational sense. The idea of sense-making in enactivism shows that the world is meaningful and constitutive inasmuch as it allows the organism to perform a certain action that is relevant for its autonomy, which is close to the ecological idea of affordance, that is, things are perceived meaningfully as they call for action (Costall, 1995, p. 470; Heras-Escribano,

2019, p. 23) and therefore the unit of analysis is the animal-environmental system as a coupled unity. In short, they are both embodied and situated approaches to cognition committed both with non-representationalism, with the continuity of perception and action and the end of the dualism between internal and external or agent and environment.

It might seem that not all conceptions of affordance proposed within ecological psychology are conceptually compatible with the cognitive agent proposed by enactive theory. For example, conceiving affordances as dispositional properties might seem like reducing cognitive agents’ engagement with the world to an almost mechanical response which directly contradicts the enactive conception of sense-making. I believe, however, in line with Baggs and Chemero (2018), that this conception of affordances as dispositions describes one of the various possible levels of analysis of the agent-environment engagement, namely, the total set of skills shared by agents with a common biological organization, a common niche and a common pattern of behavior, while the enactive approach describes a different level, namely, the individual level. In general, while the enactive account of agent-environment interaction in terms of sensorimotor schemes describes the configuration of the point of view of the cognitive agent, affordance theory focuses on the relational and dynamical properties that arise precisely in this sensorimotor interaction from the perspective of a population that shares a form of life, but I will explain this in the next section.

In this paper, the hypothesis is that by saying that environment is constitutive of cognition and adding that by understanding how the scales of temporality of the processes by which the engagement with it occurs (i.e., the perception of affordances) we can step forward in bringing together both approaches. For this, I claim that the conception of affordances 2.0 (Chemero, 2009) has to be taken seriously and further explained as a bridge between them. This involves taking the temporal dimension of abilities in affordances seriously, particularly in terms of interaction across multiple temporal scales. For this, I think that perception of affordances should be characterized in terms of dynamical agent-environment systems, with abilities and aspects of the environment (affordances 2.0) understood as constraints on the potential trajectories of such systems.

For this, in the first part of the paper I explain why temporal dynamics of affordances and affordance perception is incredibly important and how is it that Chemero (2009) proposed them. I also explain the division between physical world, habitat, and *umwelt* developed by Baggs and Chemero (2018) to understand the difference between objective and subjective affordances and the interplay between them, when they are potential and get actualized. In the second section I expand on the notion of intrinsic temporality of the perception of affordances, borrowing the husserlian structure of time consciousness and argue that it can be used to explain action/perception and experience of affordances which is a fundamental part of the temporal dynamics in them. In the third section, I introduce Varela’s (1999) three-fold distinction for neurodynamics and explain why, in my hypothesis, I think they can serve for characterizing the dynamisms of the perception and learning

of affordances. I claim that differences in temporal scales is significant because they are constitutive of sensorimotor schemes dynamics, and sensorimotor schemes dynamics are constitutive of affordances, hence affordances. Henceforward, affordances are constituted by the abilities and the environment as relations that occur with an intrinsic temporality that is related to different temporal scales interconnected between them. These three scales are constitutive of the perception and learning of affordances whenever they are actualized and therefore whenever they bear an experience for the agent, so it might make sense to say that the entire organism-environment system retains changes in its structure as a result of the organism's learning of sensorimotor contingencies. Finally, I discuss the importance on scales from the macro to micro levels of understanding behavior through affordances, considering them as synergies, where abilities and aspects of the environment are understood as constraints on the potential trajectories of such systems.

AFFORDANCES 2.0, HABITATS AND UMWELT

Affordances 2.0

In the ecological psychology tradition, there are at least three important assumptions at its basis: that perception is direct, that perception is for action, and that perception is of affordances (Chemero, 2009, p.98). As mentioned in the introduction, not all conceptions of affordances are compatible with the idea of bringing together ecological psychology and enactivism. Briefly put, there has been much discussion about how to characterize affordances. Some of Gibson's followers have stated that affordances are dispositions in the environment (Turvey et al., 1981; Turvey, 1992) that get actualized through an effectivity from the individual that perceives them. I believe, however, that overcoming differences between the ecological and enactive theories has to do with the conceptualization of affordances you make and is essential for constructing a robust post-cognitivist framework in cognitive science, which is part of the aim of this paper. I believe Chemero's conception of affordances 2.0 is an excellent departing point for that. As he claimed:

Combining Affordances 2.0 with enactivist studies of the organism makes radical embodied cognitive science a fully dynamical science of the entire brain-body-environment system: non-representational neurodynamic studies of the nervous system and sensorimotor abilities. (Chemero, 2009, p. 152)

And this is so because as Chemero has rightly noted, ecological psychologists usually "define affordances statically" (2009, p. 150). Consequently, as an attempt to dynamize the concept of affordances, he introduces the concept of affordances 2.0:

Affordances are relations between abilities to perceive and act and features of the environment (2009, p. 150). Affordances and abilities are not just defined in terms of one

another as in the dispositional and relational views (...), but causally interact in real time and are causally dependent on one another. [...] This reconceptualization of affordances is explicitly formulated to make the natural, but largely unmade, connections between ecological psychology and the enactivist movement in cognitive sciences. (Chemero, 2009, pp. 151–152)

The key point is to conceptualize affordances as interacting in real time, as dynamically coupling with the rest of the environment and among them. Silberstein and Chemero (2011, p. 7) expand on this saying that the animal's endogenous system has endogenous dynamics that generates and constitute the sensorimotor abilities and the whole nervous system. The sensorimotor abilities are coupled with a specific niche which in turn modulates the dynamics of the nervous system. So, "affordances and abilities are not just defined in terms of one another, but causally interact in real time and are causally dependent on one another in a non-linear fashion" (Silberstein and Chemero, 2011, p. 8).

Affordances 2.0 are compatible with the enactive idea that agents actively make sense of their environment in terms of how it affects them, but how does this happen and in which temporal scales? I will discuss this in the next section.

Environment, Habitat, and Umwelt

Another important conception that I will use in this paper is the difference between physical world, habitat, and umwelt that Baggs and Chemero (2018) recently developed. They used this distinction to clarify disagreements between ecological psychology and enactivists, as well as to clarify certain tensions within the former in relation to the conceptualization of affordances.

Gibson (1979) made a crucial distinction between the physical world and the environment of animals.

The physical world exists at all spatial and temporal scales, from nanoseconds and nanometers to millennia and galaxies. The animal's environment is limited to the behavioral, middle scale. For humans, the spatial scale of the environment is from millimeters to kilometers and the temporal scales can be from hundreds of milliseconds to years. (Gibson, 1979, p. 12)

Gibson also pointed that the environment of animals is perceived in terms of ecological events, and not in terms of time; time is actually an abstraction. Ecological events have been characterized as "changes in the layout of affordances of the animal-environment system" (Chemero, 2000, p. 39). Notably, "the physical world is inherently meaningless, but the environment is not: it contains affordances" (Baggs and Chemero, 2018, p. 4).

The relevance of scales starts here: the ecological scale matters as I want to highlight in the title of the paper. This scale is crucial when explaining what cognition is because within it there's clarity about the environment being a subset of the whole physical world, and therefore, the ecological scale sets up in space and time the *behavioral scale* for animals, where and when affordances

occur. Because the environment contains affordances, there is no need for the animal to construct meaningful experiences by building or manipulating representations in some phenomenal realm, or even in the brain. “In fact, meaningful experience doesn’t happen inside the animal but as perceiving occurs: an animal using information to learn about the affordances of the environment is having meaningful experience” (Baggs and Chemero, 2018, p. 5).

Furthermore, Baggs and Chemero argue that it is necessary to subdivide what Gibson referred to as the environment. “We need to make a finer distinction between, (1) the environment as a set of resources for a typical, or ideal, member of a species, which we call the habitat, and (2) the environment as the meaningful, lived surroundings of a given individual, which we call the *umwelt*” (Baggs and Chemero, 2018, p. 6).

The environment in which perception/action is situated, that is, what appears meaningful to the agent and toward which she orients her actions, is called her *umwelt*. This concept was originally introduced by Jakob von Uexküll, and it captures the *phenomenal world* an organism inhabits and in which everything it will ever experience occurs. An *umwelt* arises from the coupling of one single organism, with its needs and physiological possibilities, to its physical environment through a functional cycle of perception and action (Uexküll Von, 1929, 1957). In the terminology of Baggs and Chemero, this would amount to a finer distinction, this would be the coupling with a particular habitat, not a physical world, because according to Gibson this later one is meaningless (it is the scale of the physical, not the behavioral). This means that the *umwelt* is not shared by a whole species nor does it consist in the physical world to which everything belongs; instead it belongs to each individual organism (although different *umwelts* can actually be quite similar for different individuals of the same species). Thus, in von Uexküll words, biologists consider “as many worlds as there are subjects” (1929, p. 70). An *Umwelt* is not exclusively constituted by the biological needs and possibilities of an individual: what appears meaningful to a human agent is largely constituted by her repertoire of acquired sensorimotor abilities. An aspect of the environment appears meaningful to an agent when it becomes part of what makes her action possible, that is, when it allows her carrying out networks of sensorimotor abilities; in other words, when it becomes a relation. This means that when sensorimotor abilities are learnt and carried out, new affordances (potential at one point in time, from the habitat) are incorporated in an individual’s *umwelt*. An individual’s *umwelt* is thus shaped by the action possibilities proper to the specific biological organism she is but also by her personal history of interactions with her habitat.

This distinction between physical world, habitat, and *umwelt* allows for distinguishing the individual’s set of affordances given its biological set up, its development, and her history (the *umwelt*) from the general (objective) set of affordances that are possible for a group of individuals or species (the habitat), the ones that could be seen as dispositions or potential affordances 2.0 (relational). In other words, there are affordances that exist objectively for an individual as a member of a species or of a group of individuals and some affordances that are perceived as

soliciting for a given individual given its histories and interactions within that particular niche, and that become actualized and thus, form part of their ever-changing *umwelt*.

So, here we have two levels of description, one for particular agents and one for a group of individuals. Importantly, the conception of affordances is also dependent on these levels of description. Chemero argues that affordances 2.0 are relational and that they can give an account of learning and bodily capacities into the perceptual processing, which in turn can explain why some affordances are salient for a particular individual and not for others. On the other hand, the affordances as dispositions (Turvey, 1992) allows affordances to play a role in evolution but is not clear about how some affordances are actualized or are salient to a particular individual in a species. This is a tension also noticed by Reed:

An affordance is only a relation when an animal perceives or uses it, because then the animal comes into relationship with the relevant feature of its environment. Affordances in the animal’s niche are not relations; they are instead resources—in this case, resources for obtaining value from the environment. (Reed, 1996, p. 26)

So, the tension is solved with the distinction that Baggs and Chemero explained between habitat, where affordances are objective dispositions for the species that could or not invite behavior for particular individuals, and the relational affordances that entail an *umwelt*, where affordances depend on the particular history of development (ontogeny) and thus, are subjective and salient for a particular individual when we perceive and act upon them. Finally, it is important to notice that an individual’s *umwelt* can actually go beyond some particular habitat due to significant individual variations; here we can think in some perceptual variations, like autism, or even a more sociocultural habitat, like that of a particular culture or form of life.

Enactivism in the Habitat and Umwelt

As we just saw in the last section, Gibson understood that the physical world as a whole is meaningless for the behavior of animals. When one considers it from the point of view of an idealized member of the species, “parts of it partly constitute a habitat of that species, and when one considers it from the point of view of an individual, parts of it partly constitute an *umwelt*” (Baggs and Chemero, 2018, p. 12).

The way to put this idea for phenomenologists and sensorimotor enactivists is by saying that the *umwelt* is given in experience, while ecological psychologists say it is perceived directly. This will be crucial for this paper, because this means that “given in experience” and “perceived directly” implies the same: that the access to the *umwelt* is not mediated by representations, but it is enacted, acted upon in the ongoing couplings with the environment. This connotes that is “brought forth” in the historic relation between the agent and the habitat. The *umwelt* then is not stable either, it changes by the history of structural coupling the individual goes through in her development. For enactivism, the world (meaning, intentionality) is not pre-given or predefined, but is structured by cognition and

action, and shows up as an affordance space (Brincker, 2014; Gallagher and Lindgren, 2015) or a “landscape of affordances” (Rietveld and Kiverstein, 2014).

For enactivists, the role of environment is constitutive of cognition because of the way agency is shaped in the relationships with it. The role of the interaction of the organism-environment is explained through sensorimotor contingencies. Sensorimotor contingencies allow us to explain cognition in the way Varela et al. (1991, p. 173) put it: “perception consists in perceptually guided action.” The organism couples with the environment through a feedback relation between perception/action and sensations. The correspondence of action and incoming sensation establishes regularities, which are the contingencies, and when they get mastered by the agent and integrated with other contingencies, they become sensorimotor schemes and with time habits that allow to anticipate upcoming events and guide behavior. O’Regan and Noë (2001, p. 82) put it like this: “agency in a cognitive sense is understood as the skillful purposive behavior of the whole organism, and this skillfulness is based on the mastery of these sensorimotor regularities.”

Another notion in sensorimotor enactivism that enlightens the conception of *umwelt* is the idea of sense making. This concept explains the meaningful or valuable environmental aspects for the organism (Di Paolo, 2005). Sense making occurs as every agent establishes a particular history of interactions (sensorimotor contingencies) through repertoires of sensorimotor schemes and regulations (adaptivity) (Heras-Escribano, 2019, p. 9) that shape constantly her individual perspective in a particular habitat. This is also why we can say that the *umwelt* is never complete and it’s a continuous activity of the organism. This is the reason why enactivists also analyze affordances as objects of perception (Nöe, 2004; Di Paolo et al., 2017), because they share the idea of meaning as a product of the way in which the environment is related to the organisms’ capacities in an embodied and situated way. Baggs and Chemero (2018) explained that the *umwelt* “requires work,” which means, like in the enactivist approach, that the internal organization of the animal (the sensorimotor schemes that fill in the theory of sensorimotor contingencies) can explain how the animal is continuously making sense and adapting to its surroundings, in the process of shaping her continuously changing *umwelt*, and also, constituting her agency.

To conclude this section, we can resume that the definitions of environment for enactive and ecological approaches share that it is meaningful in an embodied, non-semantic, non-representational sense. For the enactivists, sense making permits explaining how the agents live in a meaningful world inasmuch as it allows the organism to perform certain actions, which also is in the core of ecological psychology with the idea of affordance, also called “the meaning of things for action” (Costall, 1995, p. 470).

HUSSERL AND THE STRUCTURE OF TEMPORALITY

As mentioned before, Chemero proposed affordances 2.0 to introduce dynamism into its conception. In this section

I will develop an account of this dynamism, borrowing some conceptions from Husserl and importing them into perception of affordances.

The question is: How can we characterize the temporally extended character of the perception of affordances? We will adopt Husserl’s analysis of the intrinsic temporal structure of experience that can be applied not just to experience/consciousness but also to embodied action. Berthoz (2000), for example, suggested that the Husserlian analysis of the retentional-protentional structure of experience is a model that also works for the processes involved in motor control (Gallagher, 2011; Gallagher et al., 2017). This structure gives an intrinsic temporality to all motor actions. This is to say that nothing is an affordance if there is a knife-edge present, because at a single present moment, nothing would be afforded, because a temporal window for its realization is needed. If there wasn’t an intrinsic temporality in the actualization of affordances, if there weren’t anticipations in a set of possibilities in the world, we would never be able to perceive affordances.

Intrinsic temporality is something we can find in all the dynamics of bodily movement and action and manifests itself at both the subpersonal and the personal levels of analysis, which we will explain further on.

This intrinsic temporality is not objective time that can be measured by a clock, although action certainly does take place in time, and it may be important in various contexts that its duration can be measured. Phenomenologists distinguish objective time from lived time (e.g., Merleau-Ponty, 1962; Husserl, 1991). The latter is time as we experience it passing, sometimes seeming to pass slowly and sometimes rapidly. Intrinsic temporality includes more than lived or phenomenological time; it includes a temporal structuring that shapes action and experience. (Gallagher et al., 2017, p. 84)

With regard to action and motor control, this intrinsic temporality is expressed in Henry Head’s definition of the body schema. “According to Head, the body schema dynamically organizes sensory-motor feedback such that the final sensation of position is ‘charged with a relation to something that has happened before’ (Head, 1920, p. 606). Merleau-Ponty borrowing Head’s metaphor of a taximeter suggests that movement is organized according to the “time of the body, taximeter time of the corporeal schema” (Merleau-Ponty, 1968, p. 173). Body schematic processes incorporate past moments into the present” (Gallagher et al., 2017, p. 86):

At each successive instant of a movement, the preceding instant is not lost sight of. It is, as it were, folded into the present. Movement draws together, on the basis of one’s present position, the succession of previous positions, which envelop each other. (Merleau-Ponty, 1962, p. 140)

Reaching for an object, for example, involves feed-forward components that allow last-minute adjustments if the object is moved, and the grasp of my reaching hand tacitly anticipates the shape of the object to be grasped. “This is

not blind automaticity since the grasp is shaped according to the specific intentional action involved (see MacKay, 1966; Wolpert et al., 1995; Jeannerod, 2001). Berthoz (2000, p. 25) suggests that anticipation is “an essential characteristic” of motor functioning. Similar anticipations characterize the sensory aspects of perception (see Wilson and Knoblich, 2005 for review) (Gallagher et al., 2017). Since these prospective processes are present generally, even in infants, the “conclusion that [anticipatory processes] are immanent in virtually everything we think or do seems inescapable” (Haith, 1993, p. 237).

Husserl’s model, called the *präsenzzeit*¹, is represented in **Figure 1**. He applied this model to the conscious perception of a melody, but we will claim it can be applied to perception in general. It has three structural aspects: The horizontal line ABC represents a temporal object such as a melody of several notes. The vertical lines represent abstract momentary phases of an enduring act of consciousness.

Figure 1, from Gallagher (1998, 2011), and Gallagher et al. (2017, p. 85).

Each phase is structured by three functions:

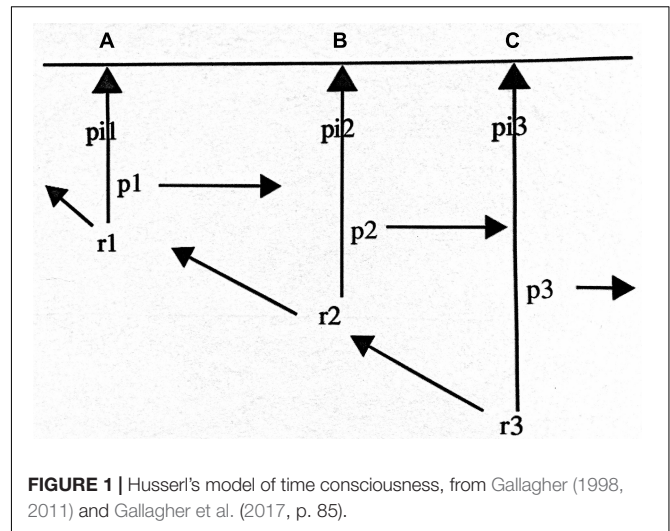
- Primal impression (pi), allowing for the consciousness of an object (a musical note, for example) that is simultaneous with the current phase of consciousness;
- Retention (r), which retains previous phases of consciousness and their intentional content;
- Protention (p), which anticipates experience that is just about to happen.

It is important to say that one could think that Husserl saw consciousness as an internal metaphysical entity, but I think this is a misreading. Let’s consider this: “Consciousness is only as long as it is open to the world; therefore, there is no interiority or exteriority. There is only one intentional fabric that is indissolubly, that of consciousness and the world” (Bech, 2001, p. 54). In his phenomenological tradition, this amounts to saying that consciousness is the experience, the “pure” experience that happens in the perception of the world.

Husserl (1989) argued that to do phenomenology properly, that is, to attend to the experiences themselves leaving all preconceptions aside, one has to bracket questions about the world beyond the experiences, but he is talking about a pre-given world as an objective (scientific) phenomena. This experience (the *umwelt*), of course, cannot be bracketed; what is bracketed are the judgments and reflections about the world. So, we are talking about the same experience, the *umwelt*, that is going to be temporally structured by this *präsenzzeit*. In other words, for Husserl there can only be experience (in the sense just explained) because there is an intrinsic temporal structure that supports it, the *präsenzzeit*.

Although the specific experiential contents of this structure from moment to moment progressively change, at any given moment this three-fold retention-primal impression-protention (RIP) structure is present as a unified whole.

¹According to Gallagher (2013, p. 138) the term simply denotes that “the experiencing (sensing) act of consciousness [is] temporally extended.”



In the current phase, simultaneous with C (in **Figure 1**), there is a retentioning (r3) of the previous phase of experience, and this just-past phase includes its own retentioning of the prior phase. This means that there is a retentional continuum—r3(r2[r1]), and so forth—stretching back over recent prior experience, on the order of seconds. There is also a double intentionality to this retentional aspect. Retention retains the prior phases of consciousness/experience (what Husserl called longitudinal intentionality), but since those phases include primal impressions of the then current notes (B and A, respectively) retention also retains the prior notes of the melody (what Husserl called transverse intentionality), in the sequential order in which we heard them, which generally reflects the order in which they were sounded. Imagine if that were not the case. If there were no retention of previous notes, then we would not hear a melody. Indeed, if our experience were of only one moment at a time without experiential connection to previous moments, it would be impossible to make sense of the world. (Gallagher et al., 2017, pp. 85–86)

Protention, in turn, provides consciousness/experience with an intentional sense that something more will happen. This protentional aspect allows for the experience of surprise. In listening to a familiar melody, there is some sense of what is to come, a primal expectation of the notes to follow. The content of protention is never completely determinate since the future itself is indeterminate. Indeed, in some cases the content of protention may approach the most general sense of “something (without specification) has to happen next” (Gallagher et al., 2017, pp. 85–86).

Summarizing, Husserl’s claim is that dynamism and flow have their origin in the retentional and protentional structure of temporally extended experience/consciousness and it is the relations between retention, primal impression, and protention which constitute the temporality of the flow of experience (Kiverstein and Arstila, 2013, p. 455).

In terms of affordances, to perceive affordances is to experience affordances, there is not a division in perceiving/experiencing, all perception implies an experience that is in itself dynamical and will include different temporal scales in its performance, as we will see in the next section. Putting it bluntly, perception/experiences of affordances also have a temporal flow that originates in the RIP structure.

TEMPORAL SCALES IN THE PERCEPTION AND EXPERIENCE OF AFFORDANCES

Bringing together the last two sections, one can say that experientially, the *umwelt* is given by affordances that “stand out” among the rest of the affordances in a habitat for a particular agent. These attractive or relevant affordances are described as soliciting, or inviting, behavior (Withagen et al., 2012; Rietveld and Kiverstein, 2014). And when this behavior happens, affordances occur in motion and entail an experience with an intrinsic temporality that has a RIP structure.

The soliciting character of these relevant affordances is the experiential equivalent of a bodily “action readiness” on the part of the skilled individual, which entails orientation toward and preparation for possibilities for future action (Rietveld et al., 2018).

Gibson noticed it:

A sequence of external stimuli or, at the very least, the rhythms of the observer's body, provide a flow of change, and it is this we perceive rather than a flow of time as such. (Gibson, 1975, p. 299)

By considering the perceiver acting and moving in an environment, its own motions “span” the entire event. This enables the perceiver to apprehend, as Gibson called it, a sequential structure. “Sequences of events can be apprehended in their entirety as an agent is resonating to the entire motion. Nonetheless, this appropriate responsiveness to the motions of the world, and the apprehension of sequences (especially on large scales of coordination), needs to be learned” (Van Dijk and Withagen, 2016, p. 10). The implication is that affordances are not properties or universals, they are unique for every animal because they emerge within the relationship between the environment and the perceiver, which means that different layouts afford different behaviors for different animals. Also, that affordances are related to movement and action of each agent in her own cadences. This is relevant because it means that Gibson's theory is related to ecological perception on the basis of agency and the actions performed by an agent or animal (Menatti et al., 2016, p. 11).

Action readiness is a form of anticipation: I am ready to do something ahead of me (and I am always aware of what I've done to be in the situation I am in the moment). This of course requires previous experiences. Once an ability is acquired after a history of training, practice and experience

in an environment (Ingold, 2011), the relationship between body and environment is modified. There is a familiarity in the world for the individual, somethings that she is attuned to, and that propitiates a particular *umwelt* for her when certain affordances solicit action. At that moment the level of skill rises to the point where the individual is able to perceive and respond immediately to affordances in this new domain (Rietveld, 2012), so that the intrinsic temporality itself changes with respect to its own as skillful practices develop and sensorimotor schemes responses become faster and faster (we will come back to this in the last section). Furthermore, action and perception of agents with a past full of previous interactions always causes that the environment is never encountered ahistorically. “All acting and perceiving is done in a flow of activity that is continuous for living beings. For us human beings the fields of action, the engagements in which we find ourselves, have both personal and cultural histories. Our subjectivity is dependent on our intersubjectivity. Social activity mediates individual psychology but does so in a manner that is fundamental, not additional [...] the environment in which we human beings live and act is cultural to its core” (McGann, 2014, p. 9).

Adding to the anticipatory temporal window, there's a concept called intentional arc (Merleau-Ponty, 1962) which adds to the readiness of coping skills. The concept of intentional arc situates skills in recursive loops of action, built up over time. Drawing on Merleau-Ponty, Dreyfus defines the intentional arc as “the way our successful coping continually enriches the way things in the world show up” (Dreyfus, 2014, p. 107). In other words, the intentional arc is a “feedback loop in which our actions and projections are drawn out of us by the meaningful features of the world and, in turn, alter the way the world shows up as soliciting us.” In short, the intentional arc shows a relationship between meaningful appearances in the environment and their performance as achieved through practice and repetition. Here is where we are borrowing a concept from Husserl to suggest that perception of affordances have a “retentional” character, that is, they do not merely guide future activity but are also shaped by a history of interactions stored in sensorimotor schemes from previous performances.

Perception based on coordinated motions radically changes the way the agent relates to the environment (Van Dijk and Withagen, 2016, p. 11). As Gibson also noticed, the perception of affordances seemed to have a distinctive temporal quality as well: “The feeling of past, present and future are merged or, more exactly, the activity of perception is acknowledged to be retrospective and prospective” (Gibson, 1975, p. 300). Gibson suggested that the perception of affordances in the environment includes a non-successive experience of time; being of the present, but also being understood only in terms of the agent's perceptual experiences (*umwelt*) and the action possibilities

²It is important to notice here that the retrospective and prospective character of affordances noticed by Gibson can now be retentional and protentional, borrowing Husserl's terminology. This can be done as I have showed that experience happens as perception does, and perception is of affordances. Experience does not belong to a metaphysical realm, but to perception itself.

still open to it in the habitat. In other words, the concept of affordances makes reference to both the agent's "past" abilities as well as to its "future" possibilities. Accordingly, what is inescapable, for human experience and action is not just the anticipatory aspect, but the full intrinsic temporality of the processes involved. A good model for this experiential part of affordances is the Husserlian analysis of the RIP structure of experience as Berthoz (2000) suggests, and as we saw in the last section, but we need a specific temporal scales proposal to analyze them from different angle, which will come in the next section.

Now, as we saw in section two, affordances can be seen as objective in the habitat or subjective as the *umwelt* for an agent, depending on the level of description. The *umwelt* is not stable either; it changes by the history of structural coupling the individual goes through in her ontogeny, as she goes actualizing affordances. In what follows, we will characterize the temporal scales that the *umwelt* (experiential affordances for a particular agent) has, claiming that the temporal integration of what constitutes the perception of affordances, offers a bridge to reconcile the "enactive" and the "ecological" descriptions of the agent-environment system in action.

Scales for the Perception and Learning of Affordances

A number of theorists have proposed to capture the subpersonal processes that would instantiate this Husserlian structure shown in **Figure 1** by using a dynamical systems approach (Van Gelder and Port, 1995; Varela, 1999; Thompson, 2007). On this view, action and our consciousness/experience of action arise through the concurrent participation of distributed regions of the brain and their sensorimotor embodiment which are established in three scales (Varela, 1999), the first two which are said to be directly relevant to protentional-retentional processes (Gallagher, 2013, p. 125; Gallagher, 2017a, p. 8):

- (1) the *elementary* scale (the 1/10 scale varying between 10 and 100 ms): intrinsic cellular rhythms,
- (2) the *integration* scale (the 1 scale, varying from 0.5 to 3 s): neuronal processes,
- (3) the *narrative* scale involving memory (the 10 scale, more than 3 s).

To account for processes, enactivists appeal to the ideas of a dynamical system and diachronic constitution (Kirchhoff, 2015). Brain, body, and environment are said to be dynamically coupled in a way that forms a system, and the coupling is not equivalent to identity of material parts; rather it involves physical relational processes. Significant changes in one part of the system will cause changes or adjustments in the other parts. For the enactivists just these dynamical causal relations constitute the system. Because these processes occur on several timescales, it is helpful to introduce this three-fold distinction in temporal and dynamical registers.

It is important to note that as Beaton (2013, p. 300), when Varela says neural mechanisms, he means it: he supposes that it is the goings on in the brain that will directly correspond to the

details of attention disclosed via phenomenology. And here we want to claim that these three temporal scales are all intertwined within the environmental constitutional situation that is involved in the particular embodied perception/experience of affordances. In other words, in the integration and in the narrative scale, the neuronal/sensorimotor processes are diachronically constituted by the dynamically coupled brain, body, and environment system; and this happens via the perception of affordances.

Through the integration and synchronization of the scales is that the perception of affordances are processed almost momentarily: there are aggregates formed that are impossible to comprehend but become complete sensorimotor schemes in the 1 scale: neuronal processes are integrated, which, at the neurophysiological level, involves the integration of cell assemblies all through the body. Phenomenologically, the integrative scale corresponds to the experienced living present (the *umwelt*), the level of a fully constituted cognitive operation; motorically, it corresponds to a basic action, for example, reaching, grasping, and as we saw in the previous section, it can also be characterized by the RIP structure.

Furthermore, from the enactive and the ecological perspective, perception of affordances is temporally extended, because differences in temporal scales are constitutive of sensorimotor enactive dynamics, and sensorimotor enactive dynamics are constitutive of the perception of affordances, hence perception of affordances is intrinsically temporal. And the three-fold distinction made by Varela is helpful for thinking how the two approaches can fit together. Thus, perception of affordances is constituted by the integration of the 2 first scales, and the experience of it has a RIP structure.

The time to complete the perception of affordances is not dependent on a fixed integration period as measured by a clock, it is dependent dynamically on the number and arrangement of cells assemblies that are contributing at that time in relation with the affordances that the subject is interacting with in a given coordination with the environment. That is why the integration scale is flexible, depending on the number of elements in the context and also with the corporal state and age, previous experiences, among others. On an enactivist interpretation, the primal impression is not the origin and point of departure but the "boundary" between retention and protention or the result of a dynamical interplay between retention and protention. The *umwelt* then is not simply a passive reception of the present; it enacts the present, it constitutes its meaning in the shadow of what has just been experienced (retention), and in the light of what it anticipates (protention) for a particular agent (Gallagher et al., 2017, p. 89).

In the case of action, the intrinsic temporality of the perception of affordances should be considered as pragmatically directed toward the meaningful possibilities the agent sees in the world. This lines up well with Husserl's conception of embodied experience as an anticipatory "I can" which draws on my prior experience and my current state. As Husserl puts it, "every living is living toward." This anticipatory intentionality is an apprehension of the

possibilities or the affordances in the present. (Gallagher et al., 2017, p. 89)

The RIP structure is an account of how experience is constituted at the integrative scale from the perception of affordances: at the integrative scale, affordances are experienced as solicitations.

Summarizing until now, we can say that perception of affordances is constituted by the abilities and characteristics of the environment as relations that occur with an intrinsic temporality that is related to different temporal scales interconnected between them. This constitution is important because perception of affordances is then temporally extended and therefore can be characterized by the three-fold scale structure proposed by Varela. The two first scales are constitutive of the perception affordances whenever they are actualized and therefore whenever they bear an *umwelt* for the agent. But what about the third scale? We will now go into it.

The conception of affordances 2.0 is actually intended to provide a way of talking about affordances while acknowledging the fact that individual organisms learn:

The variety of niche construction sketched in Affordances 2.0 is an equally tightly coupled animal–environment system. It differs from the much-discussed biological case in two ways. First, the constructed niche is for an individual organism, not for a population. Second, it occurs over shorter time scales—an animal’s activities alter the world as the animal experiences it, and these alterations to the phenomenological-cognitive-behavioral niche, in turn, affect the animal’s behavior and the development of its abilities to perceive and act, which further alter the phenomenological-cognitive-behavioral niche, and on and on. Affordances 2.0, therefore, emphasizes the connections between radical embodied cognitive science and its natural allies in biology, that is, developmental systems and niche construction. (Chemero, 2009, p. 152)

Here, we are introducing *learning of affordances*, which go in the third temporal scale, the narrative one, in the explanation we are proposing. I want to maintain that perception (or perceptual experience) occurs at the integrative scale, and that what occurs at the narrative scale is different from perception (it is learning). This goes in line with Jacobs and Michaels (2007, p. 246) proposal that there is a short time scale of perceiving and acting and a longer time scale of learning, and here we propose that this timescale is the narrative scale in the three-fold distinction proposed by Varela. At this narrative scale, the affordances are seen as potentialities in the habitat (dispositions) in particular niches and become *umwelts* when they are actually perceived. There is a lot to say about learning, of course, but that is material for another paper. For the present purposes, perceptual learning can be defined as involving the increased ability to detect relevant affordances as the result of novel experience, as action capabilities change, and thereby affordances themselves change (Szokolszky et al., 2019, p. 8).

As I can see, these temporal scales can be a useful toolkit for explaining the perception and learning of affordances and at the same time unifying enactivism and ecological psychology claiming that affordances serve a different explanatory role depending on which time scale you consider them at. If you are interested in explaining the embodied assemblies that form the always changing sensorimotor contingencies, then you see the elementary scale. If you’re interested in explaining perception at the integrative scale, then affordances are solicitations. If you are interested in explaining change in the animal–environment system over developmental time, that is, learning time, then affordances are around what Chemero said they were when he proposed Affordances 2.0 and one should see at the narrative scale. But it is important to say that the three scales are always intertwined because learning and perception are ongoing processes that in many senses are impossible to separate.

Concluding, ecological psychologists can explain how the detection of perceptual information leads to the perception of particular affordances at the integrative scale, while the enactivist theory of sensorimotor agency can explain how an individual “selects” among perceived affordances in an embodied and situated way, according to her past experiences and learnings as a body–environment system (combining the elementary and narrative scales). As Baggs and Chemero say: “The ecological account of external structure is compatible with the enactivist account of the internal organization of the animal. Life happens in the dialectical confrontation of the two” (Baggs and Chemero, 2018, p. 14).

SCALE MATTERS

Living in an environment makes us adapt to the temporal structure of events (seen as the change in the layout of affordances, Chemero, 2000) or to the intrinsic timing of them that allow us (or not) to coordinate with certain affordances in a particular habitat. We could say from the last section that that both ecological psychologists and enactivists conceive of cognition as being inherently temporally extended and Varela’s three-fold distinction provides a useful toolkit for thinking about how the two approaches can fit together. Let’s expand on this.

In radical embodied science cognition needs to be understood in terms of the organism–environment system. On a dynamical systems interpretation, neuronal-level events on the elementary scale synchronize (by phase-locking) and form aggregates (the sensorimotor contingencies) that manifest themselves as incompressible but complete acts on the integrative scale (the solicitation of affordances). The narrative scale is meant to capture longer time periods that scale to complex actions and cognitive processes that may involve recollection, planning, intention formation, and so on, particularly, that scale could be understood in terms of learning. So, temporal scales matter because affordances serve a different explanatory role depending on which time scale you consider them at.

On the standard notion of synchronic constitution, subpersonal elementary scale neuronal processes constitute mental representational contentful processes that somehow scale up to experiences. All of the other factors (environmental, bodily, social, etc.) are causal but not constitutive. But in radical embodied cognitive science, mainly in enactivism and in ecological psychology, environment is constitutive because the constitution is diachronic, the temporal scales in which perception of affordances occur are relevant because that is what explains that cognition occurs as a system (agent-environment) and not only in the elementary scale, as cognitivism would claim. In other words, intentional action takes time, it begins and ends, and takes some duration in between. The temporal frame may vary (depending on the affordances performed) but they include all the environment-agent system and the three scales discussed above integrated and intertwined.

As Corris and Chemero say:

what exactly is the relationship between the fast and small events and the slow and large events? In both cases, the relationship must be such that events at the elementary scale are constitutive of events at integrative and narrative scales, but are also (in part at least) controlled by events at the integrative and narrative scales [...] How are temporally extended events at the integrative and narrative scale able to influence the elementary-scale events that they are constituted by? How does recognizing an attractive lizard lead to the neural and muscular events involved in trying to catch it? (Corris and Chemero, 2019, p. 5)

Conceptualizing the structure of temporality of the perception of affordances serves to understand how this whole temporal window (the integration of the three temporal scales), which corresponds to the actual perception and learning of affordance(s) can be seen as a whole, and for epistemological reasons divided in temporal scales. Consequently, it might make sense to say that the entire organism-environment system retains changes in its structure as a result of the organism's learning of sensorimotor contingencies that in turn give rise to (i) an explicit temporal perceptual experience given in terms of the perception of events, which are changes in the disposition of the potentialities of the world for different interactions with the agent (what Gibson, 1979, p. 12 called the ecological scale) and (ii) an implicit temporal perceptual experience in the sense of a coordinated activity of a specific type with a characteristic timescale (constitutive of sensorimotor schemes dynamics, the integrative scale). In other words, sensorimotor enactivism and ecological psychology can be understood complementarily in different temporal scales of the perception of affordances: the scale of the sensorimotor schemes dynamics and the scales of the solicitations of affordances.

In the terms of the proposal of Heras-Escribano (2019), this amounts to two levels of description of the interaction between a cognitive agent and her environment. These levels are also conflated to establish a bridge between enactivism

and ecological psychology. For Heras-Escribano, level 1 is the subpersonal level of networked systems that give rise to agency and enable behavior which comprises the relevant changes in the neurological, physiological, and chemical networks of the agent's body. Level two, the personal level of analysis, refers to the organism-environment system that establishes a dynamical coupling thanks to ecological information, that is, through the available affordances. Level two would then be at the ecological scale, the scale about behavior: it explains how agents meaningfully interact with their environments (Heras-Escribano, 2016, p. 311). These two levels are not temporally separated, but mutually and simultaneously influence each other: "the perception of affordances may influence the patterning of habits due to [mastering] changes in sensorimotor contingencies and, at the same time, different sensorimotor contingencies may alter the movements that result from perceiving affordances" (Heras-Escribano, 2019, p. 26).

But here I would disagree in the conception that affordances are seen at the ecological scale and "influence the changes in sensorimotor contingencies," because as I see it affordances are constituted by abilities (which are sensorimotor contingencies that get mastered and can change over time) and certain features of the environment. That is, they are relational and diachronically constituted by the scales we discussed before. Affordances as dispositions, which is implied in Heras-Escribano's levels, would only make sense if talking about the habitat for a species, but not for the actualization of perceived affordances for an individual, which would, as we have seen, involve an experience, the *umwelt*, and that allows to explain why some affordances solicit to some agents and not to others. So, the disagreement would be to understand the levels as separated, because as we have explained, differences in temporal scales are constitutive (not causal) of sensorimotor dynamics, and sensorimotor dynamics are constitutive of the perception of affordances.

Furthermore, as far as we can tell all enactivists are committed to granting a special status to the given *umwelt* and oppose the idea of perception as recovering a "pre-given" world (see, e.g., Varela et al., 1991; Thompson, 2007; Gallagher and Zahavi, 2012; Di Paolo et al., 2017; Gallagher, 2017a). So that the *umwelt* needs to be incorporated in the perception of affordances, we say it does through the temporal scales: the parameters of the sensorimotor system and the environment constrain each other in a dynamic, closed, and self-organized way, that is, they form autonomous and dynamic sensorimotor loops. These loops are called sensorimotor schemes and include all body and environmental structures that allow us to perceive affordances and execute a specific action.

Now, going back to Corris and Chemero's question cited above, I would agree with them that synergies are a good and audacious answer to understand the relationship between the narrative scale and the elementary and the integrative. The basic idea is that the actualization of the affordance is what guides the processes in the first two scales, meaning that the causation would be macro-to-micro, and not otherwise: "if a behaving human is a synergy at the narrative scale, then the neural processes that partly

compose that synergy are constrained by the behavior” (Corris and Chemero, 2019, p. 7). And this behavior is given through affordances. Van Orden et al. (2012) call it the “blue collar brain,” which claims that rather than being the executive in charge of the body, the brain does what is required by the activities of the embodied person. Synergies understood as “a functional grouping of structural elements (molecules, genes, neurons, muscles, etc.) which, together with their supporting metabolic networks, are temporarily constrained to act as a single coherent unit” (Kelso, 2009, p. 83), and there is empirical evidence that there are also human-tool synergies and interpersonal synergies (Dotov et al., 2010, 2017).

So, affordances would be synergies that are temporarily constituted as a whole in the different temporal scales we have developed here, with a recurrent RIP structure in the experience scales (the integrative). “Synergies self-organize apace with the flow of context and behavior. This is sufficient to update ongoing constraints that anticipate the requirements for oncoming behavior. Invariant or smoothly changing aspects of the world yield invariant or smoothly changing constraints at a pace that is slower than brain dynamics. These constraints inform behavior by limiting the degrees of freedom about what can happen next, leaving open the possible kinematic changes that the body may enact in behavior” (Van Orden et al., 2012, p. 9). Finally, affordances should be characterized in terms of dynamical agent-environment systems, with abilities and aspects of the environment understood as constraints on the potential trajectories of such systems. Affordances, then, can be conceived as possible states of agent-environment systems, or as particular locations within the overall state space of these systems.

CONCLUSION

Radical embodied cognitive science, mainly sensorimotor enactivism and ecological psychology, share many stands. But they also have many tensions. There are many resolutions of these issues, one of them, I suggest, involves taking the temporal dimension of affordances seriously, particularly in terms of interaction across multiple temporal scales. We characterized its intrinsic temporal structure borrowing the husserlian RIP *präsenzzeit* for the experience of the perception of affordances. Also, taking affordances as relations between abilities and features of the environment (affordances 2.0) we developed the temporality of the perception of them using Varelas’ three-fold model and Gallagher’s later use of it, but focusing on the dynamics of the agents’ embodied action, meaning to include the environment as a constitutive part of cognition genuinely. Behavior through affordances bears an experience with an intrinsic temporality that has a RIP structure.

I appealed to unify enactive and ecological approaches to cognitive science by emphasizing the fact that both approaches view cognitive processes as being inherently temporally extended, and my hypothesis is that characterizing the temporal scales in which perception of affordances occur, they can serve different purposes of explanation within the theories. The central claim of the present paper is that affordances should be understood

in terms of these three different timescales. I showed that these temporal scales can be a useful toolkit for explaining the perception and learning of affordances and at the same time unifying enactivism and ecological psychology claiming that affordances serve a different explanatory role depending on which time scale you consider them at. For this, I think that perception of affordances should be characterized in terms of dynamical agent-environment systems, with abilities and aspects of the environment (affordances 2.0) understood as constraints on the potential trajectories of such systems. These constraints or parameters are themselves modifiable over time, in terms of both the development of abilities and the shaping and informing of the material world. Abilities and situations in the environment (affordances 2.0) are not the same the first time one engages with it than the second, third time, etc. This has as a consequence that the repetition of the perception of affordances has an impact on the other temporal scales, mostly because of neuronal facilitation and plasticity in the sensorimotor schemes: when one masters an ability, the sensorimotor scheme occurs faster (in the elementary and integrative scales) than the first times one performed it. Likewise, in the narrative scale the tempos move, because expectancy and anticipation are transformed (one already expects what will happen and knows the *umwelt* about it).

Finally, sensorimotor enactivism and ecological psychology can be used as complementary explanations through the scales of the perception of affordances: while ecological psychology focuses on explaining the dynamics at the level of the organism-environment system (the ecological gibbonian scale, the narrative and integration temporal scales), sensorimotor enactivism focuses on explaining the dynamics at the intra-organismic level (the elementary and integrative scales). But, remarking it again, the three temporal scales constitute the perception of affordance(s), where the scales are always integrated and intertwined. Likewise, these temporal scales can be a useful toolkit for explaining the perception and learning of affordances and at the same time unifying enactivism and ecological psychology claiming that affordances serve a different explanatory role depending on which time scale you consider them at. If you are interested in explaining the embodied assemblies that form the always changing sensorimotor contingencies, then you see the elementary scale. If you’re interested in explaining perception at the integrative scale, then affordances are solicitations. If you are interested in explaining change in the animal-environment system over developmental time, that is, learning time, then affordances are around what Chemero said they were when he proposed Affordances 2.0 and one should see at the narrative scale. But it is always important to say that the three scales are always intertwined because learning and perception are ongoing processes that in many senses are impossible to separate.

This also has a consequence that ecological psychology can explain how the detection of information in a habitat leads to the perception of particular affordances for a particular species, meanwhile the enactivist theory of sensorimotor agency can account for variations in perception-action of affordances at the level of the individual organism, explaining how certain affordances get a soliciting character because of previous

experiences and through the particularities of the sensorimotor schemes dynamics which permit them to actualize. This is because perception brings forth an experience, so it might make sense to say that the entire organism-environment system retains changes in its structure as a result of the organism's learning of sensorimotor contingencies that in turn give rise to (i) an explicit perceptual experience given in terms of the perception of events, which are changes in the disposition of the potentialities of the world for different interactions with the agent (the ecological scale) and (ii) an implicit perceptual experience in the sense of a coordinated activity of a specific type with a characteristic timescale (constitutive of sensorimotor schemes dynamics). In other words, sensorimotor enactivism and ecological psychology can be used as complementary explanations for different temporal scales in the perception of affordances.

Describing cognitive processes as being constituted in this temporally integrated dynamic system could also be very helpful in explaining more precisely the relationship between cognition and action with the toolkit of the temporal scales. Practically, I think this way of thinking could promote research that systematically varies a hierarchy of time scaled contexts, both for ecological psychology and for sensorimotor enactivism.

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Multiscalar Temporality in Human Behaviour: A Case Study of Constraint Interdependence in Psychotherapy

Juan M. Loaiza^{1*}, Sarah B. Trasmundi² and Sune V. Steffensen^{2,3,4,5}

¹ Independent Scholar, Colombia, United Kingdom, ² Centre for Human Interactivity, Department of Language and Communication, University of Southern Denmark, Odense, Denmark, ³ Danish Institute for Advanced Study, Odense, Denmark, ⁴ Center for Ecolinguistics, South China Agricultural University, Guangzhou, China, ⁵ College of International Studies, Southwest University, Chongqing, China

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*Correspondence:

Juan M. Loaiza
juan.loaizare@gmail.com

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Ecological psychology (EP) and the enactive approach (EA) may benefit from a more focused view of lived temporality and the underlying temporal multiscalar nature of human living. We propose multiscalar temporality (MT) as a framework that complements EP and EA, and moves beyond their current conceptualisation of timescales and inter-scale relationships in organism-environment dynamical systems. MT brings into focus the wide ranging and meshwork-like interdependencies at play in human living and the questions concerning how agents are intimately entangled in such meshworks, utilising them as resources for skilful living. We develop a conceptual toolkit that highlights temporality: Firstly, we address lived temporality. We use a case study from psychotherapy to show how a person's skilful engagement with the world is best described as adaptive harnessing of interdependencies of constraints residing across a wide range of timescales. We call this skill time-ranging. Secondly, the case study provides a proof of concept of the integration of an idiographic approach to human conversing and a more general theory of emergent organisation rooted in theoretical biology. We introduce the existing concept of constraint closure from theoretical biology and scale it up to human interactivity. The detailed conceptualisation of constraint interdependencies constitutes the backbone of the proposal. Thirdly, we present a heuristic mapping of what we call organising frames. The mapping guides the conceptualisation of the emergence of inter-scale relationships and serves as an epistemic tool that brings together nomothetic and idiographic approaches. Finally, we combine new ideas with re-interpretations of existing EP and EA concepts and elaborate on the need of a fresh new look at the implicit and sometimes missing conceptualisations of temporality in the EP and EA literature.

Keywords: time scale, temporality, constraint closure, psychotherapy, enactive approach, ecological psychology, distributed language, cognitive ethnography

INTRODUCTION: ENVIRONMENTS, BODIES, AND TEMPORALITIES

We present a conceptual model of multiscalar temporality (MT), which brings a more nuanced understanding of the temporal dynamics of human living and a richer interpretational frame for both ecological psychology and the enactive approach (hereafter EP and EA, respectively). The model integrates work on temporality from a distributed language perspective (Steffensen and Pedersen, 2014; Uryu et al., 2014; Cowley and Steffensen, 2015) with a view of biological organisation based on the notion of constraint closure (Montévil and Mossio, 2015; Moreno and Mossio, 2015).

We propose that EP and EA may benefit from a more focused formulation of MT. Our proposal constitutes a third perspective in which EP and EA may find some of their commonalities as well as divergences expressed in a new way.

Whereas our proposal highlights the varieties of *temporalities*, EP and EA focus on varieties of *environments* and varieties of *bodies*, respectively. On the one hand, EP, especially in its radical embodied version (Chemero, 2009) together with the skilled intentionality framework (Rietveld and Kiverstein, 2014) provide a more nuanced view of ecological information¹ that we interpret as an account of the varieties of environments or, more precisely, varieties of ecological information (Bruineberg et al., 2018; Baggs and Chemero, 2019; see also Heft, 2001; Heras-Escribano, 2020). On the other hand, a recent development in EA upgrades the discussion of autonomy and individuation to what Di Paolo calls a “theory of human bodies” (Di Paolo, 2020). EA seeks to substantiate the hypothesis of the continuity of mind and life (Thompson, 2007). According to EA, the continuity consists of the individuation of bodies at various levels – metabolic, sensorimotor, inter-subjective, and linguistic – by virtue of the dialectics between the openness that maximises self-production and the closeness that maximises self-distinction. The idea of a variety of bodies finds its most explicit elaboration in Di Paolo et al. (2018).

The third perspective complements and brings forth some of the missing links between EP and EA, yet it is rooted in a different ground. It is neither based on the preoccupation with ecological information (EP), nor on the question of the individuality of cognitive agents (EA). Instead MT is about the wide ranging and *meshwork-like interdependencies* at play in human living and the questions concerning how agents both are intimately entangled in such meshworks and utilise them as resources for skilful living.

Nevertheless, across the three perspectives we identify a common effort to understand the place of lived experience within relational views of mind and cognition that do justice to essential interdependencies beyond the individual agent. Our starting point is an account of *lived temporality*. We use a case study from psychotherapy to show how a person’s skilful engagement with the world is best described as adaptive harnessing of

interdependencies of processes and constraints across a wide range of timescales. The patient in our psychotherapy case study (pseudonymised as “Alice”) experiences a complex here-and-now characterised by an entanglement of fast changes of vocal gesturing, sudden emotional changes and distorted proprioception, together with recurrent negative narratives about herself, and the persistent conflicting relationships with her spouse and parents, the latter characterised by cycles of abuse and neglect. Alice’s experienced tensions in the present, we suggest, can only be understood in the light of a deeper view of interdependencies beyond here-and-now.

Crucially, we show how, as the conversation progresses along several sessions of psychotherapy, the therapist picks up important correspondences between the fast timescales of Alice’s vocal gesturing and the emotional effects of slow timescales of family relationships. Guided by the therapist, Alice is exposed to the tacit interdependencies that permeate the painful tensions experienced in conversation. By doing so, she expands her own capacity to modulate and eventually improve the grip on everyday life situations. We suggest that with the skilful intervention of psychotherapists, patients may develop more flexible and adaptive ways of harnessing and meshing processes and constraints at multiple timescales.

The case study provides a proof of concept of the integration of an idiographic approach to human conversing and a more general theory of emergent biological organisation. As a generic example, the case study is used across sections “From Lived Temporality to Mapping Interdependencies” and “The Backbone: Constraint Interdependence”, demonstrating different aspects of the general framework we propose.

We elaborate on two main themes combining new ideas with re-interpretations of existing EP and EA concepts. Firstly, we address how persons bring forth *lived temporality* as a matter of skilful navigation in a temporally deep present. We unpack the view that persons align and position themselves with respect to multiscalar temporal phenomena – for example, biological cycles, cycles of ritual and social life, and personal relationships. In doing so, we claim, persons maintain the coherence of their lived here-and-now. In section “From Lived Temporality to Mapping Interdependencies”, we introduce the notion of *time-ranging* to account for skilful intentionality,² a concept that highlights the richness of lived temporality. Secondly, we address the nature of the temporal entanglement itself by elaborating on the theme of *organisational interdependence*.³ We map the actual networks of constraints at play in human real-life situations. To this aim, we use a coarse-grained heuristic distinction of various *organising frames* each with a characteristic temporal depth. The mapping serves initially as an epistemic tool, bringing

¹ An important difference with classic EP is the more liberal take on the notion of affordance. In Bruineberg et al. (2018, p. 6): “the overwhelming majority of affordances available in the human social relations are not lawfully specified by the energy in the environment, but are determined by conventions, customs, practices, or other regularities”.

² Although the current framing of time-ranging incorporates some of the phenomenological insights of the “skilled intentionality framework”, as elaborated by Bruineberg and Rietveld (2014), the original introduction of time-ranging in Cowley and Steffensen (2015) does not rely on those insights. Instead, the original version brings elements from the interactivity and distributed language literature.

³ Elements of the two themes are familiar to the reader with a background in EP and/or EA. The characterisation itself of two themes, one experiential and the other organisational re-elaborates EA’s dual phenomenological and operational perspectives. We signal the appropriate links with existing EP and EA ideas along the text and summarise the connections in the discussion.

together nomothetic and idiographic approaches. In section “The Backbone: Constraint Interdependence” we elaborate a fine-grained account of inter-timescale dependencies with a more precise use of the *constraint closure* notation.

In section “Time-Ranging in Psychotherapy: An Ethnographic Investigation”, we return to a fully expanded account of Alice’s case and show how the lens of MT gives us a principled way of understanding the dynamics of human interaction. We demonstrate the applicative perspectives and integrative potential of our model of MT.

Finally, in section “Discussion”, we use these insights to reconsider the relation of our proposal with EP and EA, and conclude that a new third perspective can complement those approaches while addressing their conceptual obscurity with respect to human temporality.

FROM LIVED TEMPORALITY TO MAPPING INTERDEPENDENCIES

Time-Ranging Phenomena and Skill

We introduce two complementary terms: *temporal range* and *time-ranging* (Cowley and Steffensen, 2015). Temporal range, in contrast to the more common notion of timescale, captures the range of processes spreading across multiple spatiotemporal scales. A relevant range of timescales must satisfactorily describe a domain of interdependence of some processes and constraints. In our case study, we observe that Alice’s utterances are not so much serial events occurring in a single conversational timescale against the background of some generic or fixed sociolinguistic context. Instead, each of Alice’s vocal gestures presents wide configurations of connections between various converging events. A sudden rise in speech rate during therapy may reveal itself to be connected with the current affective state of the relationship with Alice’s mother, a relationship that stands as a living legacy of childhood neglect. The therapeutic conversation, we argue, is shaped by the widening and narrowing of temporal ranges related to multiple events in Alice’s life.

Time-ranging refers to the performative aspect of managing [i.e., (re-) entangling/disentangling] temporal ranges. Theoretically, it corresponds to the ability to modulate temporal ranges in ways that grant a unique degree of adaptive behaviour when managed skilfully. In everyday life,⁴ persons imbued in their various life-projects rely on time-ranging when exploring past experiences, projecting future activities, and further exploiting sociocultural norms and habits to reduce tensions and improve their experiential grip on the “thick here-and-now”⁵. Persons use utterances and navigate interpersonal coordination in ways that swiftly switch their attention between earlier events and latent projects in a wide trans-situational range (cf. Linell, 2009). Consider for example the social practice of

performing non-contemporary music based on music scores. One could see the musical score as a code that dictates the minute movements of the musicians, so that the musicians’ only task is to create a one-to-one conversion of the sheet into an audible format. However, as musicians and audiences are well aware, no two performances are alike. Any performance is a complex social event, and the score is only one constraining element in this event (Loaiza, 2016). To exemplify, consider how a choir performs Allegri’s piece, *Miserere mei, Deus* (ca. 1630), based on one of the biblical psalms.⁶ The skilful performance does not only depend on their ability to coordinate their vocalisations to perform the music, and it does not only depend on their attuning their vocalisations to the coded information in the musical score. Rather, they enact a thick here-and-now that solicits many temporally spread resources. Beyond the vocalists’ here-and-now situated behaviour and Allegri’s score, these resources include slow changing constraints pertaining to the social institution of Church music, and Psalm 51 in the Christian canon, as well as the musical enskilment that the singers have acquired through their training and experience. Somewhere in between these timescales, one finds professional knowledge about various ornamentation techniques in Renaissance polyphony, such as the so-called *abbellimenti*. Thus, years, decades, centuries, and millennia are enfolded within the duration of the piece. Accordingly, the conductor and the choir can meaningfully mould their performance depending on different interpretations of the text, the music, the composer’s intentions, the traditions involved, and even the location of the musical performance. In doing so, they enact their present through multiple temporal ranges, and they give weight to the one or the other of these ranges. In short, they act as *time-rangers*.

As a form of skilful and habitual intentionality, time-ranging is also susceptible to impoverishment. Such an impoverishment comes to the fore in psychopathology, which may be understood as a form of time-ranging where a person cannot escape the affective matrices of past experiences, so that sedimented emotions dominate their present behaviour. In Modell’s (2003, p. 40) succinct formulation, the past invades the present.

Psychotherapy serves as a good case for demonstrating the function and importance of developing time-ranging skills. Time-ranging, when managed successfully, enables personal development, emotional self-regulation, flexible embodied enskilment, and self-reflexivity.⁷ Human living is constrained by multiple temporal ranges, and psychotherapy is an activity where patients are given the opportunity to renew their sensitivity to the interdependencies of processes and constraints within some of those ranges. In psychotherapy, recent events in the patient’s life are explored in relation to how memories and legacies from the patient’s childhood and adolescence become persistently re-enacted in the ecology of personal relationships and narratives.⁸ In our case study, by exploring how Alice’s

⁴Trasmundi and Steffensen (2016) discuss one such example where an emergency medical team orients to habitual solutions in order to decide on the future line of action *vis-à-vis* a patient.

⁵An expression used by EA theorists to describe the historicity of agents (Buhrmann et al., 2013, p. 13).

⁶The example is taken from Cowley and Steffensen (2015, p. 478).

⁷See an EA approach to reflexivity in de Haan (2020).

⁸There is a rich embodied cognition and EA body of literature that emphasises the importance of phenomenal temporality in psychotherapy (e.g., Kyselo and Tschacher, 2015; Tschacher et al., 2015a,b; Fuchs, 2018). For instance, Fuchs (2018) argues that linear time is a result of measurements of physical events,

situated behaviour and emotions relate to past, present, and future events – involving a history with traumatic events, impaired interpersonal relationships, and inability to control emotional reactions – Alice is encouraged to develop a repertoire of reflexivity pertaining to her lived experience (we fully unpack the case study in section “Time-Ranging in Psychotherapy: An Ethnographic Investigation”). The goal of psychotherapy is thus to develop a richer cognitive-emotional repertoire that allows for more flexible, adaptive, and reflexive agency in challenging situations.

How Do We Map an Entangled Whole?

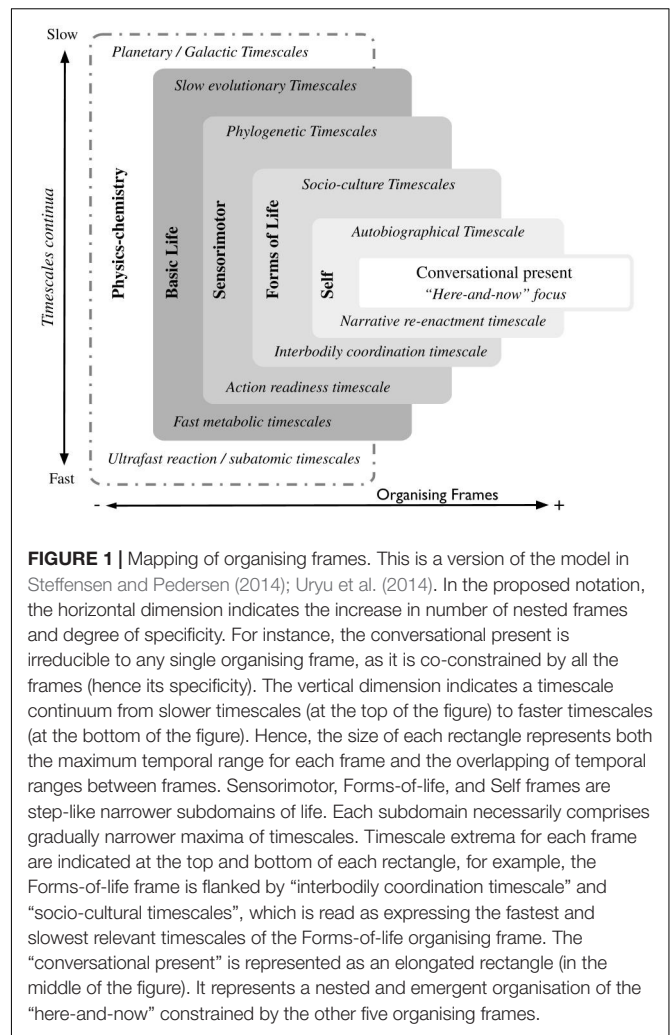
In the process of psychotherapy, we examine the interplay between temporal ranges pertaining to Alice’s self-narrative, the sociality of an interpersonal relation that maintains a legacy of childhood experiences, the therapist’s own expertise as a time-ranger – sedimented through participation in institutional practices – and the basic commonalities of the two individuals’ sensorimotor coupling in conversation. Given this entangled whole, a crucial empirical question remains: how do we map such complex multiscalar interdependencies? Or more specifically, how can we, for example, distinguish between the tight links of Alice’s vocal gesture, mood, and current family situation, and the more generic dynamics of two adult humans coordinating interaction in conversation, without severing interdependencies or reducing the phenomena to narrow and thus uninformative timescales?

Following a previous model by Steffensen and Pedersen (2014)⁹, we propose a map (**Figure 1**) that represents a general logic of emergence of (sub)domains of activity that we call *organising frames*.

In the map, smaller frames represent sets of narrower temporal ranges emerging from larger, temporally wider frames. Similar to a cartographic map, its logic is generalisable, but the content of the map, in this case the particular themes of the progression from wider to narrower frames, corresponds to particular research interests. Each frame allows us to make an approximation to a variety of possible boundaries of the interdependencies at play, in our case study, in conversations. Using Alice’s therapy sessions as a template, the map represents the emergence of a focal frame of “conversational present” in which psychotherapy plays out. The conversational present is enabled and emerges from a frame of Self (Alice’s self-narratives), itself emerging from Forms-of-life (Alice’s social life and relationships), Sensorimotor frame (Alice’s bodily habits with respect to an environment), Basic life (metabolic processes with respect to evolutionary trajectories), and finally from a general frame of Physics-chemistry.

whereas temporality of life emerges as cyclical processes that often manifest in subjective whole-bodied experiences. He argues, in line with our approach, that such manifestations are the result of an experience that is being re-enacted again and again. However, while Fuchs – and colleagues – emphasise lived time, or the temporality of the body, our approach extends this view by providing a model that traces temporality to multiple temporal ranges that constrain personal development. See also Enfield, 2014.

⁹The logic of the map is based on “specification hierarchy” (Salthe, 1991).



The map allows us to make important empirical distinctions, for example, allowing us to render the links between Alice’s vocal gesture, mood, and current family situation under the forms-of-life and Self frames, and the dynamics of two adults coordinating interaction in conversation under a more generic sensorimotor frame. Thus, as a heuristic, the map allows us to draw particular temporal ranges of interdependent processes and constraints, and move our focus between frames in a manner that best suits the nature of the phenomena under scrutiny: we can move to the left of the map, for example, to make considerations only with regards to the statistical regularities of human bodies in a species-specific ecological niche. Alternatively, one can move to the right of the map to investigate the (re)-organisation of interdependent processes and constraints at the level of particular persons or specific activities, such as Alice’s conversation with the therapist. In this way, the mapping strikes a balance between nomothetic and idiographic approaches.

In summary, we propose a heuristic mapping of organising frames to explore how people time-range in a meshwork of interdependencies. More generally, the map presents the idea that (human) living is simultaneously determined by multiple

organising frames. Each frame represents a degree of emergence and enablement of complex activity.

THE BACKBONE: CONSTRAINT INTERDEPENDENCE

Organising frames can be distinguished by their nested rank and temporal range, but *what exactly is* organised within each frame? We need a fine-grained and bottom-up approach addressing the *kind* of organisation involved when we talk about organising frames. The answer we propose consists of seeing inter-timescale relationships as comprising multitudes of constraints on processes in a temporal range.

The key idea that connects the map of organising frames with the notion of constraint is that *networks of constraints constitute forms of emergent organisation that manifest degrees of collective interdependence*.¹⁰ For example, the map represents the basic domain of life as contained within distinctive temporal boundaries: life's maximum temporal range spans from the slowest timescales of evolution to the fastest timescales of molecular bonding in metabolism. What this framing means is that the maximum temporal range of life contains networks of interdependent constraints that sufficiently account for the maintenance and emergence of life from the wider domain of physics. Constraints lying beyond the timescale extrema of life constitute life's necessary material conditions but do not form interdependencies with the constraints properly emergent within life.¹¹ Similarly, the temporal ranges sufficient to describe a particular personal trajectory contain only a subset of the timescales of life. A single person's life trajectory is populated by constraints tightly interdependent in a much narrower frame to which external constraints lying on very slow or very fast timescales of evolution and metabolism constitute its boundary material conditions.

From Independent to Interdependent Constraints

Independently considered, constraints are seemingly prosaic: while being sat on a chair, the chair's solid surface opposes the gravitational trajectory of your body towards the ground beneath; the chair's surface is a constraint. This basic limiting aspect is extrapolated in the metaphorical use of the word constraint, such as when one says that budgetary limitations

constrain an architectural design. However, when examined closely, constraints do not just limit, they also allow something else to happen (Juarrero, 1999). Doors can pivot on one side because of the constraining action of hinges attached to door frames; hinges and door frames are constraints that *enable* swinging doors. Such constraints are thus simultaneously reducing degrees of freedom and making an otherwise less likely behaviour more likely to happen.

Constraints allow non-spontaneous changes to happen by channelling energy into fewer degrees of freedom (Kauffman, 2008). Doors that are not attached to door frames will not swing from one side spontaneously with the wind. Conversely, with hinges in the right places, the kinetic energy of the wind is transferred into the few degrees of freedom that allow a particular, otherwise unlikely, rotational motion. An example of making the unlikely become much more likely is what enzymes do in metabolism. Enzymes are constraints by virtue of channelling the thermodynamic flow of a process into an alternative pathway that increases the process's rate of reaction. Given the presence of enzymes, reactions that would otherwise take too long to occur (and thus are non-spontaneous), take just the right amount of time within the temporal range of metabolism.

Crucially, any constraint is always degrading at some timescale, yet the timescale of degradation of the constraint and the relevant timescale of the constrained process are necessarily different. The capacity of constraints to act on processes depends on constraints being statistically stable structures in a temporal-relative way. For example, from the relative point of view of the constrained processes, enzymes remain unchanged¹² – similar to how chairs and hinges are stable from the point of view of the ecological scale of sitting people and swinging doors. What matters is that constraints are not consumed in the process on which they act and thus maintain their *temporal symmetry* with respect to the constrained process (Moreno and Mossio, 2015). This symmetry occurs either by means of keeping a stable structure (a hinge), or maintaining a constant flow of fast degrading structures with similar and replicable properties. Accordingly, there is nothing in principle against the possibility of finding fast-degrading constraints acting on slower processes.

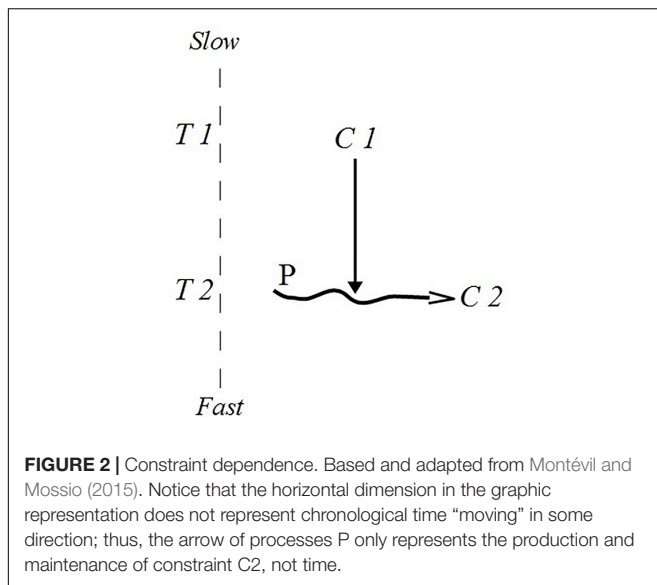
Systems biology theorists Montévil, Mossio, and Moreno point to crucial properties of sets of constraints.¹³ By hypothesis, they propose that any two constraints may constitute *mutual dependency* (Montévil and Mossio, 2015; Moreno and Mossio, 2015). Their crucial observation is that biological constraints such as enzymes are constantly maintained, repaired, and replaced by non-spontaneous processes that require the existence of enabling constraints at other timescales. In this way a direct dependence of at least two constraints can be established without implying any form of exchange of energy/matter between the two. In **Figure 2**, constraint C2 in T2 (timescale 2) is dependent on C1 in T1 because the process P that maintains C2 is constrained by C1. T1 is a slower timescale relative to T2. We may think of C1 and C2 as

¹⁰Many constraint-based views crop up across various fields of scholarship that seek to explain so-called "higher" cognition while circumventing traditional explanatory concepts, such as reference, representation, content, and semantic information. A constraint-based view shows up in current versions of radical embodied cognitive science (Bruineberg et al., 2018) as well as in various theories of linguistic action (Pattee and Rączaszek-Leonardi, 2012; Steffensen and Harvey, 2018; van den Herik, 2018). Other influential constraint-based views have been formulated previously by Ashby (1961), Polanyi (1968); Juarrero (1999), Deacon (2013) amongst others. Constraint interdependence, based on the idea of "constraint closure" (Montévil and Mossio, 2015; Moreno and Mossio, 2015; Kauffman, 2019), is however, a novel addition to the constraint-based literature within ecological and radical embodied approaches.

¹¹For example, the distance of the earth to the sun constrains life to follow a particular evolutionary path, but it is not interdependent with the processes generated within life. Such distance is an external independent constraint.

¹²Not significantly changed. In other words, enzymes do not significantly transfer energy to or become consumed by the process they constrain; thus, they degrade at a different timescale.

¹³Based on the work of Stuart Kauffman, Robert Rosen, Howard Pattee, and Alicia Juarrero.

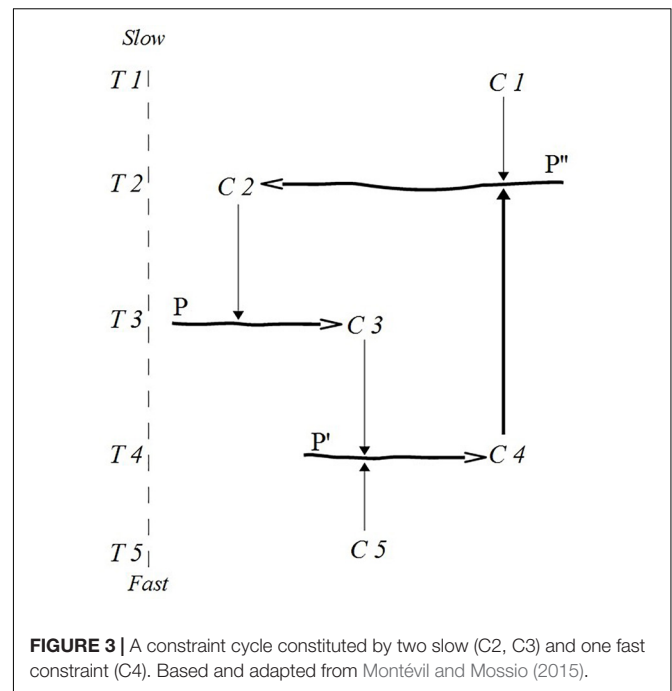


being catalysts, whereby catalyst C2 is dependent on the catalytic action of C1 on the process P that regenerates catalyst C2 in T2.

In principle it is possible to find *cycles of interdependency* whereby a chain of dependent constraints closes onto itself: a chain of constrained processes (re-)generates constraints for other processes that in turn generate the constraints at the beginning of the chain. One may think of C1 as being dependent on a series of constraints that link back to C2, which is itself dependent on C1. Montévil and Mossio call this loop “constraint closure” Montévil and Mossio (2015). Crucially, a distinction between *fast constraints* and *slow constraints* is necessary to make this loop work. It must be possible for processes belonging to the cycle to be affected by constraints maintained at faster timescales.

At the physiological range, fast constraints can be found in processes of growth and remodelling of tissue in which the slow (re-)shaping of a tissue is under control of fast constraining flows.¹⁴ In anticipation of subsection “Replicable Constraints in Conversation”, vocal gestures (“utterances”) are seen as instances of “replicable constraints” (Pattee and Rączaszek-Leonardi, 2012). In the terms of the constraint dependency logic, such replicable constraints can operate as fast constraints on other processes in interpersonal interaction. In any case, fast constraints are populations of similar structures that manifest statistical properties that warrant their constraining action at the relevant timescale.

Thus, logically, *cycles of constraint interdependence are achieved by the heterogeneous linkage of slow and fast constraints*. This logical requirement is a way of bringing light to interactions between timescales far apart in a temporal range. Since cycles of constraint interdependence occupy temporal ranges they cannot be reduced to single timescales.¹⁵ In **Figure 3**, the process P' that maintains constraint C2 in T2 is constrained by C4. C4 is



a fast constraint that needs constant replicating flow in T4 in a way that renders it with statistically similar properties at T2. The whole cycle includes only C2, C3, and C4, and their slow and fast dependencies in a temporal range consisting of at least three timescales (T2, T3, and T4).

How Do We “Scale-Up” Constraint Closure?

Going from enzymes to vocal gestures, or from cells to the global society (Chavalarias, 2020), requires a careful unpacking of how we can scale-up the constraint closure formalism. Being an organisational principle, with scale-invariant properties, constraint closure allows for implementations in multiple systemic levels. For example, it has been recently applied to mapping glycemia regulation (Bich et al., 2020). Likewise, Nunes-Neto et al. (2016) use constraint closure to map interactions between plants, soil microorganisms, and pollinators in large ecosystems.

Nevertheless, we do not scale-up in the conventional sense of going from “small to large” (e.g., from cell to tissue, to organ, to organism, etc.) or from “fast to slow”; instead, we use the mapping of organising frames (**Figure 1**) to go from general to specific. What this means, starting from the basic life frame, is that we go from a wide range of metabolic and evolutionary networks of constraint interdependencies into narrower frames that manifest deeper entanglements at “mid-range” timescales – timescales of everyday human living. As we narrow down and move from strict metabolic organisation to the complexity of social life and personal histories, the concept of closure needs to be carefully calibrated to softer and more fluid interdependencies at play in those frames. Montévil and Mossio (2015) suggest that on empirical grounds, constraint closure should be interpreted as

¹⁴Montévil and Mossio (2015) point to the slow process of bone mineralisation constrained by the (fast constraint) enzyme alkaline phosphatase.

¹⁵The word *cycle* thus refers to a logical form, not to cyclicity on a single timescale.

a matter of degrees of intensity, or better, as a *tendency towards constraint closure*. We use this idea to transition from the kind of hard constraint interdependencies present in the basic-life organising frame to the softer interdependencies of the forms-of-life and Self frames. We could think of each of the organising frames as domains in which a tendency towards constraint closure may be expressed with different degrees of intensity. In what follows we show different degrees of intensities of constraint interdependencies with the use of the notion of affordance.

Affordances and Constraints

From a relational perspective, affordances are action-relevant relations between organism and environment (Chemero, 2009). In the case of chairs, for instance, there is a relation between the material stability and regularity of chairs, the statistical regularities of human bodies and movement (also called effectivities in canonical EP), and the histories of coupling agent-environment under particular socio-material conditions – the history of a particular person in a community in which chairs are regularly manufactured and used for sitting. The three relata in this account – regular chairs, regular bodies, and the biases in social practices – can be seen through the lens of constraint theory. Firstly, the dynamics of sitting behaviour P1 at timescale T1 is constrained by the two slow constraints C1 (regularities of chairs) and C2 (regularities of bodies). Secondly, beyond the timescale of sitting behaviours, C1 and C2 are maintained by slower (and faster) processes associated with the physical stability of materials (the chair) and the self-generating processes of the body. Thirdly, the third relatum, the social niche and practice, brings a meshwork of processes and constraints in wider temporal ranges. On the one hand, an agent's history of interactions undergirds the particular biases of the fast endogenous dynamics of their central nervous system and body. In the skilled intentionality framework, these fast changes correspond to fluctuating states of action readiness. These states amount to experiences of tension and a tendency towards optimal grip in the situation by responding (or not) to the sitting affordance (Frijda, 1986; Bruineberg and Rietveld, 2014). On the other hand, a person's current participation in social practices belongs to slow timescales of change and has its own inertia manifested in a myriad of regularities in the inherited social niche, such as the geographical places in which chairs tend to be present, how they tend to be located in space according to particular uses, etc. Crucially, some of these aspects can be seen as constraints binding together to produce the saliency of an invitation to sit in a given situation, including particular habits and other idiosyncratic regularities that play a role in modulating selectivity and responsiveness, and determine the invitational character of a particular affordance (see Heft, 2001, 2013). For example, the constraint of ritual sitting in religious services acts on an individual's socially acquired attunement and responsiveness to using chairs.¹⁶

With a more radical version of affordances seen as temporally extended phenomena, van Dijk and Rietveld (2017) tackle the

problem of acting in anticipation of complex sociomaterial events. They discuss how multiple affordances at fast timescales can be intertwined and nested within larger affordances at slow timescales. They bring examples from artistic and architectural projects that can take several months to complete; projects that not so much implement a prefigured plan as unfold diachronically (Ingold, 2013). In their view, a project such as building a shed for the next harvest season is constituted by a large-scale affordance (e.g., the prospect of having a shed ready for the harvest), which sets up the conditions for its own continuation by constraining the available smaller affordances at shorter timescales, for instance, using a particular tool for cutting timber for the walls of the shed. In turn, engaged participants would guarantee the continuation of the larger project by means of acting with respect to the small-scale affordances that emerge in the activity. Converging into a particular complete product, actions – such as cutting planks to a size that fits with other planks already in place – become gradually more interdependent and constrained. As the construction process moves towards its final stages, participants are pulled into a narrower set of possible solicitations from affordances. For example, in late stages of construction it becomes less inviting to use a large hydraulic excavator.

In our view, van Dijk and Rietveld (2017) support an unorthodox temporality-based view of affordances.¹⁷ The authors capture a form of circular dependence that unfolds in the improvisatory performance of the activity and funnels itself into a particular subdomain of possibilities.¹⁸ In our interpretation, the circularity corresponds to constraint cycles whereby slow-timescale trajectories selectively constrain fast-timescale dynamics, and the pursuit of fast-timescale action selectively channels slow-timescale dynamics.

Unpacking the Ecological and Enactive Connections

Affordances may be complex meshworks of fast and slow constraining relationships criss-crossing organisms and the socio-material environment. We benefit from using the concept of affordance, broadly defined, to exemplify the use of the logic of constraints in human-relevant temporal ranges,¹⁹ yet this beneficial connection is bidirectional.

The framework introduces a precise notation capable of capturing inter-scale relationships (e.g., between events, rhythms, deadlines, etc.) and may be able to show how affordances

¹⁶We leave out a detailed characterisation of the example with the use of the constraint notation.

¹⁷van Dijk and Rietveld (2017) use the idea of temporality mainly to substantiate the claim that affordances are always anticipatory regardless of timescale (van Dijk and Withagen, 2016), we propose to use temporality itself for a characterisation of affordances that involves unpacking the range of relevant timescales.

¹⁸This view, however, seems incomplete and needs a discussion of what Stuart Kauffman calls the “adjacent possible” (Kauffman, 2019; Kauffman, 2000) at the root of innovation – the emergence of completely novel solutions, situations, trajectories, etc. (cf. Cowley and Markoš, 2019).

¹⁹We, however, do not uphold the dependence of the proposed framework on the notion of affordance. As we show in section “Time-Ranging in Psychotherapy: An Ethnographic Investigation”, the investigation of constraints in a real-life case study promises to be, strictly speaking, a self-standing theory. We thank a reviewer for pressing us to clarify this connection.

are maintained by constraint interdependencies within an organising frame. Accordingly, the mapping of organising frames (**Figure 1**) can be used to clarify distinct types of affordances based on the underlying constraint cycles from which affordances derive their regularity.²⁰ We may be able to define: (a) species-generic affordances, (b) affordances related to conventions and the socio-cultural niche, and (c) the emergence of idiosyncratic affordances based on personal histories. In brief, external and lawful relations between stable properties of the environment and the animal's effectivities are reinterpreted in terms of the correspondence between constraints, at very slow phylogenetic and material timescales, acting simultaneously on the (fast) ecological timescales of behaviour. Very slow constraints manifesting law-like properties belong to extremely wide temporal ranges that include phylogenetic and speciation timescales in the sensorimotor frame. Likewise, moderately slow constraints are associated with social conventions in the Forms-of-life frame (Bruineberg et al., 2018), and personal idiosyncrasies belong to narrower temporal ranges of the Self frame.

The connection with EA is most evident in the light of the continuity thesis of mind and life.²¹ For EA "the organisational properties distinctive of mind are an enriched version of those fundamental to life" (Thompson, 2007, p. ix). The framework we propose is precisely based on the idea that the organisational properties of sets of interdependent constraints can be found across all organising frames, from basic life to instances of human interaction, for example, psychotherapy.

An important common ground with EA is the effort to seek the basis of the organisation of life in a balancing act precariously played on the edge of imminent material decay (Di Paolo and Thompson, 2014). Biological constraints are neither infallible nor law-like; they decay irreversibly unless processes catalysed by other constraints replenish them. The more nuanced insight offered by the constraint perspective is the crucial distinction between constraint closure and process closure (Moreno and Mossio, 2015; Kauffman, 2019). The latter, unlike the former, is constituted necessarily by a chain of transformations of matter/energy that closes onto itself, whereby the material outputs of one process become inputs for the next one and a closed loop is achieved. Constraint closure, however, does not require a chain of matter/energy transformation; it only requires that each localised constraint is maintained by a particular process of transformation of

matter/energy.²² If such a local process fails, the associated constraining capacity deteriorates (Deacon, 2013), and a series of failures may propagate in the constraint loop, not because a pipeline of transformations of energy/matter fails but because the series of constraining actions fail to occur. In short, constraint closure, and more generally constraint interdependence, although fully grounded on particular material dynamics, does not constitute a closure of the underlying processes themselves.

This subtle but crucial distinction allows us to link widely heterogeneous kinds of processes spread across broad temporal ranges by virtue of their local constraining capacities. For example, we can link vocalisations and other behaviours, not by virtue of how matter/energy is transformed (air molecules in movement do not cause other motor activations), but by virtue of how they are organised as a cycle of constraining actions. In what follows we finally sketch how to take the logic of constraint cycles to the realm of human conversation. We briefly unpack the conversational present (see **Figure 1**) in a way that serves the analysis of the case study in section "Time-Ranging in Psychotherapy: An Ethnographic Investigation".

Replicable Constraints in Conversation

Vocal, manual, and facial gesturing of persons in conversation configure particular structures in a flow that has constraining effects in the current moment. For any skilful individual, these structures manifest the fine-tuned entrainment of vocal tract, hands, and facial musculature in a way that allows them to be reproduced quickly and economically at fast-paced behavioural timescales. In the flow of a conversation, vocal and other types of gestures constitute the locale of constraining activity within a much larger meshwork of constraints at slower and faster timescales.

Following the constraint-view in ecological linguistics (Pattee and Rączaszek-Leonardi, 2012; Steffensen and Harvey, 2018; van den Herik, 2018), utterances are behavioural events that operate as *replicable constraints*, reducing the degrees of freedom and harnessing an interactional dynamic. Crucially, in the logic of constraint closure, replicable constraints satisfy the necessary condition of the existence of fast constraints within constraint cycles.

Utterances, moreover, can be characterised both as fast and slow constraints relative to the component of interactive dynamics on which they have constraining effects. For example, when Wittgensteinian builders yell "brick", "pillar", and "slab" in order to orient the attention of a fellow builder, their linguistic actions take place at a timescale between faster interbodily sensorimotor coordination (grabbing and moving stones) and slower paced task/work coordination. The linguistic activity is responsible for the production of discernible changes in

²⁰By mapping interdependent constraints in wide temporal ranges this proposal can be part of an effort to connect slow evolutionary processes and processes of niche construction in social practice. As has recently proposed (Heras-Escribano, 2020), linking niche construction with natural selection brings the theory of affordances closer to a grander extended evolutionary synthesis (Heras-Escribano and de Jesus, 2018).

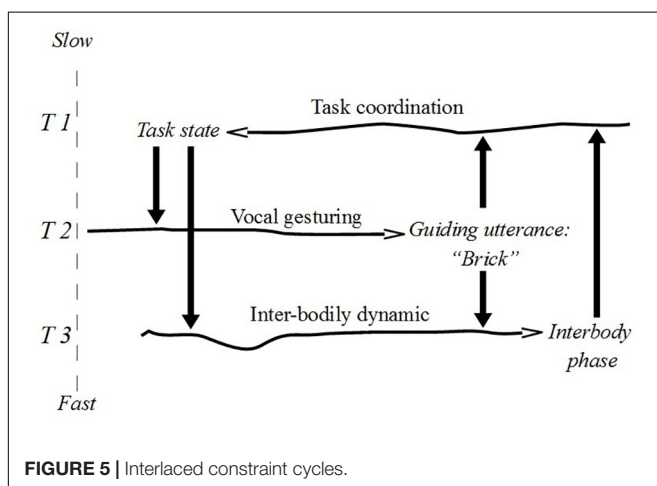
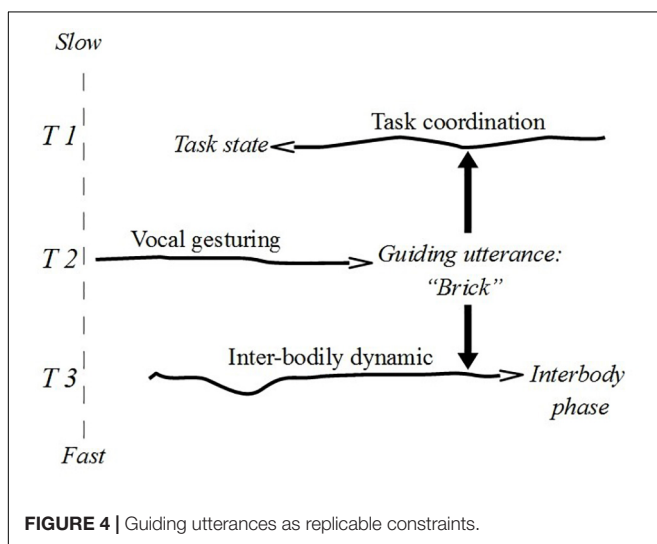
²¹There is a history of productive exchanges between autopoietic EA (e.g., Thompson, 2007) and the work of Moreno, Mossio, and colleagues. The history of the "constraint" approach and the development of constraint closure theory extends more than 20 years. See an early example in Ruiz-Mirazo and Moreno (2004). The intricacies of the history, parallelisms, and differences between EA's autonomy and constraint-based perspectives, however, exceed the current proposal. Both are theories of organisational closure (see review in Moreno and Mossio, 2015) and manifest a scale-invariant logic, organisational rather than mechanistic, that can be extrapolated to domains beyond metabolism. We thank one of the reviewers for pressing us to clarify this connection.

²²Clearly, the distinction is not whether we are dealing with open thermodynamic systems. All instances are thermodynamically open far from equilibrium. A process/work cycle requires exergonic ("energy releasing") and endergonic ("energy absorbing") processes linked in a chain of energy/matter transformation (Kauffman, 2000); a constraint cycle only requires that exergonic and endergonic processes are present in a way that maintains the constraints necessary for a particular organisation.

the medium (air)²³ that bear on the interbodily sensorimotor dynamic and on the task coordination. **Figure 4** shows these double constraining actions (fast and slow) with the constraint notation.

The covariance between vocal gesturing and task coordination can be made explicit by singling out mutually dependent constraints between these processes. Assuming a fast constraining action on task coordination, we can now characterise a slow constraint looping back on vocal gesturing. In this case we may think of particular states or phases of task coordination as constraints reducing the degrees of freedom of linguistic attentional orientation. Call this covariance a *tight constraint cycle*. We show this cycle in **Figure 5** (the cycle

²³“Articulatory gestures (Goldstein and Fowler, 2003; Fowler, 2014), highly regularized synergies among the various components of the articulatory tract whose repetition results in auditorily, visually, kinesthetically, and acoustically similar events. [These] resources function normatively in that adult humans regulate their micro-scale vocalizations to match the appropriate patterns and instantiate the appropriate synergies. They achieve this by means of rich phonological memory, entrenchment, sensitization, and related mechanisms” (Harvey et al., 2016).



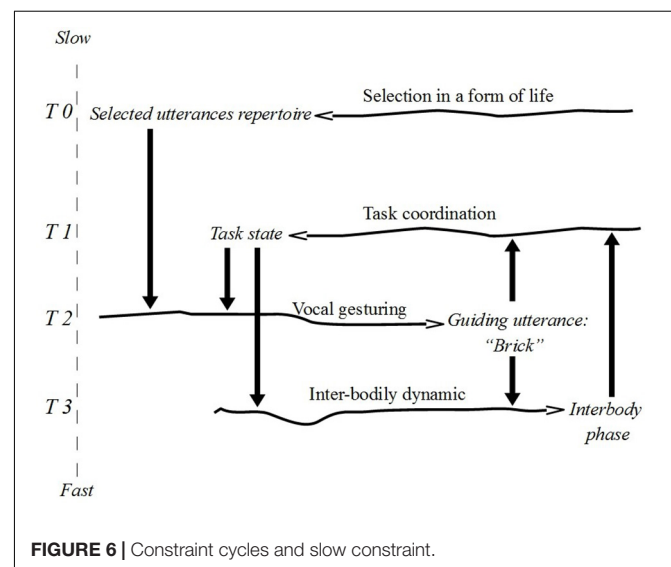
in T1–T2) interlaced with another cycle describing the close relation between particular phases of fast interbodily dynamics and the states of task coordination (the cycle in T1–T3).²⁴

By singling out fast-produced constraints that manifest statistical similarity across iterations, we are able to show how sets of constraints fold onto themselves to form constraint cycles. The covariance between features of body-to-body entrainment and the use of vocal gestures can be interpreted in an economical way through the multiscalar constraint cycle logic. However, it is clear that dialogical interaction is underdetermined by such a tight cycle. Indeed, the covariance does not tell us much about how vocal gestures can have the specificity of its constraining effects in the first place (Steffensen and Harvey, 2018).

To ask how vocal gestures become constraints is to ask how the unlikely synergy that regenerates and maintains specific vocal gestures becomes more likely; that is, we need to ask what other constraints are in place operating on linguistic activity (and on the tight cycle). We point to social linguistic practices (in forms-of-life frame) that select a repertoire of utterances as a source of constraints (specific selection and distribution of utterances) on vocal gesturing (Pattee and Rączaszek-Leonardi, 2012). This is depicted in **Figure 6**.

At this point, we can only sketch other possible slower constraint dependencies, for example, social practices that calibrate attention, slow changing moods, roles and membership in family relationships and social practices, etc. (van den Herik, 2018). Crucially, we suggest that the task of the observer is thus to interpret and establish the maximal temporal range necessary to lay out a satisfactory number of constraints that collectively manifest constraint interdependence. There are no special kinds of constraints that can do the explanatory work. The task of mapping meshworks of constraints demands real-life examples.

²⁴We are not showing other possibilities of cycles, for example, how interbodily coordination in terms of body distance and alignment in a conversation may alter the flow of linguistic activity.



TIME-RANGING IN PSYCHOTHERAPY: AN ETHNOGRAPHIC INVESTIGATION

We propose that one interpretation of the aim of psychotherapy is that it helps patients develop time-ranging skills in disentangling and re-entangling constraint cycles of stable, but dysfunctional and painful, patterns of behaviour. The empirical questions of the analysis thus amount to: How do patients become skilled time-rangers? How is cognitive-emotional change established in a conversational present in a way that allows patients to integrate changes in their bio-social systems?

In this section, we investigate how time-ranging skills are practised by emphasising the role of embodied languaging (Fowler and Hodges, 2011; Thibault, 2011; Steffensen, 2013, 2015; Jensen, 2014; Cowley, 2019). In essence, by eschewing mentalist models of psychopathology and psychotherapy, we trace psychological change processes to the increased mastery of time-ranging and the recalibration of constraint cycles in psychotherapeutic interactions. We argue that attention-guiding and perceptual learning, as well as guided interoception, are crucial resources for patients' self-reflexive sensitivity towards painful behavioural patterns.

We explore these themes by investigating a single case from an ethnographic dataset consisting of video and audio recordings of all therapy sessions for 24 patients in psychotherapy. The data were collected as part of the research project *The Ecology of Psychotherapy: Integrating Cognition, Language and Emotion*, conducted at the University of Southern Denmark. The data were collected at an outpatient clinic for patients with anxiety disorders, obsessive-compulsive disorders, and personality disorders at a Danish psychiatric hospital.²⁵ The analysis is guided by the conceptual model of MT presented in previous sections as an explanatory framework for demonstrating how time-ranging emerges in psychotherapy. Methodologically, the analysis relies on a qualitative-idiographic framework, as known from cognitive ethnography (Hutchins, 1995; Steffensen, 2013; Trasmundi, 2020) and multimodal interaction analysis (Goodwin, 2018).

The case involves a female patient in her mid-thirties (pseudonymised as "Alice"). Alice is treated by an experienced female therapist (at about the same age) with expertise in mentalisation-based treatment (Bateman and Fonagy, 2016). Alice was referred to the outpatient clinic after hospitalisation because of a long-lasting major depression and severe panic disorder. After her initial assessment, she was diagnosed with agoraphobia with severe panic disorder, and with recurrent depressive disorder currently in remission. Alice has suffered from lifelong conflictual interpersonal relationships, and she

experiences serious relational problems with her spouse and her mother. She is easily agitated, and a recurrent theme in the therapy is how this agitation manifests.

Speech Rate Between Embodied Behaviour and Social Systems

We explore Alice's case by taking a starting point in a phenomenon that appears repeatedly in the dataset: the therapist picks out an increase in Alice's *speech rate* (i.e., number of phonetic or phonological syllables per second). Pertaining to the conversational present, speech rate is an easily observed phenomenon. Apart from idiosyncratic variations and context/genre differences, it depends on the speaker's emotional arousal (Siegman, 1985). However, rather than assuming that arousal is an unobservable phenomenon in the head/mind of the patient, we follow James (1983) in assuming that arousal is an embodied phenomenon, which includes accelerated speech rate, breathing, and facial and manual gesturing. It is this tight coupling between arousal and accelerated speech rate that justifies our focus on speech rate as a core phenomenon within the conversational present (see T5 in Figures 7, 8).

Given her dual role as an observer and participant, the therapist can intervene in the interaction as soon as she observes relevant changes in Alice's behaviour, including her speech rate. These interventions take a highly standardised form across the dataset²⁶:

so I notice that you begin to speak significantly faster
(session 5; timecode 23:05)

I- I start noticing that whoops now it begins to go fast
(session 8; 13:08)

whoops now- now it begins to go fast again (session 8; 27:49)

I notice that ehm it goes fast today (session 11; 12:50)

it goes fast right now (session 14; 33:24)

I notice that you begin to talk a bit fast (session 17; 15:07)

To exemplify the implications of the interventions, we highlight the first occurrence in session 5. This intervention follows a 14-s long patient narrative, where Alice produces 91 phonological syllables, that is, a speech rate of 6.5 syllables per second.²⁷ This speech rate is significantly higher than elsewhere in the interaction. For comparison, the first time the patient produces a coherent narrative (2:01 min into the session), Alice's speech rate is 4.6 syllables per second, and in a similar narrative 2 min before the therapist intervention (i.e., 20:07 min into the

²⁵All patients enrolled in the research project were asked to volunteer for a project that aimed to understand "how language and body dynamics influence the therapeutic situation". The patients were informed about the data collection, protection, and pseudonymisation. The patients did not receive any payment or compensation for their participation in the project. The patients were recruited for the project by their therapist during a pre-therapy start-up meeting. All patients and therapists have given written consent to participate in the study, including being the subject of analysis in a research article. Prior to the enrolment of patients, the project was reported to the Danish National Committee on Health Research Ethics.

²⁶See **Supplementary Material** for original transcriptions in the Danish language. Data translated by the authors.

²⁷We follow Hilton et al. (2011) in distinguishing between phonological and phonetic syllables. Since our purpose is to compare speech rates at different stages of the interaction, there is no gain in relying on phonetic syllables. We calculate speech rate in a given segment by identifying a segment of at least 10 s during which one participant produces one coherent turn (ignoring minimal response of the other interlocutor). We then count the number of phonological syllables in a normalised transcript within the identified segment.

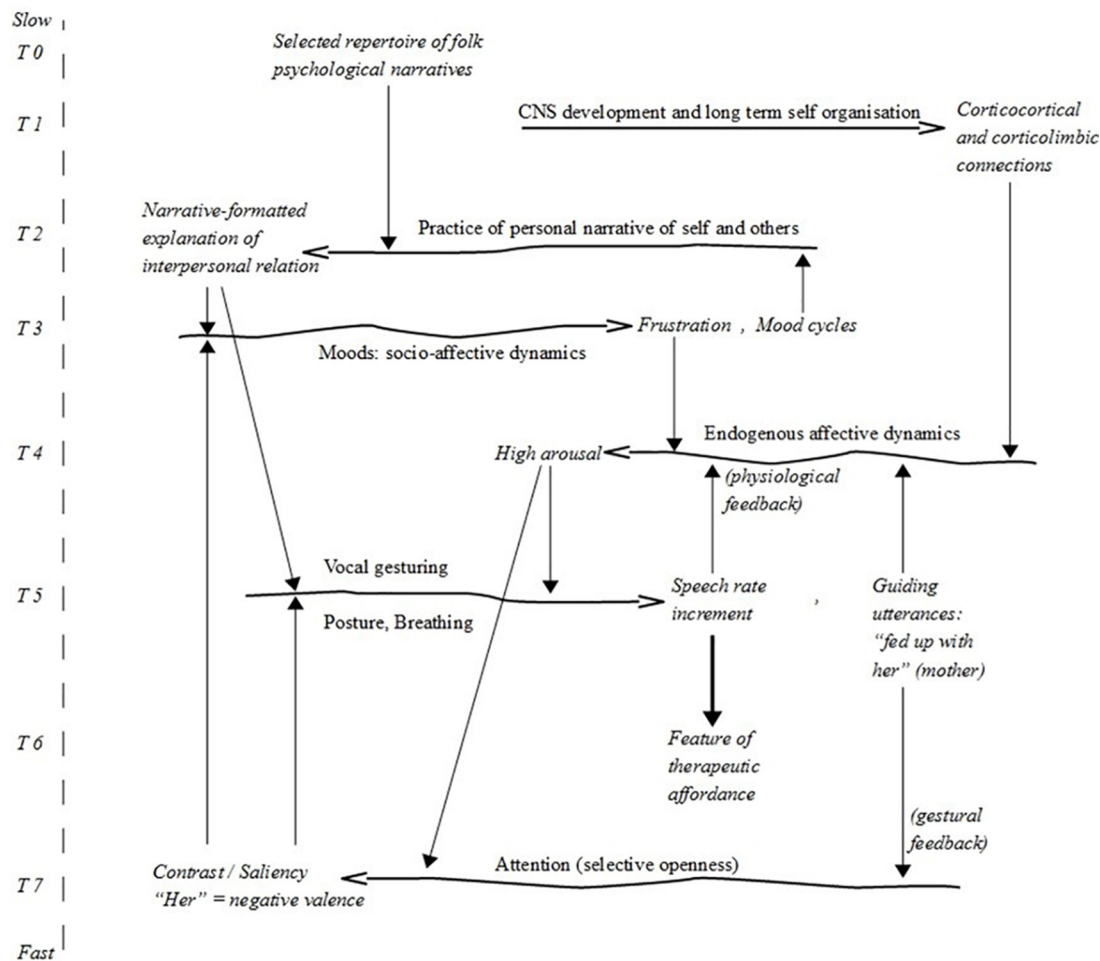


FIGURE 7 | Constraints cycles *before* the intervention. For simplicity, we do not show the organisational frames shown in Figure 1. T4–T7 pertain to the conversational present. The specific constraint dynamics are extensively discussed in the text. Note the status of the constraint “speech rate increment” as a feature of the therapeutic affordance.

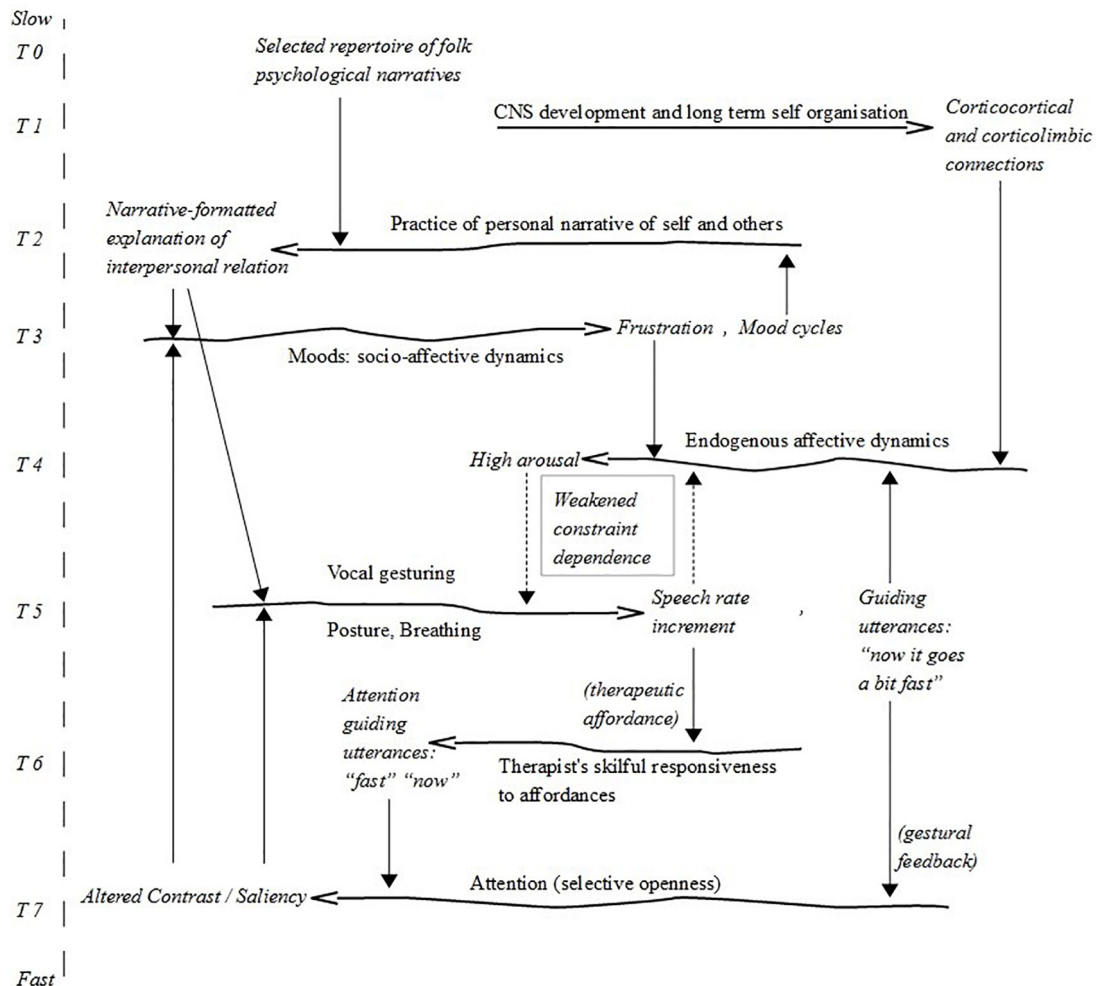
therapy), her speech rate is 4.6 syllables per second. In other words, the therapist reacts to a sudden increase in Alice’s speech. Immediately after the intervention, Alice’s speech rate drops to 5.6 syllables per second (measured in her first segment longer than 10 s), and half a minute later it has further dropped to 5.3 syllables per second. Ten minutes after the intervention, Alice’s speech rate is 5.0 syllables per second, and hence almost back to the initial rate. A similar pattern is found in the other examples listed above.

Crucially, by pointing Alice’s attention to her speech rate, the therapist in fact prompts Alice to change it. This change is an instance of time-ranging. Before the intervention, we observe a constraint cycle between arousal and speech rate, where arousal constrains speech rate in a tight feedback loop (T4–T5 in **Figure 7**). In the intervention, a new constraint cycle is established between Alice’s arousal and speech rate and the therapist’s expressed observation (T4–T5–T6–T7 in **Figure 8**). This constraint cycle is conditioned by the therapist’s skilful responsiveness to vocal gesturing and behavioural changes

(“feature of therapeutic affordance” in T6) dependent on the cycle of speech rate-arousal co-variation. From an ecological point of view (van den Herik, 2018), language functions as a perceptual tool. Thus, the therapist’s expressed observation constrains Alice’s attention (T6–T7 in **Figure 8**), which in turn constrains the speech rate, allowing Alice to weaken the constraint interdependence between her high arousal and her speech rate increment.²⁸

Therapy has an overt focus on helping the patient regulate their emotions. Generalising from this example, we may hypothesise that patients appropriate a way of regulating their emotions by learning to notice, and in turn to modify, a feedback loop between a given emotional pattern and a specific behaviour in the conversational present. The change observed in this case consists of Alice’s weakening the constraint interdependence

²⁸Given the human bodily layout, attention, however, flighty it may be, manifests statistical similarity across iterations, which allows it to function as a fast constraint on behaviour, in this case on speech rate.



These two excerpts suffice to demonstrate that the constraint cycle between arousal and speech rate in turn is constrained by Alice's feelings of frustration due to her mother. Alice's enacted arousal is constrained by emotions pertaining to her position in a larger (non-local) social system (Steffensen, 2012): *I'm fed up with her*. By taking Alice's social relations into consideration, we move beyond the conversational present and into the organisational frame of forms-of-life (cf. **Figure 1**). Thus, we observe a new tight constraint interdependence between Alice's high arousal and a stabilised pattern of socio-affectivity that pertains to Alice's social system (T3–T4 in **Figures 7, 8**). However, it is not simply the case that these emotions build up in the patient's social system (at an "everyday timescale") and surface in the dialogical system within the conversational present. The relation allows for a reciprocal dynamic where the emotional reactions are investigated in the dialogical system. In other words, by modifying her way of attending to the non-local socio-affective dynamics, Alice can alter the pathological constraint cycle between the social system and the dialogical system (the large cycle T3–T4–T7 in **Figure 7**). Again, a key factor is a change in attention, which is brought forth by the therapist's use of languaging as a perceptual tool.

To determine a complete network of constraint cycles, we should consider how Alice's personal narrative practices are present in the dialogical system, whereby narrative-formatted utterances habitually trace Alice's emotional dynamics (be it in the social system or in the dialogical system) in a way that orients attention to a longer timescale of Alice's childhood experiences and trauma. An example is found in the following excerpt from session 8:

Excerpt 3: session 8; timecode 02:18 – 03:53

P: I don't know how to [...] like mm with all those (.) with the neglect I felt from my mother when me and <SPOUSE> started to date and (.) when she found out (.) that we should have <CHILD> and (.) the neglect from my dad when I was very young and such things.

On the one hand, these autobiographical narrative elements concern the frame of Alice's Self, that is, how she accounts for her past, which in turn is an organising frame that enables how she experiences and interprets the conversational present. On the other hand, it relates to the sensorimotor frame, that is, how she has developed a set of embodied reactions in her childhood, which impact on her adult behaviour, both in her social systems and in the dialogical system.³⁰

While we cannot go back in time, we can observe how legacies of childhood events manifest in Alice's real-time embodiments in part constrained by a stable neural architecture (T1–T4). We see that in relation to the therapist in the conversational present, as well as in her renditions of earlier encounters with

her spouse. Thus, the past is part of the patient and not detached from her present embodied behaviour: there is a constraint cycle between her anxiety as a habituated bodily response (since early childhood within the Sensorimotor frame), the persistent presence of her mother in her current social system (within the Forms-of-life frame), and her behaviour in the conversational present. This temporal entanglement is an important aspect of the therapeutic work, for instance by weakening these constraint interdependencies by attending to the stabilised patterns in other organisational frames that underlie Alice's behaviour. In the next section, we will explore how Alice and her therapist do so by engaging in time-ranging.

Time-Ranging and Perceptual Learning

In section "Speech Rate Between Embodied Behaviour and Social Systems", we established the constraint cycle entanglement outlined in **Figure 8**. Further, we have argued that therapeutic progress is achieved by weakening the tight constraint interdependencies through extended constraint cycles that involve the therapist guiding Alice's attention. In this section, we will explore time-ranging as a reconfiguration of constraint cycles. We take a starting point in Excerpt 4:

Excerpt 4: session 8; timecode 27:49 – 28:01

T: whoops now- now it begins to go fast again

P: yes

T: can you feel that

P: yes haha

T: we just entered the irritation there

P: yes

T: yes (.) so can we- can we just- if you should take me back to when you left from here last time

P: yes

The therapist's first and last utterances exemplify time-ranging techniques. As previously discussed, the first utterance follows a sequence in which Alice gets carried away by her frustrations over her mother. By sharing her observation about the increased speech rate, the therapist prompts Alice to time-range by attending to her situated behaviour. The last utterance has a somewhat different dynamic: having established that the speech rate is caused by the patient entering a difficult emotional space, the therapist requests that they jointly explore the difficult emotion connected to past events in the social system. Following Conversation Analysis, we consider the initial phrase *so can we-can we just-* as an example of *repair*, that is, "a set of practices designed for dealing with the types of difficulties which emerge in talk" (Liddicoat, 2011, p. 208). In this case, the repair indicates that the therapist acknowledges that staying in the difficult emotions is somewhat troublesome for Alice, which is exactly why she tries to escape them. By eliciting Alice's acceptance to stay focused on the difficult emotions, they collectively attend to Alice's traumatic past, but now not only from Alice's vantage

³⁰In this context, we ignore the sensorimotor and forms-of-life ranges of the therapist. These temporal ranges include, amongst others, both her own embodied reactions in the conversational present and her training. As for the latter, functioning as a psychotherapist requires enskilmant and what Goodwin (1994) famously called *professional vision*. Therefore, the educational background of the therapist, as well as her institutional embeddedness (with leaders, colleagues, supervisors, etc.), condition the dynamics. In spite of that, we focus on Alice, as she is the locus of the psychological change process.

point, but from the vantage point of a distributed cognitive-emotional system. Thus, the dialogical system is effectively a distributed cognitive system where the therapist provides the trustful context necessary for Alice's exploration of the past. In other words, by relying on an experienced time-ranger (an emotional Sherpa, so to speak), Alice can re-appropriate her past, and hence change her present (social and dialogical) situation.

Such time-ranging dynamics are a crucial aspect of psychotherapy. However, given the long-term goal of psychotherapy, it is obviously insufficient that Alice is capable of engaging in time-ranging when guided by the therapist. For therapy to work, Alice must develop her time-ranging skills further, so she can monitor and moderate her behaviour and her emotional reactions outside of therapy. Due to the nature of the dataset, we have no data on such behaviour outside the therapeutic setting, but we do have a glimpse that indicates that Alice's self-reflexivity changes throughout the course of therapy. The context of Excerpt 5 is that Alice is engaged in a rather agitated narrative about her relatives, when suddenly she interrupts herself in the first turn in the excerpt:

Excerpt 5: session 10; timecode 27:11 – 27:19

P: *now it goes a bit fast*

T: *yes that-*

P: *[yes]*

T: *[that] you could hear*

P: *yes*

T: *[yes]*

P: *[haha]*

T: *that was very well done that you noticed that (.) because I noticed too that I got detached*

It is striking that the typical “therapist formulation” (picking up on the increased speech rate) is uttered verbatim by Alice (Alice's own guiding utterance in T5 in **Figure 8**). Alice appropriates time-ranging skills by emulating the therapist's perspective. She observes and attends to her own speech rate, which is what the therapist usually does. She thus exhibits what Eleanor Gibson called perceptual learning (Gibson, 1969): “Perceptual learning is the process whereby perceptual information becomes increasingly differentiated and specific to the things in the world and to what one can do with those things” (Adolph and Kretch, 2015, p. 130). While the paradigm case of perceptual learning is infant development, learning to differentiate between levels of speech rate, and learning to associate them with different levels of arousal is a crucial skill. Alice's perceptual learning hinges on her ability to pick up differences in her own speech rate. Alice develops her ability to register the emotional dynamics, established through past interactions, that constrain her embodied, situated behaviour. Thus, the perceptual learning *vis-à-vis* her own embodied behaviour, becomes a tool for registering how past events still play a role in her present situation. By learning to detect the signals

of how the body reacts to the memory of these past events, we can learn to detect the past as a temporal pattern in the present. In short, Alice learns to *feel* how she feels – through reflexive self-perception and the ability to link it to organisational frames beyond the locally perceived reality.

Alice engages in increased speech rate behaviour on multiple occasions after this episode, so while we have seen the initial enskilment, we have not seen the habituation of that behaviour. However, therapy is a non-linear phenomenon, so it is unsurprising that this skill is not developed once and for all. Further, it must be kept in mind that this case study pivots on a specific behavioural pattern, the perception of increased speech rate. The perceptual learning associated with self-reflexivity, can be directed towards all kinds of behaviour, and given our restricted focus we will not be able to detect a general increase in self-reflexivity.³¹

Time-Ranging as a Transformation of the Constraint Cycle Network

So far we have established how the interactional noticing of speech rate functions as a time-ranging device, and we have argued that developing flexible time-ranging skills goes hand in hand with the possibility of using the dialogical system as a distributed cognitive-emotional system (cf. Hollan et al., 2000). Thus, we have shown how Alice engages in the dialogical system to act more reflexively and less habitual in the social system. Thus, by appropriating the therapeutic organisation of perceptual learning, Alice engages skilfully in time-ranging, making her more sensitive to her bodily reactions and behaviours in the dialogical system, and potentially also beyond. The crucial question to be raised here is how this time-ranging skill allows Alice to explore new dimensions of her psychopathology.

To answer this question, we take a starting point in the therapist's speech rate observation in session 8 and trace the kind of time-ranging triggered by it:

Excerpt 6: session 8; 13:08 – 13:27

T: *I- I begin to feel whoops, now it begins to go fast*

P: *yes*

T: *and I think when was it that- that it began to go fast (.) do you have a sense of that*

P: *I think it did so when I should tell about my mother and the- what she*

T: *her role in [it or]*

P: *[her role] in it yes*

T: *that's where it began to go fast (.) okay*

Alice's observation that accounting for her mother's role in her traumatic past triggers the accelerated speech rate sets off a deeper

³¹However, the dataset includes daily responses to the *Therapy Process Questionnaire* (Schiepek et al., 2019). Alice does report a significant improvement in her therapeutic progress and in her self-reflexivity/insights.

reflection, not on the temporal range of her childhood, but rather on the temporal range of her recent *reflections* on her childhood:

Excerpt 7: session 8; 13:29 – 13:27

P: but I think that the reason why my mother has also begun to- it's because it is only recently that I, like- I have always blamed my father always

T: what have you [blamed him for]

P: [that it has always been] his fault

T: yes

P: well, that he has beaten us and my mother and (.) whatever he has done

T: that he has beaten you

P: yes

T: that he has [xxxx]

P: [that he has] yes that he has subjected us to the things he did, well I have never seen my mother play a role in that (.) but the more I like talk to people about it and stuff, where they say, well your mother has also played a role in it she has- she is like the one who should protect you

There are two crucial observations to be made. First, Alice accounts for a para-therapeutic change in her recent past, which has made her reconsider her mother's role in her childhood. While we have no way of ascertaining if this change is constituted in or beyond prior therapeutic encounters, it is clear that Alice experienced an important change process in-between an autobiographical and a social systemic timescale. Second, in her account for this recent insight, Alice opens with two noticeable self-interruptions: *but I think that the reason why my mother has also begun to- it's because it is only recently that I, like- I have always blamed my father always*. In the first instance (*my mother has also begun to-*). Alice interrupts herself just before she ascribes blameworthy agency to her mother. In the second incident, she interrupts her narrative about her recent feelings for her mother by recurring to a more stabilised narrative structure of her father's culpability. In both cases, Alice reveals an inhibitory mechanism that prevents her from uttering critique of her mother. This mechanism has become a crucial part of her Self frame, and for that reason, it is connected with many upsetting feelings when she, later in the therapy, considers breaking up with her mother. Interestingly, while this inhibitory mechanism is at play, Alice also opens a self-reflexive space where she can in fact explore the vulnerability of how she has held her mother inculpable for her own struggles. We get a further glance into this vulnerable space in Excerpt 8, which follows 3 min after the previous excerpt.

Excerpt 8: session 8; 16:39 – 17:02

P: I get so angry that she at all- that he is (.) such a swine and he th- (.) can take the liberty- well, he thinks he can take the liberty to treat other people like that (.) but that my mother

she (.) () that she (.) could let it happen haha that she had children with him (.) that she didn't (.) end it earlier on

Here we see a micro-transformation from the inhibitory pattern (cf. the self-interruption in *I get so angry that she at all-*) to an explicit critique: *but that my mother she (.) () that she (.) could let it happen*, where the micropauses indicate that it is a difficult perspective for her.

This emergent pattern shows us that Alice enacts a deeply entangled triad of constraint cycles through which her conversational Self reflects on how her social Self has developed a more nuanced view on her childhood Self. Alice's time-ranging thus allows for polyphonic reasoning where she recruits multiple voices (Linell, 2009) and perspectives in her struggle to understand her past. This polyphonic reasoning is prompted by the therapist's modulation of the narrative temporality, and it indicates that the overall constellation of constraint cycles is itself transforming in a way that allows Alice to develop a more nuanced self-reflexivity.

In summary, by weakening the constraint interdependence between fast speech and high emotional arousal through modulating attention, the therapist prompts the system to explore other possible constraints available in a larger frame of forms-of-life. What Alice implicitly finds is that she can introduce a new narrative to her way of telling the personal story. In Excerpt 7, she starts with an acknowledgement of her usual story (*"I have always blamed my father always"*), before she moves on to a novel story line: *"she is like the one who should protect you"*. In Excerpt 8, she effectively *integrates* the two story lines by connecting them: *"he thinks he can take the liberty to treat other people like that"* leads directly to *"she (.) could let it happen haha that she had children with him"*.

What Alice gains here, it seems, is a new story line that allows her to keep track of why she has ongoing relationship issues with her mother. This change of perspective is achieved through the following steps: (1) weakening the constraint interdependence (by relying on the therapist's attention orientation), (2) exploring new constraints (narratives available in forms-of-life), and (3) creating a new constraint interdependence (a narrative-formatted explanation of why she's angry with her mother).

Crucially, the second step requires an access to a public repertoire of narrative-formatted folk storytelling (Hutto, 2008) at the population level in the Forms-of-life frame. This particular format consists of agents that behave with unfairness (the father), patients that receive mistreatment (the mother and Alice), as well as patients who end up being agents who act wrongly by omission (the mother in relation to Alice). Persons learn these formats through media (e.g., novels, etc.) and other people's stories. It is a crucial dimension of psychotherapy that it involves *deep time-ranging*. It involves not just the personal Self frame but *exploratory acts* in the Forms-of-life frame as well.

Time-Ranging and Embodied Memory

We have shown how time-ranging allows Alice to explore her embodied behaviour in the conversational present, in relation to the slow processes that constitute her social system, as well as to her Self (as narrative) and her traumatic autobiography.

In terms of **Figure 1**, this time-ranging unfolds in the interplay between the three organisational frames of the conversational present, the Self, and the forms-of-life. However, as it is clear from **Figure 1**, our overall theoretical framework predicts that the sensorimotor frame constrains Alice's psychopathology as well. This assumption is fully in line with both EP and EA, in which there is a rich history of tracing emotions to embodied experiences (Colombetti, 2013).

In this last part of the analysis, we explore the sensorimotor embodiment of Alice's time-ranging. It comes to the fore when Alice is prompted to explore how her autobiography is not only narrated but crucially also *experienced* as a situated embodied sensation. In terms of **Figure 8**, the behavioural continuity on T5 is not just in terms of speech, but crucially also a question of posture, breathing, and interoception.

We see that in Excerpt 9, which surfaces shortly after Excerpt 8. Alice recounts an episode that her mother has told her, in which Alice's father violently assaulted her mother, when she was pregnant with Alice. As expressed in Excerpt 8, Alice is angry, which prompts the therapist to explore the embodied sensation of her anger:

Excerpt 9: session 8; timecode 17:23 – 19:24

T: () Alice (.) what is it that you feel right now (.) when we talk about it

P: well it is that feeling of unreality (.) I just come to think (.) well she even fears for her life (.) but she chooses to have kids with him anyway

T: what happens in your body right now (.) ()

P: mm (.) that- th- that I cannot explain (.) I cannot explain it

T: no

P: a bit hopeless I think

T: ()

P: I mean

T: breath a while

P: yes (.) yes

T: yes

P: and I do think

T: do try to stay here

P: yes haha

T: you are drifting away

P: yes haha

T: yes (.) try to tell me how it feels like

P: I've got a dry throat

T: you got a dry throat

P: or a dry mouth

T: yes

T: how do you feel in your shoulders

P: I don't know- I can't feel that

T: you can't feel them

P: I can't feel shit

T: how does it feel right here

P: I don't know

T: how ()

P: so shallow

T: [shallow]

P: [it all]

P: yes

T: yes (.) how do you breathe

P: shallowly (.) I think

T: shallowly

P: not all the way down with my stomach

T: no (.) so when we talk about (.) your childhood and the things that happened (.) to your mother and to you (.) then it becomes very unreal

P: yes

T: it becomes something that has happened to another

P: yes

T: and it is as if you disconnected

P: yes (.) but I have to consider it in order to find out why I am like I am

T: okay

P: I think (.) and perhaps under- perhaps under- also get to understand why I suffer from anxiety and why I am so (.) vulnerable and in general a very troubled person

Strikingly, Alice reports that she is unable to feel her bodily reactions when prompted by the therapist: *I can't feel that, I can't feel shit*, etc. By confirming a feeling of being disconnected, Alice is confronted with a time-ranging barrier: rather than re-experiencing her own autobiography, *it becomes something that has happened to another* – in the words of the therapist. The trauma is present in the local here-and-now, and not just a past event long ago. Or vice versa: the body is irreducible to a present state, it is its past too. On this deep sensorimotor level, time-ranging appears in Alice's disability to feel her shoulders, her breath, her body. Thus, her time-ranging is dysfunctional

because she is unable to integrate her bodily reactions with her self-reflexivity in the conversational present.

In this excerpt, we see an important dimension of psychotherapy, as the therapist picks up on the embodied aspects of Alice's time-ranging. By prompting her to feel parts of her body, she helps Alice to realise that she cannot feel her body as she invokes her traumatic past. On this account, *guided interoception* functions as a time-ranging technique that allows patients to explore the sensorimotor experiences that are part of the psychopathological entanglement. Further, the therapists asks two questions (*"it becomes something that has happened to another"*) and (*"it is as if you disconnected"*), that functions as interpretational frames for Alice's interoception, so that they contribute to her self-reflexive understanding of how the horizontal stretch of temporality curls into a present body-with-a-history.

DISCUSSION

The case study shows how the framework of MT allows us to single out particular instances of constraining action (e.g., changes in speech rate, changes in narrative content) for purposes of analysis whilst taking seriously the necessity of building a bigger picture that does justice to the interdependencies criss-crossing the boundaries of brains, bodies, and environment. Those boundaries, although existing in nature, are secondary for the framing of the proposal, instead, our starting point is in the middle of the changing meshworks of processes that realise mutual constraining interdependencies. With the guide of the proposed mapping, the observer is prompted to locate particular relationships on the map by moving, not so much inward/outward across the traditionally assumed boundaries of the brain and body (Ramstead et al., 2019), but "up"/"down" across layers of timescales, temporal ranges, and organising frames.

The particular outlook afforded by the framework coincides with important aspects of experience. Thus, rather than standing alone as a seemingly abstract theorisation, the framework speaks of aspects of lived temporality just as they appear not only in the experience of psychotherapy but also in everyday life: persons converse in the shops, write their memoirs, or make works of art, with a spontaneous sense of deep temporality and the self-reflexivity brought forth by time-ranging. The concept of time-ranging is proposed to capture the experiential signature of MT: the lived richness and depth of field of the present moment populated by non-local events and what appears to be absent in the here-and-now.

Persons gain the skills of (re)configuring the coherence of the here-and-now by meshing multiple temporalities. For example, by using vocal gestures that bring forth constraint interdependencies to bear on the situation, persons live a rich present as they navigate the constraint landscape in flexible ways, positioning themselves within long-term projects and established relationships (cf. Steffensen, 2015).

We show how time-ranging manifests in the professional skills of psychotherapists and in instances of therapeutic progress. Firstly, psychotherapists are capable of picking up

and pointing to a series of relevant gestures from the patient and trace their interdependence with slower-than-conversation timescales of the patient's changing participation in family life, career, public life, intergenerational relationships, and beyond, into population-level patterns and narratives. Secondly, with exploratory actions accompanied by the therapists, persons may learn to notice and then reconfigure the coherence of their here-and-now by reorganising and bringing other constraint interdependencies to the fore, thus transforming their agency and their ability to anticipate future events, that is, becoming more flexible time-rangers.

With the framework, the idea that individuals navigate in a thick here-and-now thanks to a history of interactions acquires a sharper rendition. Moreover, it brings together under the same light both the ecological legacies and organismic habits belonging to a deep history of individuals and populations, and the quick changes at short timescales responsible for the variability and flexibility of particular interactions. Each of the organising frames proposed connects long timescales of legacies/habits and short timescales of variability.

Crucially, the proposed distinction between slow and fast constraints within a temporal range brings light to the synergy between long-term habits and the capacity to explore new unprescribed possibilities. Fast constraints, which vocal gestures instantiate, may provide a key to understanding the mutability of interactions. Iterations of fast constraints are never identical, thus, by harnessing the improvisatory nature of articulatory gestures – as fast constraints – individuals may pull new constraint interdependencies to bear on the present situation. Slow constraints allow change by virtue of the existence of larger repertoires of regularities, in the case of psychotherapy, in the form of substitutive or complementary narratives of personal relationships, existing in a public storytelling domain, that can be incorporated anew into the patient's own interpretations of the present situation. In this way, the unique synergy of fast and slow constraints accounts for both the (re)production of behaviour and the emergence of genuinely new configurations of constraint interdependencies. This synergy is a more precise reason for analysing interdependent networks of constraints rather than observing constraints in isolation.

Further Discussion: Ecological and Enactive Connections

We elaborate on the need of a fresh new look at conceptualisations of temporality in the EP and EA literature. MT, as a third perspective, brings a different light to these concepts.

The concept of time-ranging incorporates aspects of the "ecological-enactive" view offered by the "skilled intentionality framework" (Rietveld and Kiverstein, 2014). Following the skilled intentionality framework, time-ranging implies that persons need to be minimally sensitive, selectively open, and ready to act towards reducing the felt tension in a situation. In other words, a basic form of skilled intentionality needs to be in place whereby actions tend towards an optimal positioning in a "field of affordances" (Rietveld and Kiverstein, 2014). The notion of tendency towards an optimal grip captures

this phenomenon (Merleau-Ponty, 1945/2002; Bruineberg and Rietveld, 2014). In a situation, through sedimented histories of experiences, persons find themselves being pushed and pulled into particular actions, positions, and trajectories, usually leading to a temporary “improved grip in the environment” (Bruineberg and Rietveld, 2014). Merleau-Ponty’s basic example is the “microscopic” adjustment and positioning of the enthusiastic art gallery visitor near the optimal distance to a picture (Merleau-Ponty, 1945/2002, p. 352). In the current proposal, we have elaborated on how persons optimally position themselves in temporal terms, reconfiguring constraint interdependencies with the use of actions that seek to reduce the felt tension in a situation.

We have also shown how part of the canon of EP can also be translated into the perspective proposed. The work of the therapist is to guide attention and thus expand the repertoire of temporal ranges that are meshed in the present situation. We have argued for an interpretation of the therapeutic work in terms of perceptual learning and education of attention.

More interestingly, we leave open the discussion regarding a fruitful connection with the theory of affordances by showing how affordances manifest different historical depth in terms of their associated constraints. As we have pointed out in section “Unpacking the Ecological and Enactive Connections”, what seem to be contrasting views between different interpretations of Gibsonian notions are seen, we propose, as based on a difference in what is assumed to be the fundamental extent of the temporal range of phenomena under scrutiny. Similarly, the distinctions between organising frames may parallel contemporary distinctions between physical world, habitat, and *Umwelt* (Baggs and Chemero, 2019), thus, potentially bringing temporal depth to the evolving ecological literature.

The framework of MT remedies the current poverty of concepts with regards to how human living spills over many timescales. EA correctly notes how dynamics unfold in what can be called a “thick here-and-now” (Buhrmann et al., 2013, p. 13). This expression conveys the idea that the current moment is not simply a narrow window constituted only by those actualised states of a system. Instead, “The current state reflects a history of changes that the system has undergone over time. In this way, the totality of past events is brought to bear on the current situation” (Buhrmann et al., 2013, p. 13). The thick here-and-now is thus a necessary consequence of the strong dynamicism present in EA and its focus on the histories of interactions (Cummins and de Jesus, 2016), that is, the established tendencies of the agent(s)-environment coupling, its “virtual traces”, and “virtualities” (Di Paolo, 2015). However, while EA acknowledges the importance of “complex temporal and intensity conditions such as speeds, deadlines” (Di Paolo et al., 2018, p. 28) as well as “different rhythms, temporal scales, and phenomena of synchronization and co-variation [...] at the core of [a living system’s] constitutive processes” (Barandiaran et al., 2009, p. 379), it falls short of offering a toolkit for addressing and tracing these temporal phenomena in a concrete way. The aim of this article is to remedy this lacuna with a combination of a mapping of temporal ranges, organising frames, and an expanded conceptualisation of the constraint closure formalism offering an economical way of accounting for the structuring effect of histories of interactions.

The constraint closure formalism by Montévil and Mossio (2015) has various unique characteristics that may be complementary to EA’s notion of individuation. Sets of constraints that form a constraint closure collectively maintain and stabilise one another across a wide range of spatiotemporal scales without additionally requiring strict closure of underlying processes. We have developed this idea further by proposing networks of interdependent constraints that necessarily occupy wider temporal ranges and do not fit squarely into traditional boundaries of the brain, body, social groups, and environment. In our interpretation, these properties allow us to flexibly narrow down or open up the scope of temporal ranges under consideration. Accordingly, rather than stipulating *a priori* and singling out the existence of essential constraint closure structures, we propose to use the mapping of organising frames to investigate domains with different intensities of tendencies towards constraint closure. By doing so, the framework could deal with different research interests and smooth the conceptual transition between nomothetic and idiographic perspectives: from theoretical biology to the analysis of particular personal histories (e.g., in psychopathology).

Finally, by proposing a tendency towards constraint closure in wider temporal frames we leave open the discussion of the conditions and constituents of normativity (bio-social norms) (Steiner and Stewart, 2009). The effect of a tendency towards constraint closure implies that activities and situations channel themselves into forms of path dependence and habits that manifest norms generated within the domain itself of habitual interactions (James and Loaiza, 2020). Likewise, in EA, habits display the requirement of self-maintenance that is needed for an account of normativity (Barandiaran and Di Paolo, 2014; but see a critique in Barrett, 2017). Our view may elaborate further the notion of habit and is inclusive of the varieties of bodies view of EA (Di Paolo, 2020). The framework, however, is not exhausted by conservative views that ground normativity essentially in body-bound individuality, self-production, and self-distinction.³²

Future Work

We have shown how the proposed framework occupies a space not only in between but also beyond EP and EA, while facilitating the conversation across the table. Although we do not foresee a unified “E” theory – a marriage of EP and EA – the framework shows promising connections between E approaches and recent attempts to develop a distributed perspective on language that takes a starting point in meso-scale organism-environment interactivity (Cowley, 2011, 2012; Thibault, 2011; Steffensen, 2015; Harvey et al., 2016; Thibault and King, 2016; Steffensen and Harvey, 2018; Gahrn-Andersen et al., 2019), as well as wider anthropological discussions of social life in “E”

³²Similarly, we leave open the discussion about how the notion of autonomy used in EA literature can be complemented, constrained, or even subsumed within the models of constraint closure and the more liberal idea of a tendency towards constraint closure in wider temporal ranges. Accordingly, the notion of autopoiesis (itself a subclass of autonomy. See Maturana and Varela, 1980, 1987; Varela, 1997), may be seen as a dense subset of constraints within the larger network of constraint interdependencies in what we call the basic-life organising frame (Figure 1). The semipermeable membrane of an autopoietic system is an important, but not uniquely special, constraint on the interior reaction processes (Virgo et al., 2009).

terms (Loaiza, 2016, 2019; James and Loaiza, 2020). Many details of these connections are, however, still missing. Future work could also focus on a more robust methodology of analysis, for example, by linking to other existing non-reductionist views in mental disorder research. In particular, it is possible to see how the theory of constraints could be complemented with the network model of mental disorders (Borsboom, 2017). While this article has contributed with a proof of concept for the viability of taking a starting point in MT, we hope that future work will pave the way for a broader methodological applicability.

DATA AVAILABILITY STATEMENT

All datasets generated for this study are included in the article/**Supplementary Material**.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Danish National Committee on Health Research Ethics. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JL proposed the hypothesis in “The Backbone: Constraint Interdependence” and “Discussion”, and the overall outline. SS

designed the study (see acknowledgments). SS and ST collected data, analysed data, and identified the case. JL and SS wrote the final draft. ST contributed to earlier drafts, provided input, comments, and suggestions that were implemented in the final drafts. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2020.01685/full#supplementary-material>

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Reading: How Readers Beget Imagining

Sarah Bro Trasmundi* and Stephen J. Cowley

Centre for Human Interactivity, Faculty of Humanities, University of Southern Denmark, Odense, Denmark

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Edited by:

Anthony Chemero,
University of Cincinnati, United States

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Elena Clare Cuffari,
Franklin & Marshall College,
United States
Maurice Lamb,
University of Skövde, Sweden

*Correspondence:

Sarah Bro Trasmundi
sarbro@sdu.dk

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We trace reading to an embodied synthetic process that drives the rapid scales of imagining. As sensorimotor engagement with written artifacts permeates experience, it sharpens the sensibility that brings forth understanding. We thus trace material engagement with written artifacts to fine control over saccadic eye movements and voicing that draws on humans or what the Greeks knew as *aisthesis*. In reading, we identify aisthesis in how prereflective judgments punctuate the flow of engagement with written documents. While the study of reading often begins with “texts,” we start with how written artifacts are put to use. We use cognitive ethnography to trace reading to how fine multiscale coordination enables readers to engage with written artifacts such as books. Our ethnography of reading provides descriptions of how readers use sensorimotor activity to integrate understanding with saccading and actual or imagined vocalization in ways that show how reading connects sensorimotor schemata with highly skilled use of written artifacts. By pursuing the power of rapid multiscale dynamics, we complement views of reading as slow-scale subjective experience. Rather than focus on interaction between a reader and an imagined author, we turn to coordinating with an affordance-rich environment. Human prereflective judgments demonstrably use collective experience with written signs. In fine-grained analysis of authentic data, we therefore track kinesthetic experience to how a child’s vocalizations beget understanding and, at once, imagining. These observations show how engagement brings life to written signs by connecting other peoples’ pasts with the use of gaze, gesture, voice, and touch. While describing saccades and bursts of vocalizing, we reach beyond analogies with interaction and, in so doing, the multiscale approach takes enactive-ecological work beyond the slow interactional and social scales or reported experience. Imagining arises as readers use multiscale happenings to bind the anticipated, the seen, and collective aspects of experience.

Keywords: embodied cognition, imagination, aisthesis, reading, dialogicality, distributed language, languaging, cognitive ethnography

INTRODUCTION: READING MECHANISMS AND IMAGINATION

As Di Paolo et al. (2018, p. 304) modestly suggest: “we are still a long distance from being able to say what happens while we are reading a text.” Likewise, Dehaene, a neuropsychologist with expertise in the reading brain, states that reading, at first sight, appears to be almost magical and a special talent that our brain was not originally designed for. According to him, a true science of reading is only recently coming into being, and it deals with broad questions such as “how is a reader able to immediately understand written marks in ways that opens

up imagination?” “Why do readers take delight in reading small stories and ancient tomes?” “What are the underlying mechanisms that allow a reader to draw on a social technique of reading as well as lived experience to accomplish the amazing feat, we call reading?” And we add “what role does the living body play for imagination?”

In this paper, we thus aim at extending our grasp of reading mechanisms that allows for imagination. While imagination is prompted by material engagement with the book, its enabling conditions are traced to multiple timescales that link lived experience, norms, expectations, and anticipations. We use cognitive ethnography by turning to how readers’ engagement with books are enabled by continuous small-scale, observable judgments (hesitations, gaze, pitch) that are traced to multiple sensibilities as well as to functional sociocultural values and norms. Following Dehaene, such a multitemporal scope is necessary, as reading draws on an ontogenetic history that rewires the brain and, as we suggest, uses a primate history of engaging with artifacts. Our argument is based on an evolutionary model of human material culture that helps us understand the enigma that when we read highly sophisticated and human-made marks on paper and screens, we use “a primate brain originally designed for life in the African savanna” (Dehaene, 2009, p. 4). That the modern human is the only species with the cultural ability of sophisticated reading is a riddle that relates to the human capability to stabilize actions over time *via* language, inscriptions, and other tools that are results of human material engagement. Material engagement is thus an embodied condition for the establishment of human culture (Dehaene, 2009; Malafouris, 2013).

Even though radical embodied cognitive research is opening the domain of what happens during reading, approaches continue to lack an account of *how* reading allows for imagination (or imaginings) and understanding without making appeal to classical functionalism. Even neuroscience reaches bedrock in the attempt to explain how understanding emerges because it lacks an account of how experience and cultural norms and values impact here-and-now sensations and the local judgment that enables synthesis and opens up imagination. Further, a reader also draws on experience that cannot be described from a standard linguistic meaning-making perspective. By that, we mean that a reader has lived experience, which matters for continuous judgments of the written page. The reader’s skilled eyes and body “give life to what would otherwise remain a dead letter” and thus involves something very different from decoding letter–sound correspondences. Different from nonprimate material engagement, such as nut-cracking behavior, reading is not just functional and hedonic. Rather, we argue that it involves overall human sensibility, a set of ever more refined prereflective abilities that Montani (2017, 2019) traces to human aisthesis. Specifically, aisthesis arises as one gains experience of attending to one’s engaging with material properties of the world. As a result, people develop expertise of sensibility. In the case of reading, as shown below, it depends on timing how we saccade (and move) while drawing on expectations and feelings. In that it is prereflective, one cannot set out to explain why it happens or what it means; one can only track

evidence for its occurrence. It plainly includes echoes of previous seeing, hearing, smelling, tasting, and touching. Aisthesis thus draws on continuous prereflective judgments that arise in local engagement with visible patterns on a page. The resulting ways of looking feeling and, in some cases, vocalizing are constrained by how one draws on expectations, emergent properties of the situation, the tools with which one is engaged and the historicity of the engaging body, in this case as a reader.

Embodiment is thus a necessary condition for imagination, and it opens up for an understanding of prereflective structures that comprise recurrent patterns of sensorimotor experience: we have learned to *appreciate* certain perceptions from a history with storytelling and reading that involves more than just functional judgments. While we do not know how or when nonfunctional and nonhedonic judgments arose, Montani (2019) argues that they have become important in the last 50,000 years – and, since they are learned, they must be traced to the evolution of ontogeny. Crucially, they draw on group values that we claim are central to human sensibility as appears in reading. “*There are almost no human societies that do not practice some form of drawing or engraving, be it on rock, mud or the human body. These forms were already amazingly well mastered by our ancestors in the upper Paleolithic age*” (Dehaene, 2009, p. 313). In contrast, no other species of monkey or great ape created and valued something similar that was passed on, developed and manifested through aesthetic judgments. Species such as bearded capuchins that crack nuts and seek out lizards using sticks – they too draw on material engagement to develop skills that they use to change cultural techniques. However, they do not show any signs of aesthetic judgment. Similarly, while nonhuman primates can learn to recognize symbols, they tend to use them functionally and to gain rewards. Certainly, they do not seek aesthetic outcomes or engage in moral reasoning; that is, they do not use symbols to take or change perspectives. In primates, the use of techniques is learned in ontogeny and thus integrates evolutionary, developmental, and individual timescales.

However, the multiscalarity of modern human agency reaches beyond that of other primates, in part, because humans make continuous judgments that are constrained by how ontogenetic history builds on social values and lived experience. In cognitive archeology and, above all, material engagement theory, their skills are traced to *modern* use of material artifacts. In making late stone age pottery, for example, human artifacts link individual skill with cultural style. We define such artful actions as the hallmark of aesthetic judgment. For Malafouris, the actions feature semiotic aspects that pertain to groups – showing that aisthesis draws on but is not to be explained by sociocultural organization. Judgments of skill and style thus arise as a flow of felt responding that arises in fitting actual experience with *de facto* expectations. They dominate talk-in-interaction and were originally traced to “contextualization cues” (Gumperz, 1982) or, in modern terms, by the play of intercorporeality.

For example, when South Asians offered “gravy,” their speech was often perceived as unfriendly. This aesthetic judgment was traced with a falling prominence (over around 200 ms): it was a reflective judgment or felt reaction (see, Cowley, 2006). Felt reactions occur in all modalities and can be described as

interactional synchrony, accommodation, sensorimotor empathy, attunement, entrainment, and, importantly, how infant-caregiver activity comes to be coregulated. We insist that the sensibility shown – aisthesis – is irreducible to the functional and hedonic. On a third person view, the results have aesthetic/axiological elements that contribute to infant musicality (Cowley, 2003) that arises from being moved and the *intrinsic motive formation* (Trevarthen, 1999) that results from “primary intersubjectivity” (Trevarthen, 1979). While the coentrainment has been debated for 40 years – there is no doubt that *de facto* judgments influence interaction, attachments, and, importantly, how a child develops. Later in the discussion section, we use the work of Rossmanith et al. (2014) to illustrate aisthesis in the musical vocalization of “velvety soft nose” (placing prominence on the syllable in bold).

Talking draws on pico-dynamics that draw on experience, expectations, and ways of orienting to a situation (and artifacts). We claim not only that reading is a mode of action but that it also draws on aesthetic judgments that integrate histories that draw on many temporal scales. Where rendered aloud, these are enacted in vocal modulations (or prosody) that are part of flow, shape, and felt reactions. These are the hallmark of aisthesis, which, while having a “subjective” aspect, is too subtle for first-person description because the judgments are too culturally complex and far too fast to be conceptualized in real time. This view is important for the current debate of agency within ecological psychology and enactivism. No appeal to a person level of description, an organism–environment system, or autonomy can capture this multiscale depth. In observing a reader, we emphasize that humans are strikingly heteronomous.

Further, it has often been within psychology that we find models that treat reading as individual and computational. With a recommendation from neuroscience to study the cultural, anticipatory, and experiential basis for reading, we thus challenge this view. By example, Dehaene (2009) argues that the saccading mechanisms involved in reading reflect cultural techniques that relate a cultural-dependent visual exploration strategy to a particular language and script (Dehaene, 2009, p. 17). Further, readers immediately perceive sounds, and there is abundant proof that this almost automatic process relates to our skill in linking multiple sensational experience, such as vocalizations, to what the reader saccades to. By expanding the brain-bound focus within neuroscience, we suggest that we can trace reading mechanisms to processes outside the brain, too (cf. the analysis). Specifically, we propose an ethnographic approach to observe the rapid scales of how embodied judgments are articulated on the rendering aloud. In pursuing reading, therefore, we focus on shifts in perception and felt reactions, which philosophers ascribe to the fringe of conscious experience, the proto-phenomenological and, especially, preconceptual judgments. Specifically, our concern is with the equivalent of prosody – a reader’s judgments that are neither hedonic nor, in any direct sense, functional, as we emphasize in the analysis.

Accordingly, as in the enactive-ecological tradition, we reject approaches that trace reading to the use of verbal structures (as in structural narratology or the individualistic-based approaches to text interpretation in communication studies). We fully endorse Popova’s epistemological challenge to

individualistic views where narratives reflect “autonomous and self-contained worlds” (Popova, 2014, p. 322). However, we do not adopt her focus on sociointeractional relation between intentions or viewing as “expressions of intersubjective meaningful action and participatory sense-making between tellers (narrators) and readers” (p. 321). Our work contrasts with that of Popova and colleagues in that we do not ask how, in principle, stories and texts are understood over minutes and hours. Given an interest in events that bear on reportable experience, Popova presents her work as:

“social interactions, rather than sensorimotor ones, dominate certain human practices, specifically the production and reception of narratives [...] while the agency of an individual is of great importance for sociality, it is acting for and through one another (interacting) that ultimately defines who we are. **Our human world is a social world and it takes place in large measure outside of our brains, in the common shared activity that is life**” (Popova, 2014, p. 315 our emphasis).

We too recognize that a “social world” unfolds outside of our brains and that reportable experience is important. It is thus no part of this paper to challenge the descriptive value of her rich account – just as we endorse literary readings that look beyond code views to pursue relevance theory. Rather, in rejecting the focus on an autonomous agent or person “level,” we turn to necessary conditions for expectations and judgments that shape, draw on, and, ultimately, ground a reader’s competence.

Our concern is ethnographic and far from offering explanation or philosophical argument; we present reading as based on primate intelligence and skill with material artifacts and finally how humans rely on prereflective judgments that draw on forms of sensibility that we ascribe to aisthesis. These arise as we use eyes, voice, and hands (and imaginings) in the scales of saccading or making/imagining rapid speech bursts (typically between 200 and 500 ms) of around five to eight syllables. Our focus on rapid activity and prereflective shifts in action/attention is intrinsic to socially derived forms of human understanding and imagining. The claim is, emphatically, not that the aesthetic somehow “causes” what is reported at a person “level”: rather, aesthetic skills and sensibility are part of what a person is such that, in Noë’s terminology, one can “do conscious experience” that has proto-phenomenological and prereflective aspects.

Our focus is not on careful reading or how, if well trained, one construed arrangements of digital artifacts as texts. We concur, in the terms of Di Paolo et al. (2018, p. 304), that we *can* choose to perceive such artifacts in terms of “material symbolic patterns” and, to the best of our ability, treat them as “products of linguistic bodies acting symbolically.” However, in presenting ethnographic work, we show that just as talk-in-interaction does not reduce to language use, textual interpretation is *one* aspect of whole-body activity – it is only partly “linguistic.” Again, we assume that, as a primate, a reader has hedonic and

functional concerns that draw on a history of responsive understanding, the resulting expectations and experience of epistemic modes of action (“play”). By that we mean that, as primates, we draw on observation-based learning in discovering cultural techniques.

As material engagement, reading too depends, in part, on intrinsic motivations that are action and other-oriented, that is dialogical (Linell, 2009). For instance, infants are moved by the movements (and voices) of others to self-motivate by using a peculiar altricial-precocial pattern of infancy that emerged about 2 million years ago. Strikingly, human infants are musical and, remarkably, develop a tendency to babble in what we – and they – hear as pleasing. Such behavior makes the voice into a cultural tool that shapes a situated sense of what is appropriate, and as such, preconceptual judgments bind hedonic, functional, aesthetic, and axiological aspects. This behavior enables infants to develop interindividual ways of acting, as they orient not just to organisms/objects but to people and things. In so doing, they behave functionally, for pleasure, and draw on aisthesis. On their own, they *improve* their babbling.

Hence, we regard early ontogenesis as functioning, above all, in discovering a world of what Linell calls “interdependencies that do not reduce to outer cause–effect relations” (Linell, 2000, p. 2). Indeed, much human action relies on interdependencies between the material properties of artifacts and the manifest expectations of persons who may themselves be present or absent. In Linell’s terms, we depend on not only context that is realized but also a wide range of contextual resources – cues and hints at what is accessible and may be relevant; that is, in his terms, we rely on “apprehension of the environment” that, as we show, is irreducible to the functional and the hedonic. Acts of saying, sign-making, talking, and reading draw on criteria that are not derived from the person who acts. In this sense, we argue that appeal to a person “level” reifies a structuralist description and masks our dialogical constitution as living human beings. As we perceive and act, we bring other people’s past experiences into play, or in Bakhtin (1984) terms, we take part in *polyphony* by drawing on preconceptual judgments that, we contend, are not just functional and hedonic but at once draw on other forms of sensibility – ones that are associated with aisthesis.

AN ETHNOGRAPHY OF THE RAPID SCALES OF IMAGINING

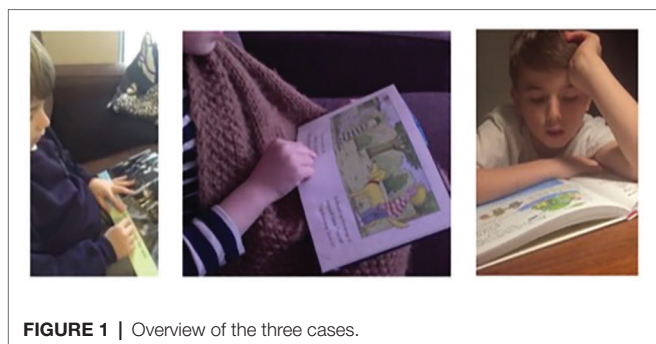
We propose that our understanding of reading activity can be extended by using cognitive ethnography in scrutinizing embodiment with special attention to pico-dynamics. Repeated viewing generates rich ethnographic descriptions of material engagement and how mediated action is punctuated without reduction in qualities based on the individual, interaction, or the environment. In emphasizing how cultural experience lead to judgments, our work emphasizes human experience: “Ecological realism, briefly, is the view that the habitat (not the *umwelt*) exists independently of a given animal, that it contains meaning, and that this is the appropriate scale at which to investigate

human and animal behavior [...] The *umwelt* of an individual organism is neither “pre-given” nor a mental construction; it is enacted during the individual’s history of development and learning” (Baggs and Chemero, 2018, p. 12). By turning to video records and relying on ethnographic methods, we stress how information pertaining to a cultural ecosystem appears *for an observer* (Hutchins, 1995; Ormerod and Ball, 2017). We can track how the *umwelt* changes both for an individual perceiver (e.g., as wordings are construed) and how public felt reactions enable one to make judgments as one picks up “real” information. Empirically, we combine video-based cognitive ethnography (Hutchins, 1995; Steffensen, 2013; Trasmundi, 2020) with the tools of multimodal interaction analysis (Goodwin, 2018) that enable reading to be traced to embodied experience of material and a flow of judgments that bring forth imagining. We thus shift the weight from information (about and for agents) to how readers use looking and voicing to bring multiscale experience to the material engagement that is a necessary basis for imagining. In putting phenomenological function at the fore, we stress how reading books – or other writing-based materials – generates punctuated experience as, in the now, people draw on aisthesis. Overall, ethnography enables us to describe shifts in the rapid dynamics of such activity and how judgments set off continuants (held gaze, marked changes in pitch, rhythm and tempo, use of drawl and breaks in the reading flow, grimaces, etc.). These events of typically ± 500 ms are traced to how saccading co-occurs with imagining or voicing. In pursuing the special cases of reading aloud, we focus on what speech bursts (whose units are typically 250–500 ms) show of judgments of appropriacy. From those descriptions, we can identify how readers skillfully use collective constraints (i.e., alphabetic marks) to pull in repertoires of codependent structures that extend beyond the immediate situation.

We explore these rapid scales in single cases from a pilot study for an ethnographic research project, *Embodied Reading*, conducted at the University of Southern Denmark¹. The pilot project involves three ethnographic case studies collected in 2012 and 2019. The data cover aspects of a boy’s acquisition of reading skills over time. In this context, we place analytical focus on how engaging with a book brings forth imagining. The recordings took place in the boy’s home as part of a study of natural reading ecologies. In this work, we show excerpts that illustrate a variety of embodied strategies (vocalizing, saccading, and gesturing) used to bring forth imagination. ELAN software² was used to annotate and transcribe video recordings. The authors (coders A and B) made the transcription and data coding individually. Specifically, the reading data use four annotation tiers: gaze, hand gestures, movements, and articulation.

¹The involved parties were informed about the data collection, protection, and data management. The participants did not receive any payment or compensation for their participation in the project. All participants and children’s parents have given consent to participate in the study, including being the subject of analysis in research publications.

²ELAN is a professional annotation tool developed by researchers at the Max Planck Institute for Psycholinguistics, The Language Archive, Nijmegen, the Netherlands. It is developed for the creation of complex annotations on visual data (Sloetjes and Wittenburg, 2008).

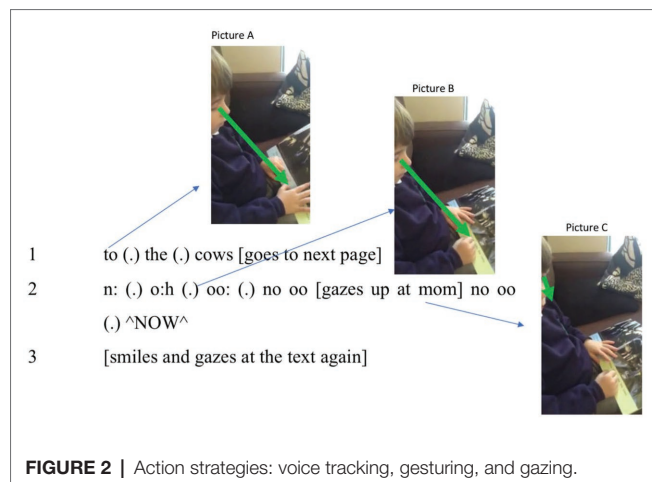


Reliability for observer judgments ranged from good to excellent as both coders A and B assessed the four domains of embodiments with a high degree of consistency. We suggest that, taken together, the excerpts show the multiscalar, embodied nature of reading. The data covers different stages of the boy's reading history spanning his initial reading experiences as well as more developed skilled reading (7 years later). Observations and interviews with the boy were conducted after the video recordings were made. In the first two examples, the boy reads in English (his second language), and in the third example, his brother also participates in activity that uses Danish (his dominant language). **Figure 1** above offers an overview of the cases and, in the first place, shows how bodily and nonbodily features are united in reading that is engineered in a socially organized domain or infrastructure.

ANALYSIS: GROUNDING READING IN IMAGINATION

Constrained Imagination: Trusting the Collective

In the first case, a 5-year-old boy is trying to bring learned procedures to what he sees. As one would expect, lack of experience prevents him from seeing meaningful "text." Despite school experience with pragmatic or goal-directed strategies, he battles to render the written patterns out loud. Indeed, in zooming in on a few seconds, he is observed to switch between five embodied strategies. (1) He reads word-by-word; (2) he also reads by letter-and-syllable; (3) he looks for visible prompts in the book; (4) he uses both index fingers interchangeably (one for the left and right pages in the book respectively) to maintain attention on digits; and (5) he brings forth a more conventional talk-like burst. Given such embodied reading strategies, we show below that prereflective judgment underpins these striking shifts in ways of attending. This observation is important because those who begin with texts often appeal to "coding" and, by so doing, completely overlook, not just observables but the importance of material engagement. That is, the code metaphor deflects interest away from why and when looking and voicing are put to use. On our view, by contrast, the boy's evolving capacity for judgment brings forth experience that rests heavily on prosody and bodily expression. The following excerpt shows the strategies in play in **Figure 2**.



In line 1, the boy fails to assimilate "to the cows" with his own articulatory habits by voicing syllables in staccato and not connected vocalizations. Rather than finding digital wholes, he relies on entities with quasi-phonetic or "word-like," properties. From classroom observation, we know that this technique is favored within in the school's cognitive ecosystem. In making use of the strategy, he shows its advantages and weaknesses. As he goes to the next page, having lost sight of the just read "cow," seconds later, he fails to recognize "now" (line 2). Being unable to utter "now," we will describe how he draws on aisthesis as he adopts a "letter-and-syllable" way of looking. As he changes strategy – and his way of perceiving – he uses prereflective understanding to bring forth expectations and actions as described below. First, he vocalizes [n] and seeks associations. He then treats "ow" as inviting, first [ou] and, when this result fails to help, he shifts to [u:] (line 2). Far from using a phonetic alphabet in *decoding*, he relies on tracking or monitoring his own vocalizations. In seeking something appropriate, he again draws on aisthesis (and his own experience). We see that as he repeats [nu:], he also seeks visible cues from mother (see picture C in **Figure 2**). During voice tracking, he is blocked until, suddenly, he blurts out [nau] in a way that is, impressionistically, triumphant. The importance of the prereflective engagement appears in his evaluation of his own empirical and perceptual actions (the multiple embodied variations of uttering n-o-w). Further, without familiarity with a language stance, he would be unable to evaluate all his variations of "now." As noted, he utters a prosodically marked *NOW* that co-occurs with a smile and a break in the phase, which we describe as judgments that punctuate the reading flow during the creation of continuants. While, in principle, a "neural search engine" might turn up a "rule," his strategy for shifts in vocal articulations show expertise in seeking a *suitable* way of vocalizing. After all, articulations of [au] are common, and moments before, he had rendered [kau] (or "cow") out loud.

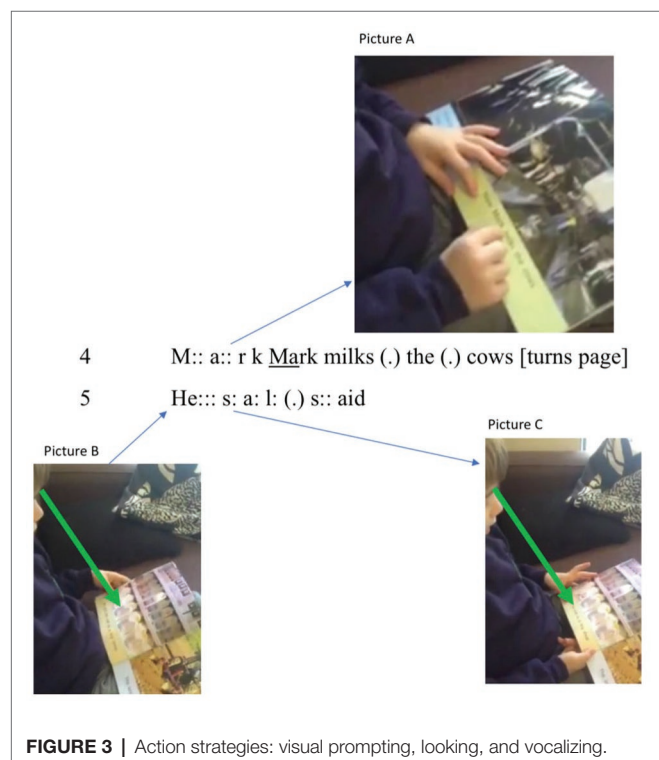
Indeed, our observations are also consistent with how "spreading activation" (Collins and Loftus, 1975) might be set off by saying "cow." Methodologically, the observation fits the multiscalar view that extrabodily resources (and echoes of collective experience) influence human agency. The boy relies on

socioculturally derived expectations that digital patterns will index familiar “words,” echoing experience with the language stance, so c-o-w is perceived or recognized as “the word cow.” We track that result to how his talk and gesture invite repeating, in ways that allow simple alphabets to shape phonological models. Further, as he says “now,” he uses a marked and very loud tone (^NOW^) as if announcing ownership of what he has brought forth. By focusing on vocalizing, the boy has no need for procedural knowledge (“decoding”) or interpreting (as in seeing “meaning” in the text); rather, he relies on aisthesis to trigger prereflective judgments and felt reactions. The output (^NOW^) enacts not a phonological structure but a phonetic event that resonates with positive experience (as noted, it sounds like a cry of triumph). In that way, his embodiment reveals feelings and the enactment of satisfaction at solving a problem as is displayed by a self-involving dialogical smile³ (line 3).

Having solved the problem, the next saccading sets off more fluent vocalizing. In what follows, we present a different strategy that, like the one above, depends on prereflective judgments or techniques of nature.

First, the boy slowly sounds out [mɑ:k] (line 4) and, then, breaking with “word-by-word” or “letter-and-syllable” strategies, shifts to an unmarked burst of talk-like vocalizing: “Mark milks” (line 4). Here, the alphabetic signs become (phonetic) words that echo the digital patterns (see picture A in **Figure 3**). With minor hesitation, he then vocalizes, “the,” followed by a micro pause, before he utters “cows” (line 4). Fourteen seconds

³Unfortunately, the smile is not possible to visualize in the picture due to poor quality, but he smiles just as he gazes down—away from the mother and back into the book.



after his struggle with “now” in line 2, the “ow” of “cow” in line 4 prompts an actualization of an [au] pattern. Then, having turned the page, he switches again. On this occasion, he uses “letter-and-syllable” as, with minimal hesitation, hearing his [sæi:] prompts him to substitute the nonphonotactic [æi:] with a standard version of “said” (viz. [sed]). Once again, we interpret this strategy as one of using the language stance in striving to fulfill expectations. As a result, he *listens to* what he vocalizes while *looking* at the page and, in this case, construing “the said” as text. Failure to glean [sæi:] “sai” seems to have triggered a negative felt reaction and, subsequently, synthesis of a familiar sound pattern (as [sed] is matched to “said”).

Appeal to decoding and text interpreta (or linguistic bodies) simply ignores a whole-bodied mix of strategies, judgments, and reliance on expectations of, in a word, the directedness of reading. Further, in ignoring the rewards of aisthesis, one fails to clarify why the boy *seeks* solutions. One simply overlooks why the boy strives to meet the standards of a wider collective and, indeed, to master fluency reading. This analysis challenges the view that *what one reads* are identified “words” or “forms” that map onto digital representations (and, for many mental or neural counterparts). Although there is no knockdown argument against appeal to the use of computational decoding rules, all such models ignore intelligent and unhidden judgments. Decoding only posits looking-based processing and not, as demonstrably occurs, activity that meets collectively defined goals. Based on the analysis, we regard the boy’s reading as aesthetic activity manifest in viable, prosodically structured wordings. The boy does not expect to be faced with nonsense, even when he only generates “quasi-words.” In short, to remain engaged, he trusts the social organization that gave digital shape to what appears on the page. As argued above, we trace this skill to expertise and making prereflective judgments as he uses the language stance and vocalizes and tracks his voice. As he does so, he creates expectations, and when they are not successful, he changes strategies and draw on how skills with the language stance prompt him to come up with possibilities. In time, he learns to articulate written marks on the paper in ways that correspond to teachers view of “text.” However, this skill, we contend, is not the basis for reading; rather, like all activity, reading has a sensorimotor basis.

The power of the collective is such that, at times, children trust it too much. For instance, in the case of another primary school boy – not yet a reader – he relies on emulating his older brother. In doing so, the boy organizes the reading practice, including his own position as a reader, because he can rely to only a limited extent on the social practices that are anchored in using books. This engagement is visualized below in **Figure 4**.

The little boy gazes in the book and, like a skilled reader, places his hands on the page to avoid the page from turning; indeed, he even synchronizes his page turning to his brother’s pace. While drawing on aesthetic judgement in attending to the page, he cannot yet perceive it as featuring “words.” Although the page does not afford rendering out loud (to him), he engages by pretending to read. In emulating his brother’s activity, his engagement is itself aesthetic. As argued above, tracing reading to how sensibility uses collective experiential imagination enables individual based heteronomy to draw on historical attunement



FIGURE 4 | Emulating a reader.

and self-dialog. Even beginning readers shift strategies as they engage with marks that they are still *not able* to see as “texts.” We ascribe these shifts to prereflective promptings whose outcomes are not just functional or hedonic by arguing that they have an aesthetic basis that is, from a third person perspective, aesthetic and/or axiological. In adding value to the shifts in movement, a reader constantly monitors vocalization and, in so doing, confirms the findings of Järvillehto et al. (2011) that reading is anticipatory. Our multiscale view of reading is crucial because a second-person orientation affords reflexivity that uses cultural norms or, in enactivist terms, new ways perceiving (Di Paolo et al., 2018). Thus, in this case, the little boy trusts and builds on already agreed descriptions and practices.

Turning to our second exemplar, we show how readers use a second-person perspective in the rapid scales of engaging with what appears on the page. Further, in anticipating understanding, the reader re-enacts experience of being interdependent with others within a given setting. As explained below, the reader’s use of a language stance permits the taking of multiple perspectives.

Dialogical Readers: Voicing Others

Evidence for how aesthesis shapes skills in projecting, acting, and judging the results of action are now illustrated by the same boy’s reading 2 months later. In Figure 5 below, we trace how a history of judgments like those described above have altered his action strategies. As a result, he has learned to immerse himself in the world of the book in a very different way.

Whereas the first excerpt features few “talk-like bursts” such as “Mark milks,” itself a partial repetition, this passage features many such continuants. While some are phrasal, others enact prosodically rich speech bursts of “W↑oaw, said Kipper” (line 1) or “this is my dog Z:og” (lines 2–3). Whereas a standard view

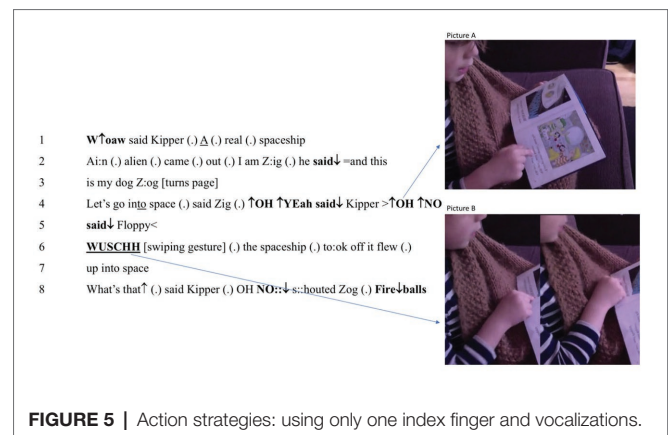


FIGURE 5 | Action strategies: using only one index finger and vocalizations.

invokes *looking* and phonological representation, such vocalizing shows a richness of experience that is made inexplicable by appeal to a linguistic model of “text.” Even as an early reader, the boy draws on prereflective judgment to gain prosodic control of, in these cases, connotations that echo verbal structure. Such appropriate utterances can only result from prejudgments that draw on not social or conventional construals but expert felt reactions. Further, in their connotational appropriacy, they attest to not machine-like processing but an aspiration to perform as well as others.

Here, we observe that the boy’s mix of strategies is thinning. For instance, he now relies on the left index finger only – and he no longer searches for visible prompts on the pages. Finally, we find only one case of vocalizing letter-and-syllable “Ai:n” (line 2). Indeed, his developing technical skills show that the word-by-word strategy is giving way to the use of saccade-based units. Over time, he has linked experience with rewards that draw on enhanced sensibility. Certainly, were technical, embodied skills are not part of reading, his actions (using left index finger to keep track of where he is as he vocalizes, for instance) would be hard to explain. Yet, since they aid in synthesis, we view them as part of the technique. Indeed, not only can saccading and action be synchronized, but also the boy’s vocalizations enact felt reactions. While prosody is unmarked in alphabetic writing, the boy uses it in rich ways (and not by, say, using the reading intonation of a weather forecast). Rather, as he projects connotational meanings onto what he sees as words, the boy’s judgments manifest the other-orientation of dialogicality (Linell, 2009). Rather than relying on self-involvement, he orients to moral norms and empathy. Not only does this other-orientation give the reading an aesthetic quality, but also it is manifestly axiological. Accordingly, we now sketch the phonetic shape of utterances of the “W↑oaw” (line 1) and, in line 4, where he simulates Kipper’s “↑OH ↑YEah”, as well as the vocalizing of both Floppy (in line 4) and Zog’s uttering of “OH NO:: ↓” (in line 8). In these cases, too, text-based “interpretation” is powerless to explain what is observed⁴.

⁴We emphasize that when arguing against text interpretation, we take interpretation to be a matter of improvising written or spoken utterances in a way that is, in some sense, equivalent to translating from text in one language to text in another.

Simply, no digital evidence bears on how prosody can or should be rendered aloud. The boy uses extratextual resources to go beyond the information given and relies on not alphabetic marks (or conventions) but linking imagined experience with felt reactions. In the case of “W↑oaw,” he finds himself prompted to use marked prosody (a rise–fall tone) that, while stereotyped, triggers a switch to a word-by-word strategy. In picking out what he sees, he makes a single use of letter and syllable to bring forth a vocalization with a curious anticipative property (in line 2). While he sees “an alien,” he overlooks the gap between the “words” by giving voice to, first, [æi:ən] and, in the saying, changing course to come up with [eli:ən]. He does not note the lack of “an” in rendering the wording and, in so doing, produces an utterance that chimes with common experience. This strategy shows how aisthesis enables him to evoke a collective abstraction from beyond the everyday. Far from being floored by the difficult pattern, he relies on embodied engagement with the book to exercise and extend his powers of imagination.

By using cases such as the above to build experience, he gains expertise and sensorimotor experience that, in later life, enrich prereflective judgments in orienting to written artifacts. In spite of the fact that the voice and its surrogates are usually excluded from models of reading, they seem crucial to gleaning even the unfamiliar (“alien”). The page itself acts as part of the cognitive system in that, through activity, its digital marks *become* “text for the reader.” The use of socially organized constraints allow uttering to mesh with the child’s nascent imaginary world of spaceships, aliens, and fireballs. Thus, while grounded in aesthetic experience of feeling and judgments, as we describe here, reading also enriches creative imagining. It allows for vicarious experience of emotion such as excitement, dread, etc. that pertain to not life as lived but a fictional domain. In this sense, the text brings forth *value* that is intrinsically aesthetic and inseparable from how collective domains organize culture and taste. In that sense, reading a book allows experience of dangerous emotions (as in “OH NO”) and exciting ideas while, at the same time, learning about their interrelations.

The ethnographic data confirms that the boy’s parents read aloud to him during his early years. As he has heard narratives over and over, he has rich ways of making judgments, using the voice, and in engaging with fictional universes and characters. While he can now see similarities between phrasal expressions, narrative voices in texts, etc., from the very start, reading never reduces to skilled perception of alphabetic characters (“decoding”). Rather, as in making a pot, aisthesis shapes looking, imagining (and, sometimes rendering aloud), and acting by tapping into the collective to conjure up affect and imagining. For example, in coming to feel excitement and fear in vocalizing [eli:ən], embodied neuropsychological models would suggest that the boy reuses neural networks (Anderson, 2014) that, later, can ground complex interpretation. As we have described, with reading, the activity is more than enactment of routines. Thus, in the second case, using a triumphant tone, the boy reads “NOW” as rhyming with “cow.” The marked prosody and concurrent smile show an expectation fulfilled. In so doing, he uses the language stance to confirm that he is

right: acting in this way *is* understanding or, in another idiom, coming to act in line with a rule. Imagining is thus a constructive process that, at the best of times, gives rise to a correct outcome. In the latter examples, we see how fluency changes the activity. For example, in reading “an alien” as, first, [æi:ən] and, moments later, [eli:ən], the boy draws on collective imagining. He connects with a culture where [eli:ən] (“aliens”) come out of spaceships. In a case such as this, he needs a language stance to treat the utterance as invoking *something* that belongs to a social domain of languaging. The peculiarities of orthography mask the phonology – ordinarily an initial “al” is pronounced /æl/ unless there is a later “e” (as in “ale”). The boy’s monitoring of the failed [æi:ən], however, adds value and understanding. In the second case, multisensory activity appears in the fluency of “mark milks” and, above all, how prosody enables him to reach beyond what is said to produce vocalizations like “W↑oaw” in ways that are appropriate to the context.

In sum, our case descriptions showcase how the child does conscious experience that grants expertise and enables him to become a readerly self who is open to many perspectives. Over time, we see how he gains flexibility by using a language stance as he renders text out loud by drawing on qualities that derive from prereflective judgments.

We now focus on both more goal directed aspects of a reading process and human dialogicality as we focus on how readers bring more fully fledged imaginative powers to material engagement as they unify saccading, silent thoughts, and uttered wordings. In doing so, we open up the discussion of how, in general, reading can be traced to the aesthetic judgments that are necessary to all cases of constructive imagination. The discussion integrates other examples of reading with our ethnography of reading to emphasize that reading is based on experience of (physical) wordings and that familiarity with engaging with written artifacts allows, with experience, for the construction of fully fledged imagined worlds.

DISCUSSION: IMAGINATIVE CONSTRUCTION

So far, we have argued that, as part of radical embodied cognitive science, languaging can be traced to perpetual dialog with a collective world. On that view, readers are seen as dialogical agents. Before consolidating the argument that imagining is a constructive process, we return to the prereflective judgments that, as shown above, ground even early reading experience. In so doing, we trace the expert syntheses to felt reactions that rise as reading insinuates aesthetic and axiological dimensions into experience. Just as social coordination uses, not knowing, but sensorimotor empathy (Chemero, 2016), sensorimotor engagement enables expertise to serve in gleaning situated “meaning.” Readers use sensibility and rapid judgments as coordinated saccading prompts use of tricks and skills with inscriptions that prompt and enable them to imagine vocalizing. That means that a reader links heteronomy, including collective voices, with burgeoning experience. We have identified two fundamental ways of so doing:

- adding value to the rapid shifts in movement, and
- monitoring the results to come up with understanding.

In the case of reading, we stress that prereflective judgments engender multisyllabic bursts of vocalization. The skilled embodiment is not only more than speech production but also fits Dewey (1958) view that, in imagining, we transform possibilities into eventualities. In the case of the boy, we have described how he uses expectations based on experience with the language stance in triumphantly vocalizing “now” as akin to “cow.” The move draws on prereflective judgments and how imagining can draw on aisthesis. In what follows, we go on to expand this insight to the wider view that imagining is not an inner process but, rather, a (re)constructive mode of sensorimotor activity with general application.

As we talk or read, we use a history of social coordination that is based on linguistic embodiment that evokes, but does not reduce to, “language” or, more precisely, wordings (see, Kravchenko, 2009; Cowley, 2011; Thibault, 2011). It is by developing sensitivity to what can be (and what is) done with these physical wordings (or unique events) by performing as a skilled actor in collective, socially organized activities. As we take part in languaging, we engage in perpetual dialog with a world that amalgamates and untwines different pasts or, in Bakhtin’s terms, rely on the unfinalizability of dialog (Bakhtin, 1984). This view of wordings can be further clarified by how Rossmanith et al. (2014) in a different study describe a moment when a mother reads to an infant who, by definition, cannot understand what is said. The mother vocalizes and punctuates the flow by putting emphasis on specific syllabic patterns. Below is an overview of their example and the transcription of the reading (see **Figure 6** below).

At the instant noted, the mother vocalizes “velvety soft nose.” The case exemplifies a *wording* or, for the authors, a “vocal arc.”

In the case in question, it features “a gradual rise in pitch peaking in ‘VEL-vety’ followed by a slow fall in pitch and a gradual decrease in the intensity of the mother’s vocalizing, during which she turns her head toward the infant” (Rossmanith et al., 2014, p. 10). Further, the PRAAT record used shows that the wording features a marked high rising tone on *vel* (of velvety) that is far above a normal pitch range at around 300 Hz. As the authors note elsewhere, this high pitch marks “infant-directed speech” (IDS). However, this moment of IDS does not reduce to style or stereotype. At this moment, promptings set off an aesthetic match between the wordings and what is loosely called “tone.” Attention to the sonographic record shows a sprightly rhythm <VE::L:: -vi ti soft> (with similar pitch peaks and range on regularly timed syllables) that is followed by a pause. After a second, the mother and the infant move in synchrony – using, no doubt, shared rhythm – as her voice returns to the top of its range. Next, she allows her voice to fall back to a normal level as she drawls “no:::se.” In our terms, the behavioral shifts are judgments that draw on aisthesis and, almost certainly, make the utterance pleasing. Perhaps attentive readers will find it evocative of touching a tender nose. Indeed, the mother mimics just such a movement as, just 1 s later, she touches the image of a cat in the book. The case shows how vocalizing can be used to beget mimetic performance. The mother links expertise with experience to make inscriptions “come alive.” The example aligns with the cases described above in showing how adult readers also rely on more than interpreting digital patterns. Finally, we suggest that this also applies to readers who rely on silent reading – and with this example in mind, this applies especially if they have experience with *the right kind of nose*. We claim that aisthesis constructs imagining in not only learners but also skilled readers that use written signs. As such, the view is relevant for all kinds of engagement with material artifacts. We now use a final brief example to spell out the point in detail.

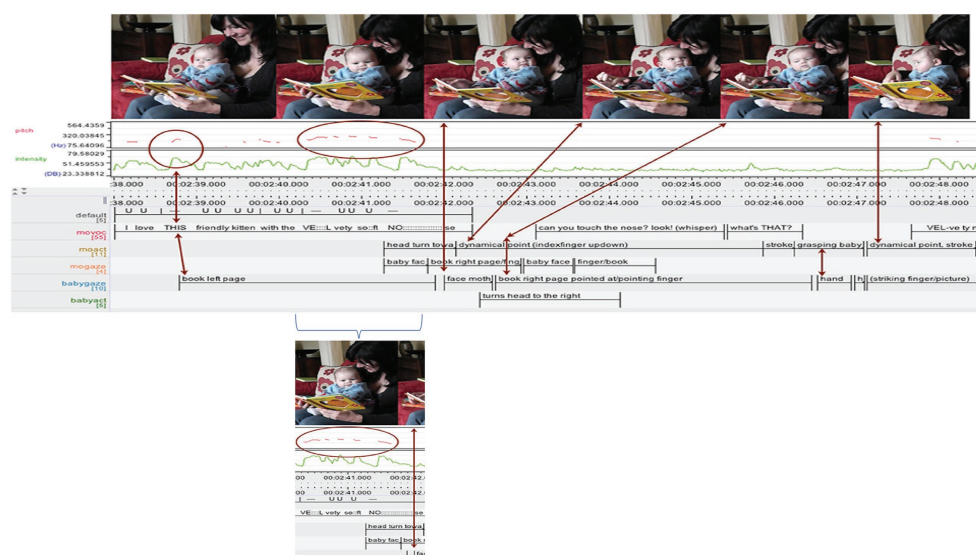


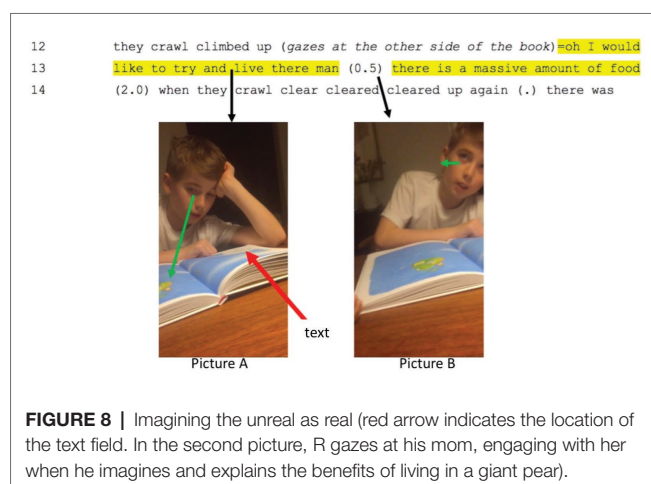
FIGURE 6 | The figure is from Rossmanith et al. (2014).

In returning to the boy who, now 7 years older, is reading to his little brother from *Den utrolige historie om den kæmpestore pære* (a Danish translation of *The incredible story of the giant pear*), while his younger brother has often heard the story, the boy is reading it for the first time. They are immersed in a world where an elephant, a cat, and a researcher escape from deputy major (Mr. Kvist) in a giant pear (see **Figure 7** below).

As the giant pear rolls down a hill and into the sea, a colonel is instructed to shoot it with a canon. When he refuses to shoot the pear, the deputy major, Mr. Kvist, himself fires a shot that goes through its upper quarters (see the picture below). As shown in the transcription in **Figure 7**, in line with the marks on the page, the boy's reading prompts him to say, first, that he would happily fight for his country and, then, that he would not shoot at a pear. As he reads on about how the drifting pear moves through a fog, he turns the page, and, in so doing, he interrupts himself (in yellow below):

His fantasy sets off a 2-s silence that would be enough to read around 20 syllables. Of course, no one can report *all* that goes on in the 2 s. However, the boy's stance both enables his imagining of the pear – as he *says* that he would like to live there – and, as he draws on other-orientation, a shift in gaze to the picture (see picture B). As he looks, he explains: “*there is a massive amount of food*” (line 13). In arguing that imagination is synthetic and necessarily draws on aesthetic judgements, we have allowed the heard to be amalgamated with the results of gazing at the image (see picture A in **Figure 8**). Further, it echoes with an earlier passage where, having hollowed out the pear, the characters ate the inside. After the pause, as he finishes this part of the story, the little brother is prompted to echo his older brother's wish (in orange in line 16 in **Figure 7**). Just as with case of a *velvety soft nose*, a wording evokes mimetic activity. In this case, however, the activity is not kinesthetic but, rather, linguistic. Further, the wording matters for imagination, as the little brother *also* wants to live in the pear (i.e., with his big brother – as part of an imagined world). In this case, the co-construction is dialogical in two senses: not only do the boys share a fantasy of living in a giant pear but also, importantly, they mesh with collective voices. They echo a unity of aesthetic

and moral issues like serving one's country, not shooting innocent pears and, most explicitly, the joys of inhabiting an edible fruit that can escape from cannon fire. In other words, they participate in a community. In making this claim, our work complements that of Popova and colleagues. While in dialog with the researcher, cat, and elephant, the boys are also at least metaphorically in dialog with the “author,” too (cf. Popova, 2014). Like Roald Dahl, they inhabit a collective world that “takes place in large measure outside of our brains, in the common shared activity that is life” (Popova, 2014, p. 315) and, metaphorically at least, they are in interaction with him. However, we focus on not the slow scales of reconstruction and participatory sense-making (De Jaegher and Di Paolo, 2007) but judgments that shape sensorimotor dynamics. We claim that the author and the interaction are results of a history of imagining whose grounding lies, above all, in prosody and imagined prosody based on looking and saccading. Indeed, it is because books and screens can be reconstrued that, in linguistics, emphasis falls on the verbal aspect of languaging, that is, the forms, functions, and texts of grammatical tradition. In taking a dialogical and multiscale view, by contrast, we begin with activity and, specifically, how rapid prereflective judgments bring forth wordings (or imagined



1 R: I am happy to fight for my (.) c c my c[ountry]
 2 B: [home]
 3 R: and sun for sun city (.) but I cannot shoot a at a pear just because
 4 (.) it has fallen into the water that is not the way to behave
 5 B: no:::
 6 R: baba (gazes at the images while humming 'baba')
 7 B: in the meantime (.) the pear drove drifted (gazes at pictures) (2.0)
 8 ehh the pear drifted slower the pear slowly further and further into
 9 sea in
 10 B: (tries to turn the page)
 11 R: LUCA (1.0) and into a thick fog (turns the page) so you cannot (1.0) when
 12 they crawl climbed up (gazes at the other side of the book) oh I would
 13 like to try and live there man (0.5) there is a massive amount of food
 14 (2.0) when they crawl clear cleared cleared up again (.) there was
 15 still a long way [out on the open sea
 16 B: [I also want to live there
 17 R: and there ends first (.) part of the story

FIGURE 7 | Overview of the narrative.

wordings) that, for many people, evoke visualizations (see, Troscianko, 2013). In all cases, these draws on sensorimotor history and, as we have argued, synthesis during which punctuated events and aisthesis beget imagining.

CONCLUSION

In bringing cognitive ethnography to radical-embodied cognitive research, we use a dialogical view of language and cognition to highlight how, in reading, rapid multiscale dynamics bring forth imagining that draws on the collective. Not only does this view support Popova's epistemological challenge to individualistic views of narratives and "autonomous and self-contained worlds," but our thick descriptions offer the beginnings of an account of how a reader's experience comes to be made. Aisthesis shapes *synthesis* by tracing the technique of looking-and-vocalizing to sensorimotor engagement. Voicing and judgments depend on not the "text" but a reader who looks and brings forth wordings that amalgamate sensorimotor experience with collective use of tactile, pictorial, digital, and other expression. In other terms, neural, motor, and tactile systems bring forth this *now* and amalgamate the collective, the bodily, and experiential.

We presented fine-scaled analysis to show how reading experience is traced to punctuated bodily movement and, given its anticipatory nature, gives evidence of how readers learn to read by relying on prereflective judgments. Far from relying entirely on functional routines for dealing with "text," the felt reactions of embodiment shape sensibility that is manifest as reading. Further, the rapid flow of punctuated events attests to the boy's judgments or what, in Greek, was called his use of *aisthesis*. This claim is consistent with tracing aisthesis to the late stone age and changes in use of material engagement. However, in playing down conventional signs, we focus on unhidden embodied aspects of a reader's experiential trajectory. By extending Chemero's concept of sensorimotor empathy, we trace reading to not knowledge of language systems but expert sensorimotor experience of vocalizing. Based on the analysis, we argue that rich multiscale events link the anticipated, the seen, and the collective in the moment of *this now*. For instance, we trace amalgamation to the activity of vocalizing and imagining, for example, "velvety soft nose." Further, as we have argued, careful consideration can trace this multitemporality to a history of felt reactions that integrate physical wordings with expert skills in looking and vocalizing. As a result, synthetic activity – and imagining – mesh with using the words actually written (and skills based on the language stance). This view opens up new ways of describing how a reader performs as not just a person but also as a skilled participant in socially organized activity. If highly educated, a reader may even come to account for reading – and what is read – in terms of metaphorical "interactions" between her readerly self and the author of a text.

Reading thus arises because humans are partly open to and for each other. For instance, the boy draws on skills with a language stance to bring forth [naʊ] or [eili:ən] in ways that draw on the potential of a collective world. Readers are dialogical

and other-oriented as appears in the fantasy of living in an edible pear or, indeed, fine shifts of voice and rhythm that evoke a velvety soft nose. In Dewey's terms, material artifacts act as written signs that transform eventualities into possibilities. Empirically, we find cases where a mother is moved to mimic touching a velvety nose or when a younger brother comes to share a fantasy about living in the pear. While enabled by what linguists theorize as "text," they manifestly use synthesis and prereflective judgments whose connotations shape mimetic behavior. Understanding thus emerges in rapid scales when people anticipate, find expectations, and fulfilled expectations (by acting as if following rules). Indeed, over time, reading skills can lead to deep resonance with what one reads, remarkable agreement on "content," and ultimately to viewing documents as textual entities whose "meaning" appears to a reader or a critic. In our view, far from being *the basis* for reading, text serves as an ideal *result* that those who "know" the outward criteria of a given sociocultural order.

Building on the analytical results and extended discussion of the results in relation to radical embodied cognitive science, the paper makes two contributions. First, it traces a synthetic process to rapid dynamics that set off a reader's prereflective judgments and imagining. Experience is thus enriched by engaging with artifacts and cultural memory that uses, for example, spelling systems, pets, and fantastic pears. Remarkably, the openness of human dialogicality and, inseparably, languaging transform what each of us become and what we imagine. Second, we have emphasized how imagining is traced to enskillment and expert use of sensibility that sets off aesthetic judgements that often draw on the language stance. To the extent that we are successful, we show that cognitive ethnography is a methodological tool that goes beyond first- and third-person views by clarifying human openness to the collective. Hardly surprisingly, imagination is like memory: it is a (re) constructive activity that blends felt reactions with others' voices, both real and metaphorical. This appears in rapid dynamics as how people saccade, vocalize, or enact fine-scale motoric activity. Indeed, by focusing on the lived now, one brings multiscale depth to cognitive science. Only linguistic embodiment can allow a human to imagine living in a giant pear, and we suggest that this skill requires more than picking up on affordances because one needs a dialogical agent whose felt reactions are infused with collective history. If one is to grasp reading, imagining must connect with the matters of taste that are central to the normative domains of human living.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and

institutional requirements. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin. Written informed consent was obtained from the minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article.

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AUTHOR CONTRIBUTIONS

ST designed the study and collected the data. SC and ST wrote both the theoretical framework and analysis. All authors contributed to the article and approved the submitted version.

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Being Perceived and Being “Seen”: Interpersonal Affordances, Agency, and Selfhood

Nick Brancazio*

School of Humanities and Social Inquiry, Faculty of Arts, Social Sciences, and Humanities, University of Wollongong, Wollongong, NSW, Australia

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Marek McGann,
Mary Immaculate College, Ireland

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Germany

*Correspondence:

Nick Brancazio
nick_brancazio@uow.edu.au

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Are interpersonal affordances a distinct type of affordance, and if so, what is it that differentiates them from other kinds of affordances? In this paper, I show that a hard distinction between interpersonal affordances and other affordances is warranted and ethically important. The enactivist theory of participatory sense-making demonstrates that there is a difference in coupling between agent-environment and agent-agent interactions, and these differences in coupling provide a basis for distinguishing between the perception of environmental and interpersonal affordances. Building further on this foundation for understanding interpersonal affordances, I argue that in line with some enactivist work on social cognition, interpersonal affordances ought to be considered as those that are afforded by agents and are recognized as such. Given this distinction, I also make the point that because our social conventions establish persons as more than mere agents, the direct perception of interpersonal affordances may also involve seeing others as embodied selves. Distinguishing between types of affordances thus also matters ethically: there can be harms done when an agent is not perceived as an agent, and there can be harms done when an agent is not perceived as a self.

Keywords: social affordances, interpersonal affordances, direct perception, social cognition, agency, selfhood

INTRODUCTION

Are ecological psychology and enactivism committed to a difference between our perception of the environment and our perception of other agents? Drawing from James Gibson’s work (J. Gibson, 1979/2015) on perception, contemporary enactivism and ecological psychology both use the theory of affordances or perceived possibilities for interaction. Affordances are neither properties of the environment nor the agent, but are co-constituted in the agent-environment relationship, given the agent’s values, abilities (Chemero, 2003), and skills (van Dijk and Rietveld, 2017) as the agent actively explores her world (J. Gibson, 1979/2015). Ecological psychology is largely built around the notion of affordances as the main objects of perception, while in enactivism affordances have played a more subsidiary and contentious role.

Increasingly, enactivists are using the language of affordances in their explanatory frameworks (see, e.g., Gallagher, 2008, 2017; Di Paolo et al., 2017). Enactivism and ecological psychology share a number of theoretical commitments, and many see them as kindred approaches to cognition. Both reject the received view of cognition as internal, computational, and representational.

Both propose that we see cognition as an active process constituted in the relationship between organism and environment. Both argue that perception is intersubjectively developed (Gallagher, 2008; De Jaegher et al., 2016), learned (E. Gibson, 1963), and/or socially mediated (Heft, 2007). These should be thought of as broad agreements in spirit, though, rather than precise overlaps – the approaches are sisters, not twins.

Given that the ecological approach relies on James Gibson's theory of direct perception (J. Gibson, 1972/2002), we should understand affordances not as inferred through our perception of the environment, but as directly perceived. We see an apple *as* edible, rather than post-perceptually *inferring* that it is edible (for example, Nanay, 2011). Further, while apples can offer the possibility of sustenance or *afford* being eaten, this might only be perceived as a relevant affordance if an agent is actively searching for something to eat; if I were looking for something to hold down a paper that was in danger of blowing away, an apple might instead afford the possibility of serving that purpose for me.

The social contributions to affordance perception have been widely discussed and debated in the ecological psychology literature (e.g., Reed, 1991; Costall, 1995, 2012; Heft, 2007). Other people, though, are not apples, and how we perceive the affordances offered by other agents is a much smaller subset of this literature. The contemporary hybrid theory of ecological-enactivism has offered some headway on how we might approach uniquely *social* affordances (Rietveld, 2008; Rietveld et al., 2017), holding that social affordances offer possibilities for social interaction. However, ecological-enactivists have also maintained that there is an equivalence between our perception of environmental affordances and social affordances (Rietveld et al., 2013, 2017). This work on social affordances has been valuable for explaining how we might both pre-reflectively experience and conscientiously shape our interactive spaces.

Here, though, I propose that in bringing together ecological and enactivist views on social interactions, we need to maintain a finer-grained distinction between environmental affordances that offer opportunities for socializing, such as public spaces, and those offered by agents themselves. That is, I will argue that the perception of interpersonal affordances (Trierweiler and Donovan, 1994; Richardson et al., 2007; Fiebich, 2014), defined as opportunities afforded by other agents, is indeed different from the perception of environmental affordances, given what enactivism has provided on the unique nature of agent-agent coupling.

Given the role that intersubjectivity plays in the enactive framework, and the importance of joint sense-making in interaction (De Jaegher, 2013a,b), distinguishing between affordances in agent-environment and agent-agent relationships ought to be taken as both explanatorily and ethically relevant due to the differences in cognitive activities and types of coupling. Put simply, the perception of interpersonal affordances is uniquely interactive. While this is a foundational point for enactivist accounts of social cognition (Gallagher, 2008; De Jaegher, 2009), I argue here that this ought to be equally

applicable when accounting for the perception of affordances offered by other agents.

Importantly, this distinction is also ethically relevant. For human forms of life, the mutual attribution of agency that happens in social interactions involves many layers. One of these, I argue, is that we perceive other humans as selves. Selves are scaffolded by social convention and practice and are developed in relation with others (Kyselo, 2014). Here, using Maiese's "life-shaping" thesis of selfhood (Maiese, 2019), I show the importance of perceiving both agency and selfhood in interactions and, conversely, demonstrate the harm that can be done by refusing to recognize another as an agent or as a self. This advances the discussion on the ethical dimensions of affordances in interaction and helps illustrate the damage that is done when one is perceived as affording possibilities for interaction that deny their agency or aspects of their selfhood.

SOCIAL AFFORDANCES AND INTERPERSONAL AFFORDANCES

The social aspects of affordances have been detailed in ecological psychology by those such as Heft (2007), who argues that the perception of affordances is in all ways social. That is, Heft argues that both the ontogeny and phylogeny of how we come to perceive affordances, for humans, is socially developed through niche construction and the influence of culture through the constructed ecological niche (see also: McGann, 2014 on intersubjectivity, E. Gibson, 1963 on perceptual learning, and Ramstead et al., 2016 on cultural affordances)¹. The intersubjective development of affordance perception applies to both environmental affordances and the account of interpersonal affordances that I will offer here.

As Rietveld et al. (2017, p. 300) define them, social affordances are "possibilities for social interaction or sociability provided by the environment." They have been defined elsewhere even more broadly:

"Social and communicative affordances that reflect the meaning of human activity for other humans (cf. McArthur and Baron, 1983; Reed, 1988). These include not only the affordances of symbolic behavior such as human conversation and writing (Dent, in press) but also the affordances of nonsymbolic activity such as facial expressions (Alley, 1988; Buck, 1988), gesture (Tomasello, 1988; Van Acker and Valenti, 1989), body postures and movements (Runeson and Frykholm, 1983), tone of voice (Walker, 1982; Walker-Andrews, 1986), and the direction of gaze (orienting; Scaife and Bruner, 1975; Butterworth and Cochran, 1980) that provide information about the actor as well as about

¹Eleanor Gibson is often overlooked and under-cited, and oftentimes a citation to "Gibson" is assumed to be a reference to another well-known Gibson. Following the convention introduced by Miguel Segundo-Ortin, I cite Eleanor Gibson as "E. Gibson" and James Gibson as "J. Gibson" to bring more attention to her unique contributions.

other aspects of the environment. The symbolic behaviors (language) are entirely conventional and culture-specific, whereas the nonsymbolic are only partly so" (Loveland, 1991, p. 101).

Loveland's conception incorporates a list of affordances that might be related to acts of socializing or communication. Loveland's list is meant to be more limited than, for example, saying that affordances can be canonical, a term used by Costall (2012) to refer to the way that affordances can be specific to socio-cultural practices. That is, Costall uses this term to point out that some affordances are available only because those perceiving them have learned certain ways of engaging with the environment or certain meanings of items through social means. An example of this is a recycling bin. This only affords the recycling of an item if one has been raised in a social environment where recycling is a norm or somehow otherwise knows about the social convention of recycling.

Gallagher and Ransom (2016) use the term "social affordances" in an even more limited sense in discussing the social affordances provided by social media. As many of our social interactions do not take place in person, that a certain website or app affords sociability could mean many things. For example, an app can be used for facilitating meet-ups in the sense of one creating or responding to a social media event for an upcoming gathering or collective action. It could also mean facilitating direct exchange between agents in a virtual space, such as with a messaging app. This usage of the term is also becoming widespread in areas that study human-technology interaction and mediation, such as networking technology (e.g., Bradner, 2001) and social robotics (e.g., Paauwe et al., 2015).

Social affordances have also been discussed in some detail by ecological-enactivists. The hybrid theory of ecological-enactivism (Rietveld and Kiverstein, 2014) has brought together both the ecological and enactive approaches in their proposal of the Skilled Intentionality Framework (SIF; van Dijk and Rietveld, 2017). The SIF incorporates the "lived perspective of a skilled individual" as integral for understanding how it is that we perceive *relevant* affordances (van Dijk and Rietveld, 2017, p. 3). The development of the skills for being attuned to relevant affordances for the agent can be thought of as "multiple bodily states of action readiness reciprocally coupled to the landscape of affordances, in the sense that these states of action readiness self-organize and shape the selective openness to the landscape of affordances" (van Dijk and Rietveld, 2017, p. 8). Though we might think of skill in the sense of expertise, this includes any embodied or pre-reflexive skills or capacities for navigating the world. Skilled intentionality can be as simple as selectively perceiving a mug handle as graspable when one is heading to the coffee pot for a refill. Through our skills and habits of coupling, we are selectively open to the relevant affordances of the environment for the task(s) we are undertaking.

In their discussion of social affordances, Rietveld et al. (2017) offer a number of concrete suggestions for improving sociability in the sense of providing spaces where people from disparate backgrounds or with very different interests might be inclined to come together. Their suggestions include park planning and

other architectural interventions to offer options for activities conducive to social interactions in public spaces. In this sense, sociability could also be afforded anywhere that people tend to have social interactions, such as coffee shops, parks, the grocery store check-out lane, or even the sidewalk, though all of this would be heavily dependent on sociocultural norms and practices.

Because sociability and social interactions are quite different, it is important to distinguish these further. Affording sociability might apply to an area or an artifact (such as an app), in that it can lead to a social interaction, but these affordances themselves are not socially interactive in an interpersonal sense. A sociability affordance might be one that affords an interaction conducive space or can facilitate or lead to an interaction. These might often be a pre-cursor to a social interaction but are neither necessary nor sufficient to lead to an interaction. More specific claims about what is afforded by certain types of social affordances, or when sociability is afforded, should be made cautiously though. What one feels is an "interaction conducive space" would of course be dependent on culture, social position, and identity. There may be gender, race, neurodiversity, disability-related, or historical issues or dynamics that would influence whether spaces are perceived as hostile, dangerous, or uncomfortable for some and welcoming or comfortable for others (De Jaegher, 2013a,b; Heras-Escribano, 2019, Ch. 7; Jurgens, 2020).

It should also be stressed that, in the terms of the social cognition literature, interpersonal affordances should not be taken to imply a Theory of Mind, which is an inference about or simulation of the mental state of the other. A Theory of Mind is built on the idea that we are at a remove from the mental state of the other in social interactions, and that we use simulation (implicit mental simulation, e.g., Goldman and Sripada, 2005, or mirror neuron systems, e.g., Gallese, 2005) or inference (e.g., some kind of implicit or explicit theory about others' minds, e.g., Gopnik and Wellman, 1992) to explain how we as spectators (Schilbach et al., 2013) come to know the other's mental state (their intentions, emotions, etc.). Rather, perceiving an interpersonal affordance should be thought of as phenomenologically immediate, as with James Gibson's theory of the direct perception of affordances (J. Gibson, 1979/2015).

Direct perception is the basis of interaction theory, the theory of social cognition proposed by Gallagher (2008). It might be helpful to draw a similarity between Gallagher's direct perception theory and how we ought to understand interpersonal affordances. This enactivist conception of direct perception is built on the idea that cognition is fundamentally embodied and action-oriented. As such, it is not the case that mental states are locked away inside the mind of the other. In direct perception, we simply see affective states and goal-oriented actions as such, with no need for inference. Having moved away from the input-model of perception, there is no need for an inference or for simulation in order to see a motion of a hand toward a cup *as reaching for the cup*. Likewise, we see a friend *as excited* without need for inference or attribution (Varga, 2018). Reflexively, we might *make* this attribution, but in most cases this is because that is *how*

we perceived the action. And while we might sometimes use an inferential process to try to figure out what someone is doing or feeling, this is when something is complex or confusing. It is the exception, not the rule.

Interaction theory incorporates affordance perception into the explanation of how it is that we directly perceive these mental states. This is explained by Gallagher and Varga (2014, p. 189):

"According to [interaction theory] and the direct perception hypothesis, social perception is enactive. That is, my perception of your action is already formed in terms of how I might respond to your action. I see your action, not as a fact that needs to be interpreted in terms of your mental states, but as a situated opportunity or affordance for my own action in response. The intentions that I can see in your movements appear to me as logically or semantically continuous with my own, or discontinuous, in support or in opposition to my task, as encouraging or discouraging, as having potential for (further) interaction or as something I want to turn and walk away from."

While this is an excellent example of a fruitful integration of affordances with enactive approaches to social perception, interaction theory has been criticized for not being interactive enough (De Jaegher, 2009). In the following section, I will turn to the theory of participatory sense-making (De Jaegher and Di Paolo, 2007) to provide a more detailed argument, based in interaction, for holding that the perception of interpersonal affordances is different from the perception of environmental (and social or sociability) affordances due to differences in coupling.

ENACTIVE AUTONOMY AND INTERACTION

Interpersonal affordances offer opportunities for interaction with another agent and, therefore differ in definition from environmental or sociability affordances. The participatory sense-making framework, grounded in autopoietic enactivism, provides a further way of distinguishing interpersonal affordances from other types in terms of affording possibilities specific to a social interaction. That is, interpersonal affordances are offered in an autonomous interactive process that emerges in the coupling of agents.

The enactivist notion of autonomy is based on the most fundamental of organismic processes: self-maintenance and self-production. These self-organizing processes form the foundation for the autopoietic approach to cognition (Maturana and Varela, 1980). An organism must maintain itself and its boundaries through a network of biological processes while at the same time being selectively open to the world in order to take in from the environment what it needs to sustain its existence.

Summarizing Varela (1979), Thompson (2007, p. 44) describes the autopoietic view as holding that processes constituting the autonomous organization of a system: "(i) recursively depend

on each other for their generation and their realization as a network, (ii) constitute the system as a unity in whatever domain they exist, and (iii) determine a domain of possible interactions with the environment." The autonomous system thus creates the conditions of its own persistence, and the capacities of the system establish the ways in which it can interact with the world.

Maintaining these processes requires that the system be open to the world in ways that enable the system to continue these maintenance processes. Being open to the world in ways that are appropriate for the organism is possible because, in addition to having the capacities to act, organisms are able to make sense of the world in some way. Sense-making (Varela et al., 1991) involves an organism actively exploring a world through the perception of what might be helpful for maintaining organismic integrity and what can hinder or harm, and acting accordingly. Or, more concisely, it is "the creation and appreciation of meaning in interaction with the world" (De Jaegher, 2013b, p. 6).

In the autopoietic tradition of enactivism, an agent can be defined as "an autonomous system capable of adaptively regulating its coupling with the environment according to the norms established by its own viability conditions" (Di Paolo et al., 2017, p. 127). This is not to say that agency itself is attributable to the organism, as enactivism holds that cognition is a relational process rather than involving the internal processing of environmental information. On the enactive account, "perhaps agency is not a property that belongs exclusively to a system but is a property of a *relation* between that system and its surroundings. And this relation is variable" (Di Paolo et al., 2017, p. 110). Thus while we might call an organism an agent, agency itself would be the relational process of selectively attuning one's actions in accordance with the environment and others. The relational account of agency is variable, in that there is an interactional asymmetry between the organism and the environment, and the relationship fluctuates given the organism's needs and perhaps environmental demands. There can be a difference in the balance of agency in the agent-environment relationship given the particulars of a current circumstance. For instance, the balance of agency in the agent-environment relationship will be different when I am looking in the fridge for a midnight snack versus when I am fleeing a park due to a sudden high-wind storm.

While these provide a picture of the most minimal processes of life and cognition, these notions scale up to more complex behaviors and systems of organization. For social organisms, the agential process of active attunement does not simply mean that the environment includes others but that others contribute to agential processes and interactions with others can be their own autonomous processes. These interpersonal and social dynamics are captured in the theory of participatory sense-making, as introduced by De Jaegher and Di Paolo (2007). De Jaegher and Di Paolo (2007, p. 497) define participatory sense-making as "the coordination of intentional activity in interaction, whereby individual sense-making processes are affected and new domains of social sense-making can be generated that were not available to each individual on

her own." The interaction is mutually co-constituted, co-regulated, and co-sustained by autonomous agents, who are recursively shaped within the interaction they are sustaining. In participatory sense-making, we have the coupling of autonomous systems that, through that coupling, create an autonomous interaction that involves a precarious balance between participants in order to be maintained.

Being able to be involved in processes of mutual creation of social meaning is important to self-production and maintenance within the intersubjective sphere. It is through these kinds of interactions that the normativity of social practices in the social niche are created, shaped, and changed. For human forms of life, maintaining autonomy involves more than organismic processes of self-production and maintenance in a purely bodily sense. De Jaegher and Di Paolo (2007, p. 493) give a brief description of the criteria for establishing that an interaction is social, based on this interactive notion of emergent autonomy:

"Social interaction is the regulated coupling between at least two autonomous agents, where the regulation is aimed at aspects of the coupling itself so that it constitutes an emergent autonomous organization in the domain of relational dynamics, without destroying in the process the autonomy of the agents involved (though the latter's scope can be augmented or reduced)."

In participatory sense-making, preservation of the autonomy of the involved agents involves a mutual recognition of the subjecthood of the other. This recognition is meant in an immediate fashion – it is not that one decides the other is a subject, but that they are *already* seen as "a subject, not an object" (McGann and De Jaegher, 2009, p. 428; also see Schilbach et al., 2013). To this, I add that this similarly also involves the direct perception of the other as an agent. There is a direct perception of the agency *and* subjectivity of the other.

The interaction process can and does involve asymmetries of autonomy in order to maintain itself. Agency is recognized, while autonomy fluctuates. This is because the interaction process also involves ebbs and flows of mutual regulation (Di Paolo et al., 2018). In an interaction, the regulating role of the processes of mutual sense-making should, ideally, flow back and forth between agents in order to co-constitute the interactive process. This will involve coordination in multiple dimensions. For instance, two people may be engaged in a conversation at a coffee shop. There will be bodily coordination in the sense that they pre-reflectively align their postures (Richardson et al., 2005), and they will perhaps be pre-reflectively balancing their emotional states in response to the other (Hatfield et al., 1993; Kiverstein, 2015). Both participants may pre-reflectively compromise in order to attune to the comportment of the other. One may follow the other in leaning forward when exchanging a particularly juicy bit of gossip or leaning back when talking about how busy their workweek has been. One may have a long story to share, and there may be an asymmetry in regulating the flow of utterances in the interaction – one person is regulating through their continued utterances, while

the other is regulated as listener, offering a chuckle or gasp at the appropriate times. While the regulator and regulated roles flow back and forth, neither party's autonomy is ever harmfully compromised in this idealized example. Both are perceived by the other as autonomous agents within the interaction, both are involved in establishing the norms of that interaction, and regulatory roles can be seen as a matter of request, not force.

Now, consider that affordances are possibilities for action (or interaction). Rietveld et al. (2013, 2017) want to avoid a hard distinction between the perception of social and environmental affordances by appealing to the similarities in *how* we perceive them as embodied agents. Pointing to the Skilled Intentionality Framework, they note that the skill of picking out relevant affordances generates "readiness of the affordance-related ability" (Rietveld, 2008). Whether a relevant affordance is environmental or social, "starting from bodily or skilled intentionality, our perspective avoids an artificial separation between social cognition and nonsocial engagements with the environment" (Rietveld et al., 2013).

This is unproblematic if we are talking about the difference between environmental and social (in the sense of sociability) affordances. However, if we are talking about interpersonal affordances, those afforded *by* or *in interaction with others*, the lack of distinction becomes an issue. First, interpersonal affordances are not given in the relationship between an agent and an environment but in the relationship between agents. De Jaegher and Di Paolo (2007) argue that these are different types of coupling (see also De Jaegher, 2009). The divide between environmental affordances and interpersonal affordances is not artificial – in the first case, you have a mere coupling, and in the latter case, there is a mutually regulated coupling:

"Thus, social interaction has two characteristics: (1) there is a coupling, which is regulated so as to generate and maintain an identity in the relational domain. Thus, the resulting relational dynamics are autonomous in the strict sense of precarious operational closure ... and define events and processes as either internal or external to the interaction. And (2) the individuals involved are and remain autonomous as interactors" (De Jaegher and Di Paolo, 2007, p. 493).

The skill of being attuned to relevant affordances should also include a sensitivity to the possibility that one can engage in a social interaction. This would often involve directly perceiving one as an agent able to enter into an autonomous interaction, due to the intertwining of perceiving-as and action-readiness. Perception (on both ecological and enactive accounts) is an active process of looking for action possibilities in the environment, so the perception of interpersonal affordances will often involve specifically looking for affordances provided by an agent. It might be relevant that one is a specific agent (when one has an appointment to meet with a friend), or it might be relevant that one is an adult agent more generally (if I am on the street looking for someone to speak with so I can ask for directions), but nonetheless, I am actively perceiving

an agent, and the perception of agency is intertwined with my readiness to respond to a perceived interpersonal affordance.

There are many fairly innocuous reasons that an agent's autonomy might be compromised in an interaction: we can imagine a caregiver giving a child a stern talking-to for misbehavior, for example.

There are also ways in which sociocultural position, norms, and power dynamics can limit the speech affordances available in some interactions or what a speaker affords to others with their words (Ayala, 2016). A member of a marginalized group, for example, may perceive opportunities to interact differently (or perceive less of them), might find that their words have less impact or that they solicit less attention in interaction with a member of a dominant social group. This could be considered a compromise of autonomy and/or contributor to regulation role imbalance, in that it narrows the possibilities for engaging in collaborative sense-making. There also exist more extreme imbalances in autonomy, in the case that one is *not* treated as a subject and as an agent. These can constitute a grievous devaluation or dehumanization, such as occurs in torture or warfare, where one is treated as non-human (animalistic dehumanization) or as not possessing agency at all (mechanistic dehumanization; Haslam, 2006; Gallagher and Varga, 2014).

Failures to recognize a person as an agent are not only something that happens in these extreme cases though. This frequently happens more subtly in everyday interactions, when failing to recognize one's agency by perceiving them as an object or tool. Further, there are other harms of recognition, such as failing to recognize another's social selfhood in interaction. In the final section, I will expand on the ways that neglecting or refusing to perceive one as a self can be an ethical issue. First, though, in the following section, I will describe Maiese's enactive notion of selfhood (Maiese, 2019) so that we can also look at the importance of perceiving a persisting self in human interactions.

ENACTIVE AND EMBODIED SELFHOOD

For human forms of life, agency alone is often not going to be a robust enough notion to capture what it is we might want recognized in social interactions. We are also selves, persisting over time, with particular lived experiences, identities, and ways of being in the world. How it is that we can say a "self" exists, is individuated, and persists over time though is a matter of much contention. The enactive account provides a multi-dimensional and nuanced approach to agency – there are several domains of agency that enable and constrain each other through their overlap of processes and sensorimotor schemes, such as organismic agency (discussed in section "Enactive Autonomy and Interaction"), sensorimotor agency (Di Paolo et al., 2017), and linguistic agency (Cuffari et al., 2015; Di Paolo et al., 2018). The complexity of these latter kinds of agency, their intersubjective development, and their ubiquity in our social niche enables the formation of what Kyselo (2014) has called the socially individuated self. Building on the strengths of Kyselo's work, Maiese (2019) has proposed

a life-shaping thesis of selfhood, grounded in autopoietic enactivism, which like enactive accounts of agency is nuanced and multi-dimensional. I will use the life-shaping thesis here for demonstrating the importance of selfhood in human interactions, in perceiving interpersonal affordances and understanding the ethical aspects of recognizing each other as more than mere agents.

Kyselo's main concern is that we need a unifying theory of self "as a whole, something that can count as a distinguishable unit of explanation and eventually help to interrelate different aspects of the self" (Kyselo, 2014, p. 2), and that can be used to guide work in the cognitive sciences. She argues that the social self is "never fully separable from the social environment, but instead determined precisely in terms of the types of social interactions and relations of which it is, at the same time, a part" (Kyselo, 2014, p. 12). Kyselo's answer to the problem of unification distinguishes between two possible answers cognitive scientists might give in trying to locate the self. The first is the idea that what individuates the self is the living body, which she says entails that the social is non-constitutive of the self. The second is to individuate the self as a coherent unity according to the social dimension. She argues in favor of this second option, holding that the social is constitutive of the self.

To think of how the social self is determined in social interactions, we can consider the recursivity in participatory sense-making, where the autonomous agents both shape and are shaped by their social interaction. McGann and De Jaegher (2009, p. 433) say of this process that "[c]ulture transforms our body from a physical mode of cognition, action, and perception to a social one where action can be shared, values coordinated. It is a dramatic alchemy that occurs through participatory sense-making and the acknowledgement of the agency of another. The implications of this fact for the enactive approach cannot be overstressed." Thinking about social selves and the ethical dimensions of interactions is one way of taking up these implications.

However, Maiese (2019) points out that the theory of participatory sense-making only goes so far as to say that social interactions shape the participants, not determine them. Instead, Maiese offers a "life-shaping thesis" of selfhood, in which the self is individuated by the body while being shaped by the social, to account for the unification of the self over time. While Kyselo (2014) claims that the self is individuated *via* social relations, rather than *via* the body, Maiese (2019, p. 364) bases selfhood in the autonomous organization of a system, which requires that an organism individuates itself as a closed network of systems of self-maintenance. She holds that the individuated self "is fully embodied, and that the various dimensions of mindedness—that is to say, our desires, feelings, emotions, sense perceptions, memories, thoughts, intentional actions, etc.—are all partially determined, or shaped, by the social world" (also see Scheman, 1983). For humans, the intersubjective scale of agency involves individuating oneself in the social realm, but this is scaffolded by the ongoing bodily processes by which we are able to maintain our individuation over time. So while the self is shaped by the social, this does

not root the persistence conditions of the self in the social. Rather, the social would be one domain of embodiment of the organismically individuated self, which would enable and constrain other dimensions of embodiment.

Maiese's proposal of the life-shaping thesis (Maiese, 2019) provides a robust enactivist notion of the self that does not make us choose between the self of cognitive science and the social self. The enactive account holds that cognition is constituted by a number of nested processes, involving body, brain, and world – and for humans and other social organisms, shaped intersubjectively. Though Kyselo frames the discussion of the self in terms of a context/constitution dichotomy, the project of deciding between the social as contextual or constitutive of the self is perhaps a bit misguided in terms of metaphysical presuppositions. Enactivism, as a non-reductive, process-oriented, intersubjective, and multiscale account, can accommodate the social as both contextual and constitutive of the self in various ways, as Maiese shows. Further, individuation – differentiating between self and environment – has been held as one of the main characteristics of agency for minimal autopoietic systems (Di Paolo, 2005; Barandiaran et al., 2009). It is not quite clear why another sense of individuation would be necessary. On this, Maiese (2019, p. 364, emphasis added) says:

“This distinction between components that constitute the living system and elements that form its environment grounds not only biological identity, but also the identity of the self. Indeed, just as a living system should be individuated according to this form or organization, the self (or what might be described as the human *mode of life*) should be individuated according to its characteristic form or organization, rather than the energetic or relational material that ensures its continued existence.”

Maiese seems to ground unification in both the individuating (physical) and persisting (temporal) sense in the autonomous processes of living systems, in line with the autopoietic notions of individuation through self-maintenance and self-production. The life-shaping thesis holds that the social is not constitutive of the self, but that the self is fundamentally *embedded* in the social. The self, she argues, is influenced and shaped by the social in the sense that the social has a causal influence, is reciprocally shaped by us through our responses or contributions to the social, and is normative. It is normative because the social shapes our internal norms not only through enabling or constraining our embodied processes but also in the contributory sense of taking part in participatory sense-making and practices that can reinforce, shape, or transform social norms. In this way, through social participation and self-shaping, social normativity is recursive.

Grounding the self in this way is important for my account for two reasons in particular. First, understanding the self as fundamentally embodied does not allow for full determination of what unifies the self over time in the social. To say this is perhaps too dismissive of the first-person authority we have on our own existential identities (Bettcher, 2009) and the way

these identities shape how we extend ourselves (through our aims, plans, and goals) into the future (Brancazio and Segundo-Ortin, 2020). Relatedly, it is only because we *can* act out of accordance with social expectations and demands that we have the means for transformative change of the social. Second, because it preserves agency and autonomy, the life-shaping thesis can be productively integrated with the enactive theories of participatory sense-making and direct perception in interaction. The self is engaged in social interactions in which it can be shaped or influenced, but it is not fully determined within the sphere of these acts, thus fundamentally preserving the autonomy of the embodied agent. Maiese (2019, p. 363) voices similar concerns about Kyselo's determination of the self in the social and the implications for compatibility with participatory sense-making:

“...indeed, participatory sense-making presupposes and requires bodily-organismic ‘selves’ who can partake in the interaction process. Moreover, for each of these ‘selves’ to remain an autonomous interactor, it must be possible (even if unlikely) for her to defy social expectations, or even disengage from the social interaction if she feels so inclined.”

It is also important to note that by being accommodating to varying socioculturally situated notions of self, this does not necessarily mean that individuals have *a* self in the narrative or reflective sense. In other words, I believe we can take Maiese's notion of selfhood as not implying that the social self is necessarily unified, or unified in any particular way, *apart* from the embodied sense². A persistent theme in feminist theory and critical race theory is multiplicitous selves and identities. Given the numerous communities that one may navigate in their social terrain, one may have the experience of enacting, adopting, and being treated as more than one social self – especially in the case that one belongs to one or multiple marginalized groups (e.g., Anzaldúa, 1987; Harris, 1990; Wing, 1990; Ortega, 2001; Barvosa, 2008). In fact, in this work, it is oftentimes embodied persistence through multiple social worlds, or the phenomenological *mine-ness* of experience given through embodied persistence and subjectivity, that is said to ground individuation or persistence conditions through which the agent is able to enact numerous selves in the social sphere (Alcoff, 2006). Locating the individuation and persistence of selfhood in the “self-organizing” of autonomous systems opens up room for an enactive approach to how it is that selves can manifest in different ways, depending on particularities of context, social roles and cultural knowledge, power dynamics, marginalization and oppression, and other aspects that shape the way that an agent will take up an interaction.

²There is quite a bit of literature on narrative selfhood and the distinction between minimal and narrative selves, which I will not be taking up here. Maiese's account provides a way of having a unified embodied self without necessarily making commitments to any specific (or even unified) reflective or narrative self (for more discussion on this distinction, see Menary, 2008; Mackenzie, 2014, or Zahavi 2007).

The notion of selfhood proposed by Maiese (2019) captures the root of what is important for developing an account of how it is that we directly perceive and selectively respond to interpersonal affordances. On her account, the social self is an aspect of the embedded embodied self, and the persistence conditions of selfhood, while socially embedded, are maintained by the embodied processes of organization rather than being fully socially determined. The subject directly perceived in participatory sense-making is an embodied subject embedded in the social. Further, the account makes no general claims about what social selfhood is and can be sensitive to the myriad ways that sociocultural norms, practices, multiplicity, and neurodiversity can influence self-perception and experience.

INTERPERSONAL AFFORDANCES BETWEEN AGENTS AND SELVES

I will turn back now to the direct perception of agency and selfhood in the social sphere by way of interpersonal affordances. As discussed in section "Social Affordances and Interpersonal Affordances," we should take interpersonal affordances to mean *actual* possibilities for interaction *with an agent*. An interpersonal affordance is not perceived in the agent-environment relationship, but is afforded *by* another agent (whether intentionally or not). Interpersonal affordances are not necessarily already part of an interaction, but they can afford an interaction. For example, let us say that I am walking down the street and I see a friend, who is engaged in a conversation with someone else. I may perceive them as affording a social interaction, though they have not actually seen me yet – so there is no intention on their part *to* interact. Conversely, in participatory sense-making, both agents are actively affording possibilities for interaction through their ongoing utterances, gestures, bodily and emotional coordination, and so on. In both cases, the perception of interpersonal affordances is not a product of the agent-environment relationship, but of the agent-agent relationship, and involves seeing the other as a subject.

In section "Social Affordances and Interpersonal Affordances," I explained that interpersonal affordances are directly perceived: "The sight of a sad friend affords consoling him or her, a colleague at the coffee machine solicits small talk, and an extended hand immediately prepares the body for shaking it" (Rietveld et al., 2013, p. 436). It is crucial to note that in this example, the *perception-as* and the *action-readiness* are intertwined, as with the direct perception in the interaction theory of social cognition (see De Jaegher et al., 2010; Gallagher and Varga, 2014). However, the perceiving-as in interaction is not perception of a static state. Fiebich (2014, p. 1) makes the point that interpersonal affordances are "perceived within interactive reciprocal processes," where the perceived agent is engaged in ongoing action processes in response to the behaviors of the other in interaction. This is also argued for by McGann (2014, p. 26): "There is also no particular moment in time at which perceiving is 'complete' because such perception always occurs in the flow of on-going behavior – activity does not

have to wait for it." A continuous interaction offers a continuous stream of changing interpersonal affordances – and, recursively, engagement with these affordances changes the process of interaction.

The participatory sense-making account provided in section "Enactive Autonomy and Interaction" makes it clear that these reciprocal processes often happen within an autonomous interaction, where the interactors are involved in a shared, co-regulated (and co-regulating) domain of sense-making. Taking this into account, perceiving what is afforded by the other agent can also be influenced by the perceiver's desire to maintain the interactive coupling. The perception of relevant interpersonal affordances by each individual agent will involve more than the concerns of their own self-maintenance – they include concerns about the maintenance of the autonomous interaction as well. Or, perhaps, the relevance of affordances will instead be influenced by an agent's desire to leave the interaction (so they may begin glancing around the room, looking at their phone, or become slow to respond to the interpersonal affordances the other agent is offering).

As discussed above, participatory sense-making requires seeing another as a subject. In other words, maintenance of an autonomous interaction, or agent-agent coupling, already presumes agency.

My claim here has been that interpersonal affordances in participatory sense-making also involve the direct perception of agency and, to some extent, selfhood. This, I believe, has some ethical implications, in line with the ethical dimensions of the Gibsonian perspective of affordance perception: "The meaning or value of a thing consists of what it affords. What a thing is and what it means are not separate, the former being physical and the latter mental as we are accustomed to believe" (J. Gibson, 1982, p. 407). If we apply this to interpersonal affordances, we can consider how being seen as an autonomous agent capable of entering into a participatory sense-making process would be a valuation of our contributions to that shared domain of sense-making. Thus, while it does not matter to an apple whether it affords edibility to a person, it can matter immensely whether a person is viewed as a candidate for shared meaning-creation or shaping. The discussion of interpersonal affordances thus must involve examining how prejudices, power dynamics, biases, and social status influence how one is perceived and how this affects their ability to contribute to participatory sense-making.

On the farther end of compromises of agency in interaction, we can think of objectification. Objectification has many aspects, which have been detailed by Nussbaum (1995) and Langton (2009). The most important of these aspects for understanding the relationship between objectification and interpersonal affordance perception is the denial of autonomy, being treated as a tool or a means to an end and the treatment of someone as interchangeable with objects (or fungibility) (Nussbaum, 1995), as well as reduction to body and/or appearance (Langton, 2009). Black feminism has long brought attention to the objectification and dehumanization that Black women experience, especially in terms of animalistic dehumanization and the denial of agency (Rollins, 1985; Collins, 1986; Crenshaw, 1991). These kinds of

experiences (and others, such as objectification through fetishization) have also been discussed in trans theory, most predominantly in the experiences of trans persons of color (Flores et al., 2018).

Let us consider a serious case of objectification: street harassment (which may include misogynistic, racist, ableist, transphobic, classist, or queerphobic harassment, as well as many intersecting combinations of these). This kind of harassment usually involves a stranger uttering derogatory or sexual words or phrases to an individual, though this can also take place through (or include) stares, ogling, or physical menacing. In describing the psychological effects of the sexual street harassment of women, Davis (1994, p. 143) says that it "allows men to establish the boundaries of participation in the street. ... Through street harassment, men inform women that women are public participants only with men's permission." It is perhaps obvious that the individual being harassed is not perceived by the perpetrator as affording the kind of treatment that appropriately acknowledges their agency and autonomy.

This is neither a social interaction nor an invitation to create a shared domain of meaning. Objectification of this kind, seems to be more akin to a "skill" if we are using the Skilled Intentionality Framework (van Dijk and Rietveld, 2017). The perpetrator views the harassed person as a relevant affordance, not for a social interaction but for objectification (dehumanization, denial of agency, being treated as a means to an end, and so on). That is, given the above discussions about direct perception in ecological and enactive approaches, we can think of the action-readiness tied to the perception of a marginalized agent as an opportunity to enact a skill (explicitly or implicitly) intended to foreclose the possibility of meaningful participation. However, we should be cautious about going too far in explaining objectification through what is exercised by an individual, as this places too much responsibility on the individual perpetrator when we should also be looking at the systemic issues and social structures that allow (or encourage) this type of treatment to become habituated.

It may often be appropriate to objectify the local environment as affording something for you, within reason and given prevailing norms. It is not appropriate to perceive an agent as offering something for you in the same way, if it constitutes a devaluation of the person³. But even these are the situated claims of a Western anglo philosopher – the environment/interpersonal distinction, and appropriate attributions of agency and autonomy in perception, may be very different in other cultures (Kelly and Lobo, 2020), in which case we ought to look at how affordance perception in those cultures is socially shaped (as discussed in section "Social Affordances and Interpersonal Affordances") and be ready and willing to adjust our theories about affordance perception accordingly.

We also need to take into account that, as previously discussed, interactions do not just take place between ahistorical agents. I have argued that participatory sense-making involves the coupling of selves in the interaction process. This means that there is a

recognition not just of an embodied agent in the course of interaction, but also a socially embedded agent – an agent that has a way (or ways) of being in the world with others that pre-exists and continues on after the interaction. I hold that persisting embodied selfhood, as discussed by Maiese (2019), is directly perceived rather than reflectively attributed or inferred. While this is not the case for every interaction, I think this is an important aspect of participatory sense-making. Seeing the participant as an embodied, socially embedded self allows for the coordination of expectations about shared meanings that structure the interactive space. And in creating a shared domain of sense-making, there are opportunities for creating and shaping meaning for the social self that extend beyond the interaction itself.

In contrast, one who is denied aspects of their selfhood is subject to a compromise in their autonomy in participatory sense-making. One way this might manifest is through the denial of interpersonal affordances to those belonging to non-dominant or oppressed groups. Of course, while street harassment is an obvious harm, there are more systemic and pervasive ways in which non-dominant groups are not perceived as full agents or selves. Speaking on the narrator of Ellison's *Invisible Man*, Charles Mills discusses the experience of this kind of ongoing racialized objectification:

"His problem is his 'invisibility,' the fact that whites do not see him, take no notice of him, not because of physiological deficiency but because of the psychological 'construction of their *inner* eyes,' which conceptually erases his existence. ... So his problem is to convince them that he exists, not as a physical object, a lower life form, a thing to be instrumentally treated, but as a person in the same sense that they are, and not as a means to their ends" (Mills, 1998, p. 9; quotes from Ellison, 1952).

Another example of a more deliberate denial of selfhood would be engaging in an interaction with a person but consistently not using their pronouns. To do so is to perceive one as a social self, with an autonomous identity, and then purposefully undermine that very sense of self in the process of interaction through the interpersonal speech affordances offered. Insisting on denying someone's selfhood in interaction in this and other ways denies full entry into participatory sense-making, as it is a forced regulation of autonomy. This kind of harm, as a denial of selfhood and agential identity (Barnes, 2019; Dembroff and Saint-Croix, 2019), limits an agent's ability to participate in the co-creation of meaning (De Jaegher et al., 2016) in a social interaction, among causing or perpetuating other harms.

In closing this section, I believe it is important to note that looking at the experiences of those who have their agency and selfhood actively denied suggests that we ought to be very careful about what we can take for granted in enactive and ecological approaches to social interactions and affordance perception. While there is clearly more to discuss in regards to the perception and denial of agency and selfhood, my intention has been to demonstrate that the direct perception

³This would not apply in cases such as stopping someone on the street to ask the time, as this is a request for assistance, not a denial of agency.

of interpersonal affordances involves the perception of agency. I have also argued that in many forms of interaction, including participatory sense-making, direct perception will also involve seeing the other as a self. To not appropriately perceive these in some cases can constitute serious harms to a person. Using the enactive theory of participatory sense-making, I have also shown that this can limit one's ability to enter into processes of meaning creation or shaping.

CONCLUSION

As enactivism and ecological-enactivism progress in explaining complex human realms of being, they grow increasingly concerned with social normativity and social institutions. For example, De Jaegher (2013b) has looked at how patriarchal and democratic institutions can be understood through the enactive approach to intersubjectivity. Maiese and Hanna (2019) have offered concrete suggestions for transforming our political and social institutions using insights from enactivism and ecological psychology. And Rietveld et al. (2017) have brought attention to the important challenge of adapting insights from enactive and embodied cognition into resources for increasing social cohesion and inclusivity.

I have argued that recognition of selfhood and maintaining a distinction between environmental affordances and interpersonal affordances are important for these projects. On one hand, this is explanatorily important due to the different kinds of coupling involved. On the other hand, this distinction is important for theorizing about the ethical and political aspects of affordances. To say that perception of affordances is the same, whether environmental or social, generalizes away from the concrete realities of experience and selfhood in interaction.

If we are looking for ways to increase social cohesion "understood as the co-existence of disparities, not the elimination

of particular backgrounds" (Rietveld et al., 2017, p. 303), as Rietveld et al. have discussed, we first need to understand the concrete particularities of bringing people together in social spaces. In bringing together ecological and enactive approaches to evaluating the ways in which our social institutions and practices can be transformed, we must also actively build resources for examining and understanding how our habits and actions contribute to devaluation and other harms to other agents. And by being attentive to the ways in which marginalization and oppression structure social interactions, we can better examine the ethical aspects of our research on interactions, as well as practicing more ethical interactions ourselves.

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The author confirms being the sole contributor of this work and has approved it for publication.

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When Affective Relation Weighs More Than the Mug Handle: Investigating Affective Affordances

Marta Caravà* and Claudia Scorolli*

Department of Philosophy and Communication Studies, University of Bologna, Bologna, Italy

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INTRODUCTION

Enactive and embodied approaches to cognition are becoming increasingly interested in the affective dimension of human experience (Varela and Depraz, 2005; Colombetti, 2007, 2014; Colombetti and Thompson, 2008; Di Paolo and De Jaegher, 2015; Gallagher and Varga, 2015; Gallagher and Allen, 2016; Scorolli, 2019). Consistently, this issue has been addressed in empirical research, which is paying growing attention to the affective quality of social contexts by addressing motor simulations (Bastiaansen et al., 2009; Kuhbandner et al., 2010), joint actions (Godman, 2013; Pesquita et al., 2018), emotional disorders (Gjelsvik et al., 2018), and body psychotherapy (Röhrich et al., 2014).

Still, while in the relationship between two or more agents the involvement of the affective variable, even when uninvestigated, is intrinsically evoked (and extensively scrutinized by affective neuroscientists, Panksepp, 1998), in the case of the agent-object relationship the recognition of such engagement requires more specific care.

In laboratory-based studies, when dealing with an object and an observer, the practical opportunities that she is able to perceive and use (Gibson, 1979) have been mainly operationalized referring to visual manipulable properties of the object, as shape and orientation, associated with its canonical use (Tucker and Ellis, 1998). Progressively empirical research introduced, and manipulated, also the physical context, and the required responses, distinguishing between functional and volumetric gestures (Bub et al., 2008). Are these “affordances”? Strictly speaking no, as these accounts clash with direct perception, but they are undoubtedly elegant approaches suitable for outlining answers (also) to most questions of ecological psychology (for a masterly, unbiased, review, Chong and Proctor, 2020).

In light of the heated debate on affordances between philosophers and cognitive scientists, we propose to draw upon literature in both fields as our aim is twofold. (1) Exploring *the great absentee* of empirical investigations conducted so far: the affective dimension of perception-action coupling of our relationship with the physical context. To this end a clarification of the philosophical concept of “affective affordance” (henceforth AA: Griffiths and Scarantino, 2009; Hufendiek, 2016; Fuchs, 2017; Krueger and Colombetti, 2018) would be essential. (2) Specifying some criteria of definition for this construct and suggesting an analysis of AAs in its application to the individual human agent’s practice—for our proposal to be not only theoretical, but suitable for experimental investigation, promoting a constructive dialogue between philosophy and empirical psychology.

The focus on the individual level is in no way intended to overshadow the need to examine AAs in relation to a larger-scale dimension of human experience (i.e., the distribution and historical accumulation of affective meanings in different communities, Goodwin, 2013). However, the latter is necessarily a subsequent level of analysis, since empirical investigation typically requires an incremental approach, even if the variables involved in a complex phenomenon interact non-linearly.

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Ezequiel A. Di Paolo,
Ikerbasque Basque Foundation for
Science, Spain

Reviewed by:

Sarah Bro Trasmundi,
University of Southern
Denmark, Denmark
Rebekka Hufendiek,
University of Basel, Switzerland

*Correspondence:

Marta Caravà
marta.carava2@unibo.it
Claudia Scorolli
claudia.scorolli@unibo.it

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THE SUBJECTIVE DIMENSION OF AFFORDANCES

Affordances are perceived opportunities for action that arise out of the interaction between an embodied organism and its environment. These opportunities can be “either for good or ill” (Gibson, 1966, p. 285), meaning that when the agent perceives possibilities for action, she would directly perceive their goodness or badness in relation to her needs, motives, interests, and goals.

Although a valence-based approach could be consistent with the original theory of affordances (Gibson, 1966, 1979), a closer reading of Gibson’s work might cast some doubt on this interpretation. Indeed, Gibson distinguishes the concept of affordance from valence-based constructs, such as “invitation character” and “demand character” (Reed and Jones, 1982; Kiverstein et al., 2019). Thus, whereas valence-based constructs serve to account for the subjective underpinnings of perceptual experience (e.g., affective states), *affordance* only refers to an invariant combination of factors that allows the agent to manipulate her environment despite the variability of the flux of perceptual stimuli (Gibson, 1979). This focus on invariants might be one of the reasons why philosophical research started to study the subjective (e.g., affective) dimension of affordances only in recent years (Rietveld, 2008; Gallagher, 2017; Dings, 2018; Krueger and Colombetti, 2018).

Yet, there is a body of experimental literature encouraging an inquiry into the subjective contextual features of *motor* affordances. By addressing evidence that shows how objects can elicit multiple affordances depending on the context and the task, Borghi and Riggio (2015) have proposed to distinguish between *stable* and *variable* affordances, deriving, respectively, from invariant objects properties and from more temporary objects characteristics. Shifting the focus to the agent-object *spatial* relation, Costantini et al. (2011) found that the emergence of affordance is modulated also by object distance, exactly by the *actual* object reachability, constrained by the *actual* functional capabilities of one’s body (Ambrosini et al., 2012). Even language plays a role: for instance, action and observation verbs differently affect object affordance, in keeping with the proposal that language acts as a sort of filter (Borghi, 2012). Recent work has focused specifically on subjective valence: using the approach-avoidance paradigm, the stimulus-evaluation, in conjunction with the reference-frame (self/object), was shown to be critical in guiding behavior (Saraiva et al., 2013). Consistently, we believe that a systematic investigation on the role of subjective-affective components for the emergence of affordances is badly needed.

THE LIKELIHOOD OF AFFECTIVE ACTIVATION

The concept of AA was elaborated to accommodate the fact that “we perceive [...] things as affording regulative opportunities to amplify, suppress, extend, enrich, and explore [...] our affective experiences” (Krueger and Colombetti, 2018: 214). Meaning that environmental items—such as tools (e.g., musical instruments:

Colombetti and Krueger, 2015), material objects (e.g., colored clothes: Colombetti and Krueger, 2015), and cultural artifacts (e.g., a rosary: Colombetti and Roberts, 2015)¹—not only afford cognitive, motor, and functional actions but also shape affective components (e.g., bodily expressions and action tendencies) and processes (e.g., emotion regulation and enkinesthesia: Stuart, 2010, 2012, 2016).

These items of the environment may afford emotions due to the relation between the items’ properties (e.g., material properties, associated cultural and social meanings: Bar and Neta, 2006; Malafouris, 2013) and the human agent’s sensorimotor skills (Chemero, 2003, 2009), her mastery of social-cultural norms (Ramstead et al., 2016; Roche and Chainay, 2017; Veissière et al., 2019), as well as her affective abilities and states. In addition, in line with Gibson’s concept of “nest of affordances” (Gibson, 1979) and with current enactive-ecological approaches (Rietveld and Kiverstein, 2014; Rietveld et al., 2018), AAs are components of complex niches of possibilities for action, which are more or less relevant in the agent’s everyday experience depending on different factors (e.g., reliability and trustworthiness; Krueger and Colombetti, 2018).

Here we investigate these factors to better understand how some items of the environment become part of an AA relation and to lay the bases for future research. Considering the “nest-like” features of affordances and the pervasive influence of the agent’s affective skills and states on perception (Barrett and Kensinger, 2010; Zadra and Clore, 2011; Pourtois et al., 2013; Niedenthal and Wood, 2019), one may indeed claim that *any* affordance relation instantiates some kind of affective action or reaction, therefore it should be considered as a full-fledged AA. To avoid a potential overextension of the construct we propose to integrate it with the notion of *likelihood* of affective activation, suggesting that it correlates with the details of object integration in the agent’s practice.

Building on Schutte et al.’s concept of emotional affordance as the likelihood of a situation eliciting emotional states and behaviors (Schutte et al., 2008), we suggest using AA to refer to relations with objects that are able to consistently solicit an emotional behavior over time, interpreting *integration* (Menary, 2009; Kirchhoff, 2014; Heersmink, 2015) as a means to predict whether an affordance-relation of the agent’s practice is able to solicit an emotional behavior in a consistent and reliable manner. We use *integration* as a specification of the enactive concept of diachronic coupling, with the aim of identifying two intertwined dimensions that might influence the likelihood of affective activation: (i) the *level* of integration of an object in the agent’s practice, and (ii) its *modality* of integration.

¹Objects, tools, and artifacts may instantiate affective processes on the basis of a different organization of “shaping factors.” For instance, with regard to cultural artifacts, the agent’s mastery of cultural information may have a heavier weight on the affective relation with the item in comparison to what may happen in other cases, such as those involving objects that function as personalized affective mementos (Caravà, 2020). Here, for brevity, we will use “object” as an inclusive term to refer to different AA relations.

LEVEL AND MODALITY OF INTEGRATION

The *level* of integration expresses the quantitative aspect of AAs regarding the temporal dimension of the agent's practice: the more an agent interacts with that object, the higher its level of integration would be. This description of dimension (i) may be consistent with the conditions of agent-environment coupling elaborated in the literature on "extended" affectivity (Colombetti and Roberts, 2015) and it is useful to emphasize the importance of a quantifiable variable of integration: *frequency of exposure*². The agent's exposure to an object has indeed been shown to positively correlate with the agent's trust in that object (Komiak and Benbasat, 2006), suggesting the introduction and manipulation of the variable "trust," endorsed also by "extended" approaches to emotions. Support to this proposal comes (indirectly) from a study by Constable et al. (2011), who found that the automatic potentiation of action toward a graspable object is relatively strong for a self-decorated mug, used daily for 12–16 days, while it is abolished for an unfamiliar mug. This seems to point out that the action system is less sensitive to the potential for action toward objects that cannot be integrated in the agent's habitual affective practices. Hence, provided that the increased frequency of exposure might influence the agent's perception of the affective values of objects (Zajonc, 1968; Bornstein, 1989; Garcia-Marquez et al., 2016) and her expectations on their affective regulative effects, we suggest that proper AAs are instantiated by objects that have a significant level of integration in the agent's subjective practice.

The *modality* of integration expresses the qualitative aspect of AAs, and it can be used to specify the details of the agent's affective coupling with some objects, thus strengthening the theoretical connection between ecological approaches and the enactive conception of "extended" affective systems. Our suggestion is that for an object to be part of an "extended" affective system, the agent should have integrated it in her practices at some point in time according to an affective modality. This condition does not rule out the fact that an object may instantiate an AA also because of its functional properties. Still, it serves to distinguish two cases. First, the case in which the human agent interacts with an object in a mere functional way (e.g., Borghi et al., 2012) and still the object exerts an influence on the agent's affective states and behaviors, as a mug that the agent usually uses for drinking coffee. Second, the case in which an object solicits emotional states and behaviors because it is constitutive of a practice that is properly affective, as an old mug to which the agent is emotionally attached because it reminds her of her childhood. In our view, the latter case exemplifies the concept of AA in extended-enactive systems better than in the former. Indeed, in the former, the affective influence of the

object on the agent seems to be causal: the coffee contained in the mug constrains the agent's affective states because of its bio-chemical properties. In the latter, this influence seems to be due to a constitutive affective relation built over time not only on the basis of the agent's recognition of the embodied regulatory effects of the object, but also on the basis of a more complex history of affective relations with it. Like in the former case, this affective relation involves physiological reactions due to the agent's perceptual engagement with the object, but also a broader affective incorporation that pertains to the agent's self-narrative. This affective integration is indeed enabled by the agent's affective episodic and autobiographical memories that might be thought to be incorporated into an "extended" narrative self (Heersmink, 2017), which is not only diachronically shaped by the agent's habitual practices, but also by the relation that the objects manipulated in these practices entertain with the individual agent's affective history.

ARE AFFECTIVE AFFORDANCES ENTITLED TO JOIN EMPIRICAL RESEARCH? LET'S TALK ABOUT IT!

Considering these two dimensions of integration, we therefore suggest using AAs to refer to affordance-relations characterized by a high level of integration and by the modality of affective integration. This characterization of AAs emphasizes their context-sensitiveness and subjective dimension at the diachronic level.

The empirical analysis of the construct of AA certainly benefits from the progress achieved in the investigation of motor affordance and intersubjectivity, emphasizing its context-sensitiveness at the synchronic level. Laboratory research has investigated affordances using 2D, then 3D, images of objects, gradually introducing the variable *context* (Chong and Proctor, 2020). The kind of context scrutinized is not only physical-spatial, but also social and linguistic (Gianelli et al., 2013): (stable) affordances are in fact codified in language (Borghi, 2012; Borghi et al., 2013). A thorough understanding is also derived from the manipulation of the type of task (Scorolli and Borghi, 2015) as well as of the intention of the agent (Bub and Masson, 2010). These progressive improvements go in the direction of a more ecological setting. Yet, in the study of AAs it will be even more important to take into account the required (motor) response: discrete-binary responses (i.e., key presses) would not allow an accurate investigation of AAs and, more seriously, would not enable the planning phase of the movement to be analyzed separately from the on-line control phase, since the influence of each falls as the movement unfolds (Glover, 2004).

AAs are not properly visual properties (unlike those typically investigated across empirical literature on affordances), however they are conveyed (also) by vision: the re-adaptation of existing paradigms can therefore come to our aid, in particular the kinematic analysis of the temporal course of hand movement (Scorolli et al., 2015) toward known objects arranged in an everyday-like environment. From the testing of the temporal dynamics we expect to detect an effect of the AA specifically

²In literature, *frequency of exposure* (implying interaction as well) and *familiarity* are used interchangeably. Although these two variables reasonably correlate, we hold it critical to distinguish them: familiarity is properly defined by qualitative aspects [see dimension (ii)]. The pencil I use 10 times a day to write the shopping list does have the same frequency of use as the pencil I use 10 times a day to write my diary, but their degree of familiarity strongly diverges. To mere experiences of exposure, familiarity adds the emotional dimension, characterized by a specific intensity and valence.

in the early kinematic events (roughly 35% of movement duration), since they reflect planning more than on-line control, and planning is a relatively slow process sensitive to semantic contents (Glover, 2004).

Restricting our exploration to an “isolated” object has been functional to highlight the novelty and the promising contribution of the construct. Future exploration will have to include multiple, also “social,” objects. Indeed, in everyday practice the object is encountered or even used with other objects. In case of functional-individual relation (e.g., a mug and a teabag), the object overbearingly asks for the complementary one; interestingly this request is affected by the Other’s eye-gaze (both effects found in the grasping action component: Scorolli et al., 2014).

When addressing the different sources impacting the object’s “affective load,” the overall model cannot finally overlook the weight of societal norms and roles (e.g., object ownership, Scorolli et al., 2018), and most importantly of the linguistic dimension. Language incorporates certain kinds of affordances (privileging function over manipulation: Masson et al., 2008), but it also constrains and is constrained by object affordances. With

reference to existing kinematics paradigms, we would expect that AAs modulate, for instance, the weight of language in affecting visuo-motor transformations when reaching and grasping an object. In the case of linguistic labels conveying information on object intrinsic properties (e.g., size, Gentilucci et al., 2000), we would predict that their modulation of the motor response (in particular the grasping component) is weaker in the case of affectively charged objects.

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MC and CS have made a substantial, direct and intellectual contribution to the work, and approved it for publication. All authors contributed to the article and approved the submitted version.

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Through the Magical Pink Walkway: A Behavior Setting's Invitation to Embodied Sense-Makers

Simon Harrison*

Department of English, City University of Hong Kong, Kowloon, Hong Kong

This paper examines an intersection between ecological psychology and the enactive approach brought about by studying sense-making in relation to a behavior setting in Hong Kong and adopting a focus on embodied action and gesture. A cosmetics pop-up store embedded in a downtown shopping mall provides the basis for a case study involving a two-pronged analysis. I first use Barker's behavior setting theory to describe the publicly accessible structure and dynamics of the store, which reveals a bounded spatiotemporal entity with several interdependent behavior-milieu parts. I then analyze video recordings of my research participant encountering, entering, and exploring this environment. Following an enactive-informed micro-ethnographic approach to embodied communication, I examine her movements, postures, gestures, and language use as she joins the behavior setting. These fine-grained descriptions of her embodied actions provide an empirical basis to analyze enactive sense-making. On the one hand, they disclose the affective and emotional experience of perceiving relevant affordances in the environment, and on the other hand, they show the specificity of sensorimotor abilities required to join the setting's standing pattern of behavior.

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*Correspondence:

Simon Harrison
simon.mark.harrison@gmail.com

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Guess what's happening in *Jubilee Plaza* now? Hint: 🌸🌸🌸!

Let's fall in love with everything cherry blossom! Enter the first stop of a romantic cherry blossom world with us by passing through the magical pink walkway at *Jubilee Plaza* AB2! Don't forget to bring along your BFF to our pop-up store to try on our newest collection and enjoy the sweetness overload selfie moment!

First Stop: March 12–18 at *Jubilee Plaza* AB2

Second Stop: March 25–31 at *Fragrant Mall* 4/F Atrium
(Facebook post, March 13, 2019)

INTRODUCTION

On March 13, 2019, a publicly shared post to the official Facebook page of Pink Cosmetics summoned its global community of 20 million followers to Hong Kong's *Jubilee Plaza* mall.¹ This giant of the cosmetics industry (annual turnover of 1 billion US\$) was inviting Hong Kong customers to join “a romantic cherry blossom world... by passing through the magical pink

¹Details have been modified to preserve anonymity.

walkway.” The post encouraged people to come with their friends, enticing them with the opportunity to try on the brand’s latest makeup and take selfies with the “sweetness overload” (a synthetic cherry blossom that could be seen decked around the setting; **Figure 1**). Several air-brushed images shared with the post provided a bird’s-eye view of an elaborately decorated environment assembled in the mall’s ground floor atrium, along with snapshots of elated inhabitants already interacting, being made up by beauty consultants, and posing for selfies.

The Pink Cosmetics pop-up store sets the scene for this paper’s examination of an intersection between ecological psychology and the enactive approach. Rather than apposing these theories to evaluate their compatibility (see Heft, 2020), this study draws on elements from both—behavior setting theory from ecological psychology (Barker, 1968; Wicker, 1992; Heft, 2018) and enactive-informed approaches to embodied communication (Cuffari and Jensen, 2014; Jensen and Pedersen, 2016; Streeck, 2017)—to conduct a two-pronged analysis of person–environment relations at the pop-up store from complementary levels and perspectives, adopting a specific focus on embodied action and gesture.

The findings first show that embedded in the mall environment is a bounded spatiotemporal structure equipped with several interdependent behavior–milieu parts that invite a range of sense-making behaviors, which are conducive to the application and purchase of makeup. I then examine video recordings of my research participant encountering, entering, and exploring this environment and describe her movements, postures, gestures, and language use as an empirical basis to analyze her sense-making. On the one hand, her embodied actions disclose the affective and emotional experience of perceiving relevant affordances in the environment, and on the other hand, they show the specificity of sensorimotor abilities required to join the setting’s standing pattern of behavior.

In addition to these findings, the study contributes a situated example of how novel forms of consumerism and screen culture are shaping today’s urban environments (Fleming and Harrison, 2020), begging the question “of what kinds of worlds we are building, for whom, and under what constraints and possibilities” (Di Paolo et al., 2018, p. 10).

Background

Almost 70 years prior to this study, developmental psychologist Roger Barker set up an observational field station at a town in North America called Midwest (pseudonym) to investigate questions that he believed had been wrongly “excised” from psychology: “How do environments select and shape the people who inhabit them? What are the structural and dynamic properties of the environments to which people must adapt?” (Barker, 1968, p. 4).

Barker’s longitudinal study of a town’s inhabitants resulted in the discovery of *behavior settings*, defined as “highly structured, improbable arrangements of objects and events which coerce behavior in accordance with their own dynamic patterning” (Barker, 1968, p. 4). These “extra-individual” patterns of behavior–milieu around the town were shown to be better predictors of his subjects’ behavior (several of the town’s children)

than individual psychological attributes or observable sensory inputs. Examples of the town’s behavior settings included a basketball game, a worship service, a piano lesson, and the town’s drugstore during opening hours—each consisting of “one or more standing patterns of behavior-and-milieu” (Barker, 1968, p. 18). Though far removed in time, space, and texture from the environments observed by Barker, the announcement and images of a pop-up store in the *Jubilee Plaza* exhibit the hallmarks of a behavior setting, including information about its occurrence, duration, population, action patterns, and behavior mechanisms (Barker, 1968, pp. 46–80).

Bringing a Gibsonian approach to behavior settings and framing their patterns of behavior–milieu in the language of dynamical systems, Heft refers to behavior settings as “*higher order dynamic units of the environment*” constituted by the joint actions of the individuals and the material features (‘milieu’) at some locale” (Heft, 2018, p. 107; emphasis original). Heft has noted that Barker’s “momentous” discoveries remain “under-appreciated” and even “ignored” in the study of human development, behavior, and psychology (Heft, 2003, 2018).² In the embodied cognitive science and philosophy of the mind, by contrast, the theory of behavior settings (and Heft’s dynamical reframing) has been recognized for its potential to complement the enactive approach (McGann, 2014, 2016; Di Paolo et al., 2017, 2018).

The enactive approach refers to a view of embodied cognition that is rooted in the self-organizing principles of biological processes (Varela et al., 1991/2016; De Jaegher and Di Paolo, 2007; Thompson, 2007; Di Paolo et al., 2017, 2018; Gallagher, 2017). According to Evan Thompson, enaction “drew on multiple sources” including but not limited to “the theory of living organisms as self-producing or ‘autopoietic’ systems...,” empirical evidence from embodied cognitive science that “sensorimotor interactions with the world shape cognition,” and concepts from Merleau-Ponty’s phenomenology, such as *intercorporeality* (Varela et al., 1991/2016, p. xxv; Meyer et al., 2017).

Enactivists join ecological psychologists in viewing people and environments as fundamentally intertwined (McGann, 2016). Barker’s behavior settings theory focused on describing structures and dynamics in the environment and their role in selecting and shaping human behavior *en masse*. In contrast, enactivists begin with the self-organizational properties of individual organisms and examine cognitive activity as *sense-making*, defined as the “active adaptive engagement of an autonomous system with its environment in terms of the differential virtual implications for its ongoing form of life” (Di Paolo et al., 2018, p. 332).

In the enactive approach, people and their environments are always already materially enmeshed on a biological level through a ceaseless process of individuation: self-production and self-distinction (Thompson, 2007). As people act and interact with their environment, they regulate the organism–environment coupling relation through the moment-to-moment “selective

²This apparent neglect is despite behavior setting theory being carried forward and developed by Barker’s former students, such as Schoggen (1989) and Wicker (1992).



FIGURE 1 | The Pink Cosmetics pop-up store.

opening and selective rejection of material flows” (Di Paolo et al., 2018, p. 40), and in doing so, they enact the significance of the world they inhabit with respect to their own vital norms (De Jaegher and Di Paolo, 2007; Cuffari et al., 2015; Di Paolo et al., 2018). “Whatever the organism encounters,” Thompson (2007) reminds us, “it must evaluate from the vantage point established by its self-affirming identity” (p. 154). In this perspective, the environment emerges dynamically from the individual’s sense-making behaviors.

The ecological and enactive views on the person–environment relation embody an ongoing source of tension between the two approaches, with the pre-given (publicly accessible) character of the built up environment “out there” on the one hand, and the claim that individuals enact the significance of the world through sense-making behaviors rooted in the organism’s individuation on the other hand (McGann, 2014, 2016; Heras-Escribano, 2016; Di Paolo et al., 2017). McGann (2014) has explicitly formulated the gaps that each approach consequently sees in the other. In enactive approaches to cognition, “[t]he precise nature of the environment is frequently left ill-described”

(McGann, 2014, p. 2), while in ecological psychology, “much of the texture and detail of the agent... in a description of a given engagement” is similarly left wanting (McGann, 2014, p. 3). However, “what is actually happening,” as McGann (2016) later stresses, “is both are giving compatible and possibly even equally valid accounts of things, just at different resolutions of description” (p. 313). A number of researchers have proposed that behavior setting theory in particular could provide a wide-angle lens for considering enactive issues (McGann, 2014, 2016; Heras-Escribano, 2016; Di Paolo et al., 2017, 2018), though specific attempts to do so are lacking.

Embodied Action and Gesture: Bridging the Ecological/Enactive Divide?

As enactivists have sought to expand their living systems approach to encompass sensorimotor abilities and intersubjectivity, they have pointed to studies of face-to-face interaction in social settings for evidence of sense-making (Gallagher, 2005, 2017; Cuffari et al., 2015; Di Paolo et al.,

2017, 2018). However, fine-grained analyses of embodied action, language use, and gesture have not figured prominently in the core enactive literature (though see Gallagher, 2005, 2017).³ And yet, the case can be made that strands of embodied communication research are fruitfully bridging the ecological/enactive divide. Micro-ethnographic research into human communication in particular is characterized by rich descriptions of sense-making behaviors analyzed in relation to specific ecological environments and niches (Streeck, 2009, 2017, 2018; Cuffari and Jensen, 2014; Jensen and Pedersen, 2016; Cuffari and Streeck, 2017; Meyer et al., 2017; Goodwin, 2018; Harrison, unpublished).

A case in point is Streeck's (2017) suggestively titled *Self-Making Man*, a book-length analysis of one man's behaviors over the course of a day's work in his automotive garage. Streeck (2017) acknowledges the similarity of his study to the "specimen records" of individual inhabitants encountering behavior settings in Midwest (Barker and Wright, 1951). But as with the current paper, he adopts a micro-ethnographic perspective on the garage owner's embodied behavior to show how "each moment of understanding is the result of a local montage of heterogeneous resources" (p. xxviii), which range from individual histories to grammatical structures, gestures, and ecological objects on the garage shop floor.

Within this ecological friendly view of person–environment relations, Streeck (2017) also draws on enactive individuation, viewing embodied behavior as self-making (hence the title of his book) and developing an approach to "autopoieses by gesture" (pp. 287–293). Over the course of several chapters, Streeck (2017) shows, for example, "how gestures adapt to settings while structuring them... how gestures' orientations are embedded in the intercorporeal context of the moment... (and how) gesturing not only varies moment by moment in response to communicative needs or emerging significances of the moment, but also in a broader fashion between occasions" (pp. 288–292). The embodied communicative and meaning-making practices of the garage manager are always analyzed with respect to the significances he perceives and enacts on his shop floor, that is, to the functional and social affordances of a behavior setting (though Streeck does not address the garage shop floor explicitly in light of behavior setting theory).

Adopting a similar analytical methodology to Streeck—which combines transcription of naturally occurring interaction data with analytical notions from cognitive semiotics, ecological psychology, and the enactive approach—Jensen and Pedersen (2016) offer another example of gesture research bridging the ecological/enactive divide. These researchers situate their study of embodied action within clearly identifiable "organizational eco-systems," including "a hospital, a school for children with special needs, and a kindergarten" (p. 86). Alluding to individuation, they define enactive sense-making simply as "a pull toward

certain aspects [of these environments] at the expense of others" (Jensen and Pedersen, 2016, p. 86; see also Thompson, 2007, p. 154; Di Paolo et al., 2018, p. 146). The nature of this pull is shown through a fine-grained study of participants' embodied actions, gestures, and situated language use, which disclose the emotional and affective attunement of participants to certain affordances in the environment. While the environments were shown to supply "a set of expectations of how specific actions can be carried out by the participants to achieve pre-defined goals" (cf. Barker's "program circuits"; Barker, 1968, p. 168), the sense-making behaviors of individuals accounted for the unexpected actions, trajectories of situated action, and emergent affordances observable in the data (Jensen and Pedersen, 2016, p. 86).⁴

Building on enactive-informed micro-ethnographic studies of human communication in specific ecological environments, this paper takes the research participant's encounter with the Pink Cosmetics pop-up store at the *Jubilee Plaza* mall as a case study to demonstrate how concepts from ecological psychology and the enactive approach can be utilized to account for an individual's actions in a public setting from complementary levels and perspectives. A research question that addresses these different levels and perspectives is: How do people's sense-making behaviors relate to features of the behavior setting they have joined? Unpacking this question will require a double-pronged analysis of two specific sub-questions: (a) What are the structural and dynamic properties of the behavior setting? And (b) What sense-making behaviors are revealed through the actions of individuals as they join and explore this setting? The next section introduces the data and clarifies the case study methodology.

DATA AND METHODS

The Corpus

My recordings and images of interactive episodes in the Pink Cosmetics pop-up store are taken from a video-recorded corpus of everyday life in Chinese settings. Central to this corpus is a Chinese woman who gave informed consent to become a key participant in the research and allowed me to record her in a range of social and professional interactions. In filming, I have aimed to follow a micro-ethnographic approach to human action and interaction, recording with a single hand-held digital camera, guided by conventions in multimodal interaction research (see for example Streeck, 2009, Ch. 2; Streeck, 2017). I have also conducted semi-structured interviews with this participant, as well as think-aloud paradigms and post-event recalls, which I have been able to draw on to support or nuance interpretations of her embodied interaction. While acknowledging the specificity of this corpus, it has also contributed a situated example (Busch-Jensen and Schraube, 2019) for reflecting on contemporary

³In *How the body shapes the mind*, Gallagher (2005) reports lab studies of gesture during solicited narratives in a highly controlled lab setting (pp. 107–129), while in *Enactivist interventions* (Gallagher, 2017), he leverages studies of gesture in naturally occurring, multi-party situated activity (pp. 156–158). The differences between these two data sets and the conclusions to which they lead Gallagher are striking.

⁴There are overlaps between the interplay of sense-making behaviors and organizational structures in the wider environmental setting in these gesture studies with approaches formulated elsewhere as the "enactive affordance-based model" (de Haan et al., 2013) and a "user-based account of information" in the environment (Withagen, 2018). For more theoretical discussions of such, see also Rietveld (2008) and Rietveld and Kirverstein (2014).

subjectivities, lifestyles, and urban environments in China (Fleming and Harrison, 2020).

The Case Study

The case study for the current paper was recorded one afternoon in the *Jubilee Plaza* mall, a 1 million-square foot retail space located centrally in Hong Kong. The research participant had been shopping at the mall, when I alerted her to an elaborately decorated installation in the mall's main atrium and followed her there with the camera. I captured her first perception of what transpired to be the cosmetics pop-up store and continued filming as she approached, entered, and explored. Six video clips were made on this occasion, totaling 9 min 43 s. Some of these clips include moments of short dialogue between myself and the participant.

In addition to this video-recorded corpus and to the time that I spent in the store when recording, my case study draws on various ethnographic materials. These include the store's own descriptions posted to Facebook, the labels and signs that I observed in the store (both in person and visible in the data), notes taken from many conversations that I have had about this store with the research participant following the data collection, the website of the Jubilee Plaza mall, and finally, my experience of passing through this atrium and shopping in the mall over a 12-month period.

This case study could be considered as “extreme” (Flyvbjerg, 2001), meaning “well suited for getting a point across in an especially dramatic way” (p. 78). According to Flyvbjerg (2001), “extreme case studies often reveal more information because they activate more actors and more basic mechanisms in the situation studied” (p. 78). In terms of a behavior setting, for example, the pop-up store combines an intriguing combination of esthetic, business, education, personal appearance, and social contact action patterns (Barker, 1968, pp. 52–66). In terms of enactive issues, its “romantic,” “magical,” and digital qualities seem contrived to solicit specific emotions and affects, which have been established as important for sense-making and cognition more generally (Jensen and Pedersen, 2016; Gallagher, 2017).

Procedure of Analysis

To answer the research questions, I adopted a two-pronged analysis. I first applied Barker's criteria to describe salient aspects of the structure and dynamics of the settings, then examined the video recordings of my key participant exploring this setting to analyze her visible bodily actions as evidence for enactive sense-making.

Barker (1968) developed “three tests for evaluating any part... of a community as a possible behavior setting” (p. 23). The first of these was structural; the second two concern its dynamics. The structural test helps distinguish the pop-up store as a behavior setting, while the dynamic tests reveal behavioral objects, mechanisms, and action patterns that are salient to its internal unity. Barker implemented these tests quantitatively with longitudinal data and multiple raters. I apply his descriptors and definitions to describing the public environment qualitatively.

In the second step of the analysis, I zoom into my participant's sense-making behaviors by examining the video recordings of

her in the setting. I follow the enactive-informed approach to embodied communication developed by Streeck (2017), who identified his research participant's sense-making behaviors by describing “his habits of walking and standing, of looking and pointing, his methods of showing others how things work... for gesturing and speaking and organizing” (p. xxix). The analysis involves attention to the environmentally embedded moment-to-moment behaviors visible and audible in the video recordings, such as the person's “gait and posture, gaze, gesture” as well as analysis of the participant's language use and conversation (Streeck, 2017, p. xxix). This is an abductive phase of analysis, “a slow procedure, characterized by continuous shifts between a purely descriptive and a theoretical orientation to the data” (Streeck, 2017, p. 390). A similar “analytical movement” between scales of analysis, description, and theory has been proposed in psychology research as a strategy for situated generalization, referred to imagistically as *zooming in zooming out* (Busch-Jensen and Schraube, 2019).

ANALYSIS

Pink Cosmetics Pop-Up Store as Behavior Setting: Structure and Dynamics

To be a behavior setting structurally, according to Barker (1968), a part of the community must be a “behavior–milieu synomorph,” meaning to have the following “essential structural characteristics” (p. 38):

- (a) a standing pattern of behavior (a bounded pattern of behavior of people *en masse* which occurs independently of the particular persons involved),
- (b) anchored to a particular milieu complex;
- (c) at particular time–space loci;
- (d) with behavior and milieu synomorphic;
- (e) and with milieu circumjacent to behavior (Barker, 1968, pp. 37–38).

The *Jubilee Plaza* mall is described on its website as “an energized environment of innovation, originality, and pleasure... including over 200 retail stores and restaurants, a multi-screen cinema, one of Hong Kong's largest ice rinks, (and) over 220,000 square feet of office space.” Like “the churches, the schools, and the courthouse” observed in Midwest by Barker (1968, p. 23), the mall would be a “multiple-setting synomorph.” The individual retail stores, restaurants, cinema, ice rink, and offices, on the other hand, are more likely to exhibit the structural attributes of behavior settings.

Each of the outlets in the mall is anchored to a particular location that opens and closes according to operating hours (attribute *c*). They each involve a “standing pattern” of behavior, meaning the activities among people in that spatiotemporal locale are to some extent interdependent (attribute *a*). In each case, we can identify a unique *milieu* (attribute *b*). As per Heft (2018), the milieu “refers to the features of the environment that support these patterns of action and, for the most part, are synonymous with affordances in a Gibsonian sense” (p. 109; cf. Gibson, 1986).

The standing pattern of behavior is closely bounded by and reflected in the structure of the locales they are in (attributes *d* and *e*). Meaning, not only does the spatiotemporal boundary of the individual store provide a boundary for or “enclose/environ” the pattern of behavior observed therein (attribute *e*), but also, following Barker (1968, p. 19), “there is an essential fittingness” between the pattern of behavior and “the fine, interior structure” of the setting (attribute *d*). If any one of these attributes was lacking for the individual stores, they would likely cease to operate. Meanwhile, the mall would continue to function (hence being classed as a “multiple-setting synomorph”).

Before examining the dynamics of the Pink Cosmetics pop-up store (Barker’s other tests for determining a behavior setting), the store’s structural peculiarities in terms of its time–space locale (criteria *c*) and other attributes of behavior settings merit further discussion.

The Time–Space Locale, Pressure, and Population of a Behavior Setting

Pop-up stores by definition are temporary both in time and space. According to the online consultancy firm *Storefront*, pop-up stores are located in “high foot-traffic areas” and last for “typically 3 days to 3 months.”⁵ The Facebook post by Pink Cosmetics announced that the pop-up store was “happening now” in “Jubilee Plaza AB2” and would last from “March 12–18.” The location “AB2” is an atrium *cum* thoroughfare between the various landmarks surrounding the mall, including an MTR Station and a university.

Pop-up stores in AB2 are common, but the atrium is often empty too, instead offering its inhabitants a “sky-lit” shopping experience “combining natural light and open space” (Figure 2).

The montage of the open space *cum* thoroughfare with the Pink Cosmetics pop-up store in Figure 2 emphasizes Heft’s (2003) observation that “the same locale can take on quite different functional meanings at different times,” the difference resulting from patterns of collective action that determine the meaning of *place* (Heft, 2003, p. 175).

The location of the pop-up store in the atrium *cum* thoroughfare also illustrates a variable property of behavior settings that Barker called its *pressure*. “Behavior settings differ in the degree to which they bring pressure upon different population subgroups to enter and participate in them” (Barker, 1968, p. 27). As well as being advertised across social media platforms, whose software supplies companies access to potential customers’ newsfeeds, the pop-up stores at *Jubilee Plaza* are literally placed in people’s way (“high foot-traffic areas”).

Built into the design of the Pink Cosmetics pop-up store, furthermore, were outward-facing video screens relaying the company’s advertisements, which predictably screened images of female models with seemingly immaculate complexions, alternating with images of the company’s product (Figure 3).

Salient to these larger-than-life images were a range of facial expressions, eye-gaze patterns, postures, and manual gestures that would plausibly interpellate passers-by (the processes by which such signs communicate messages and ideologies are

the well-known subject matter of critical multimodal discourse analysis; e.g., Harvey, 2013). The advertisements also work to provide models (literally and figuratively) for how people can look and behave. This part of the pop-up store can be seen as projecting important features of the behaviors invited by the setting, namely, the “established ways of acting. . . (by) those who have already mastered the craft,” revealing *en passant* the way that such environments take part in “largely unobtrusive and unnoticed disciplining of the body” (Rietveld, 2008, p. 989).

To understand the functional meaning of AB2 when occupied by the Pink Cosmetics pop-up store, we now return to Barker’s criteria for internal and external dynamics.

Dynamics of the Pink Pop-Up Store: Interdependencies and Other Attributes

In Barker’s theory, the internal and external dynamics of behavior settings referred to the relations of interdependency between different behavior–milieu parts of a community. For example, Barker identified three behavior–milieu parts of Midwest that were interjacent to the town’s drug store (meaning structurally located within the drugstore): namely, a soda fountain, the pharmacy, and the variety department. The question was whether these behavior–milieu parts were separate behavior settings or parts of the drugstore setting. As Barker noted: “Structurally, they are discrete, but dynamically they are so interdependent in their functioning” (Barker, 1968, p. 22), while also being sufficiently independent from any other settings in the town.

To establish the interdependence between the behavior–milieu parts of a setting, Barker (1968) proposed seven different measures and used rating scales to calculate an interdependency score for a sample of 100 synomorphs in Midwest (pp. 40–46). The results established an empirical basis for identifying “community parts with phenomenal reality and with dynamic significance for behavior” (p. 45). The nature of the Pink Cosmetics pop-up store and my case study methodology preclude collecting the longitudinal observations and quantitative data on which Barker’s interdependence ratings were based. Instead, I will proceed by identifying salient features of the milieu, describing the patterns of behavior that could be observed there and evoking interdependence measures that were salient to understanding how the different behavior–milieu parts were related.

Nine behavior–milieu parts can be clearly identified and labeled inside the pop-up store. While Figure 4 shows a bird’s-eye view of the store’s milieu, the following section will examine this milieu with reference to its corresponding patterns of behavior.

The interdependence measures to be evoked here mainly concern behavioral objects and mechanisms, that is, “the degree to which. . . the synomorphs use the same or similar behavior objects” and “the same kinds of behavior mechanisms occur in the synomorphs” (Barker, 1968, p. 40). Where salient, an interdependency measure will also be pointed out called “population,” which concerns “the degree to which the same inhabitants enter the synomorphs” (Barker, 1968, p. 40). These observations of the interdependencies are furthermore supplemented with other salient attributes and features described for behavior settings, such as its “action patterns” (Barker, 1968, pp. 52–56).

⁵<https://www.thestorefront.com/mag/what-exactly-is-a-pop-up-shop/>

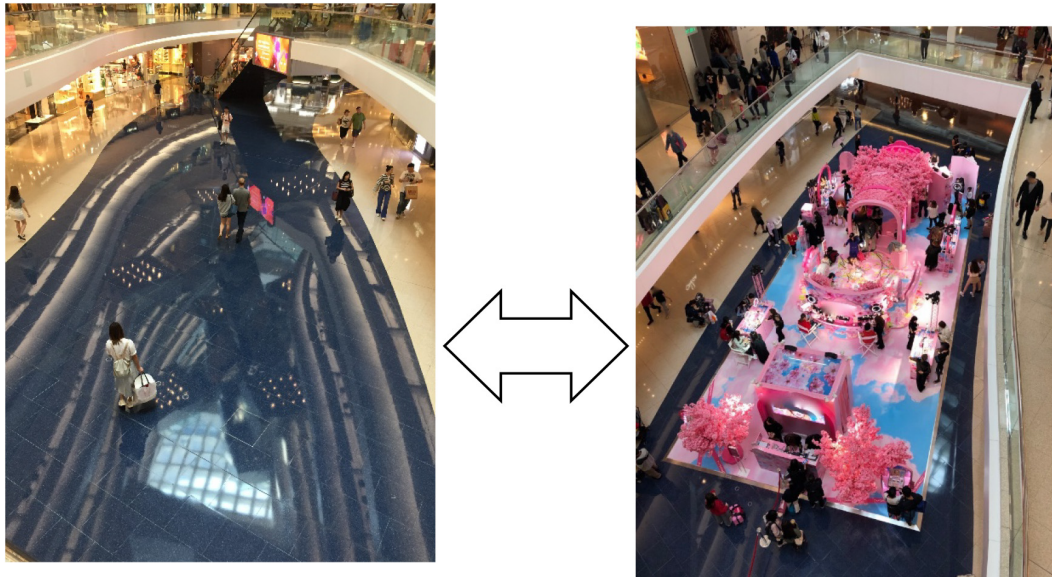


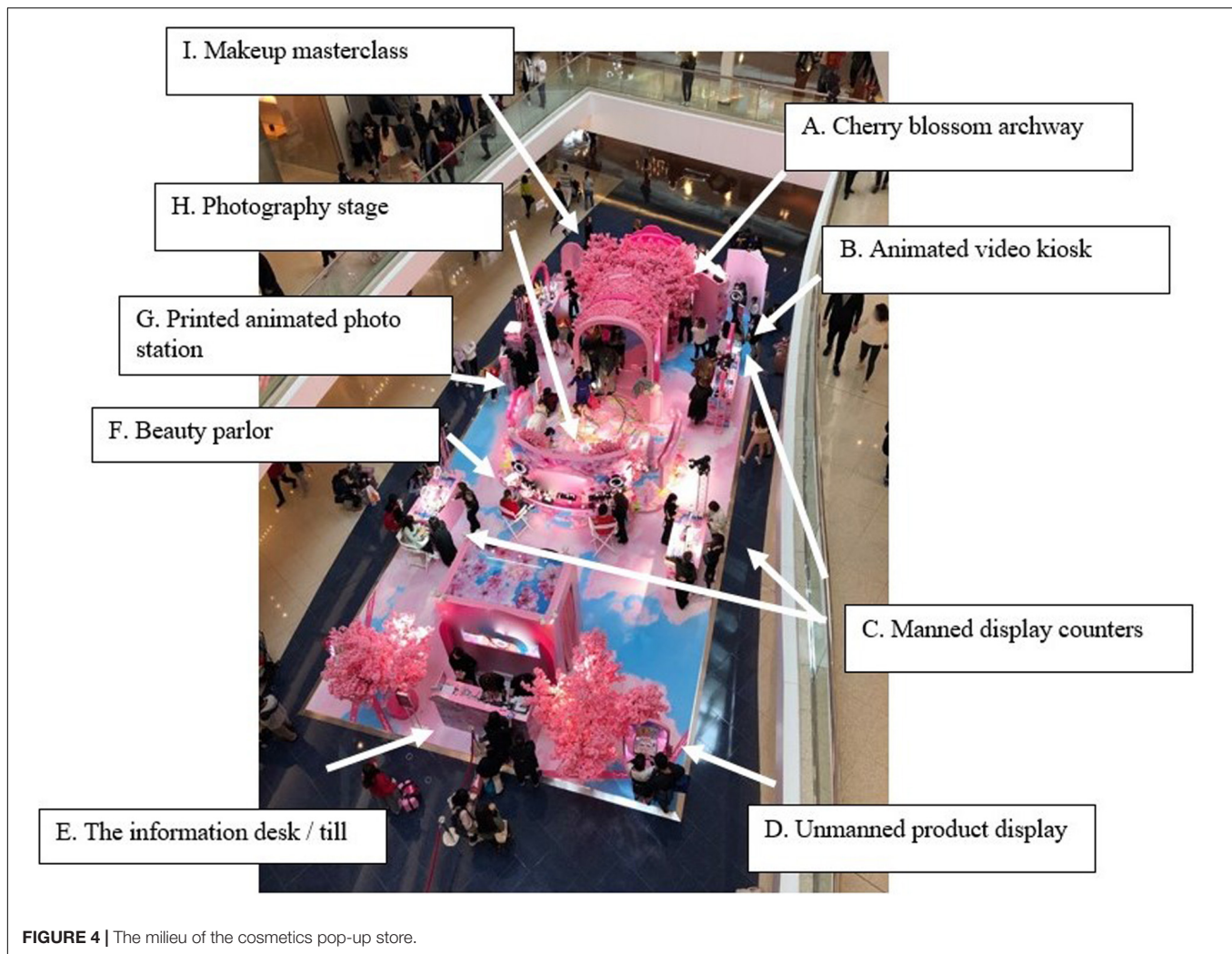
FIGURE 2 | Sky-lit shopping atrium cum thoroughfare qua Cosmetics pop-up store.



FIGURE 3 | Outward-facing video advertisements targeting subgroup population featuring range of expressive behaviors.

To start, one set of parts with interdependent behavior objects and mechanisms and where similar action patterns can be observed are the animated video kiosk (**Figure 4B**), the printed animated photo station (**Figure 4G**), and the photography stage (**Figure 4H**). They are each based on the use of screens and image-making technologies, and the associated behaviors they invite are implemented through affective behaviors, gross motor activities, and manipulation. The action patterns relate to esthetics, personal appearance, education, and social contact (Barker, 1968).

For example, the animated video kiosk (**Figure 4B**) was a life-size touch screen with a built-in camera on selfie mode illuminated by a tripod-mounted ring light, the screen being encased within a pink cherry blossom frame imploring inhabitants directly to “TAKE YOUR BEST SHOT!” (**Figure 5**). The kiosk was manned by a beauty consultant tasked with guiding customers in front of the screen, where they could make a video of themselves posing, then evaluate their personal appearance in the draft video. If not satisfied, the users could remake the video of themselves and finally share the



finished product online before moving on to the next part or station of the store.

A similar behavioral object, mechanism, and action pattern were in place at the printed animated photo station (**Figure 4G**). Inhabitants of this part of the pop-up store were similarly guided by a beauty consultant in front of a camera, which, rather than making a video, produced a personalized holographic photo. This part of the setting similarly solicited various poses from the inhabitants (such as the very common “hand heart” gesture; **Figure 6**), which they could evaluate and redo before finalizing the choice of images to be printed. The machine’s algorithm would stitch these images together into one holograph, print this out as a souvenir for the inhabitants and at the same time upload the image online to Instagram. Inhabitants without an Instagram account were prohibited from participating in the standing pattern of behavior associated with this part of the store, which emphasizes the requisite material conditions and desired population targeted by Pink Cosmetics.

In these two parts of the setting, the function of ecological objects was to capture and augment the inhabitant’s self-image to furnish those inhabitants with that image of themselves,

who could then evaluate their personal appearance before either redoing the image or sharing it online. In terms of their framing and filtering, as well as the poses they captured, these images were similar to those being relayed in the advertising displayed around the setting (recall **Figure 3**), creating further ecological unity with other parts of the store.

The third part of the setting which showed clear interdependence with the video kiosk and the animated photo booth was the photography stage (**Figure 4H**). This was a raised platform mounted with a cherry blossom backdrop and the company’s name in bright neon lights. Though unmanned, signs invited inhabitants to join the stage for an “interactive photo moment”—this being the affective action pattern described by the company on Facebook as to “enjoy the sweetness overload selfie moment” (**Figure 7**). An example of behaviors associated with this part of the setting can be seen in the sequence of frame grabs, which show one of the setting’s inhabitants performing a series of poses for the camera.

Figure 7 highlights another key behavior mechanism observed by Barker (1968), which was the “involvement of the hands in the standing behavior pattern or setting” (p. 69). Beyond the



FIGURE 5 | *Take your best shot!* A life-size animated selfie at the video kiosk.

performance of stock gestures (such as the “V-gesture” and “hand hearts”), posing on the photography stage often incorporated the touching of cherry bloom and other forms of “tactual feeling” and “manipulation,” including sniffing and kissing the fake flowers (for the benefit of the camera). Behavior in other parts of the setting was also implemented through this mechanism wherever synthetic flowers were involved, such as in the cherry blossom archway (a; see section “*Joining the Setting*”).

A functional attribute common to the behaviors discussed so far is what Barker called the “personal appearance action pattern,” defined as “behavior concerned with improving personal appearance *via* clothing, grooming, adornment” (Barker, 1968, p. 61). At the three stations described above, people could be seen engaging in behaviors clearly aimed at improving their personal appearance, such as “looking one’s best” for the camera (Barker, 1968, p. 61). The affordances of the technologies in particular were crucial. The images produced by the different machines would invariably be edited, color corrected, and otherwise filtered to enhance the appearance of the inhabitants and their subsequent appreciation of their own image. When inhabitants used their own cameras (e.g., at the photography stage), they could be seen retroactively photo-shopping their results, which can involve two-dimensional digital skin smoothing, facial feature restructuring, overall slimming, leg lengthening, and teeth whitening procedures.

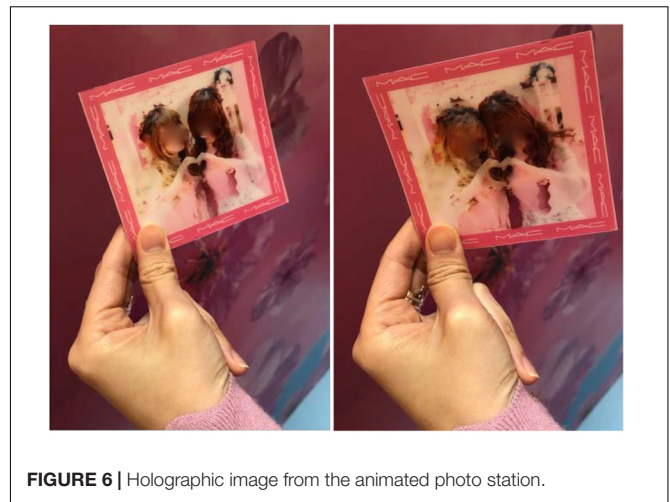


FIGURE 6 | Holographic image from the animated photo station.

In relation to this personal appearance action pattern, a rating scale of participation known as “evaluation and appreciation” is highly relevant. This scale refers to “behavior that explicitly recognizes the values of the action pattern, whether good or bad, or tests its effectiveness... To receive a rating, there must usually be a place in the program for appreciation and evaluation” (Barker, 1968, p. 53). All the synomorphs discussed so far included inhabitants appreciating and evaluating their own image. This action pattern was not exclusive to the stations that involved image-capturing digital technology (Figures 4B,G,H) but also occurred at the manned display counters (Figure 4C), where customers could try on tester makeup and evaluate their appearance in brightly lit mirrors.

The application of makeup was obviously a salient gross motor activity at these display counters. Two other settings were similar in this respect, namely, the beauty parlor (Figure 4F) and the makeup master class (Figure 4I). However, the role (or “functional position”) of the consultants across these parts revealed different “degrees of involvement and responsibility” (their “depths of penetration”) with which people could participate in the setting (Barker, 1968, pp. 49–51). While the consultants manning the display stalls typically only offered advice and assistance (as far as I could gather) and cleaned up after the customers, those manning the beauty parlor and the makeup class were trained professionals in the art of makeup application. This reveals an additional pattern being shared across these parts of the setting, namely, education.

Finally, the application of makeup in different parts of the setting reveals further interdependencies between the different stations. Having been made up, inhabitants would then go to take pictures or make videos at other stations. This illustrates both a behavioral and a population interdependence, meaning that “the physical resultants of behavior in A may spread to B and vice versa” and that “people who enter synomorph A also enter synomorph B” (Barker, 1968, p. 41). It is why the inhabitants of the store were likely to cross each other’s paths on various occasions during their time in the store. The application of one’s



FIGURE 7 | Posing on the photography stage with the cherry bloom.

own makeup was also a frequent behavior of inhabitants in all locations around the store.

With the salient structural features and interdependent dynamics of the pop-up store now sketched, I propose to zoom into the sense-making behaviors of a given individual and examine video recordings of her moment-to-moment perception and exploration of this behavior setting.

Sense-Making in the Setting

Following Streeck (2017), I will take a description of my participant's "gait and posture, gaze, gesture" (p. xxix) as well as her situated language use as an empirical basis for reconstructing an account of sense-making behavior, which I understand following Di Paolo et al. (2018) as "cognitive and affective activity manifested experientially as a structure of caring" (p.332). In this approach, Streeck (2017) has shown why any "body motion" is significant because it potentially "enacts the organism's recognition of a feature of a situation and selects it as significant for the organism" (Streeck, 2017, p. 282; see also Jensen and Pedersen, 2016; Cuffari and Streeck, 2017; Streeck, 2018). "By making gesture," specifically, it can be seen how "the speaker's living body orients itself to the cognitive and social landscape at hand as an acting body," as well as how the speaker "makes sense in the manners in which acting in the material world makes sense" (p. 295). In what follows, these relations between visible embodied action, orientation to significances in the material surroundings, and sense-making will be examined in the footage of our participant encountering the setting (see section "Encountering the behavior setting"), then entering and exploring its different parts (see section "Joining the Setting").

Encountering the Behavior Setting

X's first encounter with the pop-up store occurs from a balcony overlooking the mall's atrium (Figure 8). She approaches this balcony at an assured pace (Figure 8A), spends several seconds gazing down on the setting (Figure 8B), adopts a hands-on-hips posture (Figure 8C), then adjusts her position by moving to her left and craning her neck (Figure 8D).

In these images of X first viewing the pop-up store, we can see her embodied orientation toward the setting. After a forthright approach to the lookout point (Figure 8A), she adopts a hands-on-hips posture or stance (Figure 8C). As Streeck (2018) reminds us, the word stance metaphorically "refers to someone's disposition toward the situation," which in the case of a hands-on-hips or "akimbo" posture, has been shown to function in "projecting a sense of non-occupation, an observer's stance, being at rest" (p. 335). With this possibility in mind, X would seem to spend time taking in her perception of the store. She also adjusts her positioning to a slightly different angle, allowing for different perceptual experiences in which new features of the setting come into view.

After these first 20 s, I engage X in a short dialogue (Transcript 1). I ask her "怎么样?" (*well?*, line 1). After nodding her head (^^^), she replies "yeh 就这个牌子的" (*yeh just this brand*, line 2). I check her familiarity with the brand (lines 3–4), then ask about its reputability (line 5). She replies with details about the brand's offerings and its standing in relation to designer labels (line 6). As she mentions the product "化妆品" (*cosmetics*), she makes a gesture across her forehead. The timing of the gesture in relation to speech is indicated with underlining in the verbal transcript, while the gesture is visualized in the accompanying frame grab (Figure 9).

In this short segment, X associates the setting with a brand and with the products it sells. Given the form of her gesture and its timing with the word "化妆品" (*cosmetics*), I interpret this gesture as an enactment of applying makeup. The suggestion is that integral to her initial experience of the store is the relevance of certain embodied actions. Note that while she addresses gaze, speech, and gesture to her addressee, her torso remains oriented or "torqued" toward the setting (Schegloff, 1998). There is a hint of disapproval in her evaluation of the brand as "not one of those very good ones" and "just a kind that everybody knows."

I now follow X down an escalator and toward the pop-up store. At the entrance to the cherry blossom archway, a young couple is taking pictures, so X must wait before entering. As she arrives, I initiate another brief dialogue (Transcript 2). Using a think-aloud



FIGURE 8 | X's first sight of the pop-up store. (A) Approach, (B) gazing down, (C) hands-on-hips, and (D) adjusts position.

Transcript 1

- 1 I 怎么样?
well?
- 2 X ^^^yeh 就这个牌子的
yeh just this brand
- 3 I oh 你知道那个牌子的吗
oh you know this brand?
- 4 X yeh 我知道这个牌子
yeh I know this brand
- 5 I 有名的吗
is it famous?
- 6 X yeh 挺有名的是一个口红啊化妆品的但都不是很好的那种不是这种 Dior
Chanel 一样但是 OK 的就是大家都知道了这种的牌子
yeh quite famous, it's lipstick, cosmetics but it's not one of those very good ones,
not like Dior, Chanel, but an OK one, just a kind that everybody knows

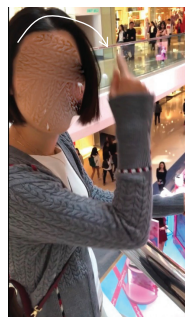


FIGURE 9 | X associates the brand with cosmetics and enacts applying makeup.

protocol, I remind her that if she wants to say anything she should feel free to do so (line 1). After about 2 s (line 2), she evokes a previous trip to a mall in a different part of the city (line 3). Her recollection is initially vague with hesitations and restarts, as she alternates gaze between the cherry blossom archway and the camera (shifts in her gaze direction are indicated in the transcript between double parentheses). When she eventually recalls having seen “差不多有这样的” (*more or less this thing*), her gaze is directed to the camera, she is smiling, but her hands gesture toward the entrance and trace the outline of an arc (Figure 10A). She then expresses the view that “不过可能香港人特别喜欢这种的 flower” (*maybe Hong Kong people really like this kind of flower*). This is expressed with a slight lean backward, frown, and repeated pointing gestures to the arch (Figure 10B).

X's reference to the “Happy New Year one” at “Shatin” is to a display that she encountered at a different mall a month earlier, where a “Happy Cherry Train Station” had been installed in the mall's atrium. As reported on the popular blog *Next Stop Hong Kong*, this display came replete with a “Japanese train station, traditional Tori, and beautiful cherry blossom to welcome in the New Year” (Figure 11).⁶

X's memory of “more or less this thing” indicates her experience of a sense of familiarity recalled from a different time-space locus, central to which is the schematic arch form produced by her gesture. These memories and experiences would be consistent with the experimental findings that features of a behavior–milieu pattern “point to a family of settings” (Heft et al., 2014, p. 389) or to what Barker called a behavior setting “genotype” (p. 80).

Despite experiencing familiarity with the structure of this entrance (specifically its arched form), however, X's second utterance involves sense-making behaviors that appear to disalign with the setting. Recall that after evoking its similarity, she says “but maybe Hong Kong people really like this kind of flower.” Bearing in mind that pointing gestures can single out referents and transform them into objects of care (Streeck, 2017), her co-occurring frown and backward lean as she makes such gestures, while verbally associating the setting with the preferences of Hong Kongers, indicate a feature of the situation toward which she (as a mainland Chinese) distinguishes herself and does not appear to be favorably inclined (Figure 10B).

The couple in the archway finishes taking photos and proceeds into the store. The archway is empty and becomes available for or “affords” entering by our participant. The next section analyzes her passage through this archway and subsequent exploration of the setting.

⁶https://www.nextstophongkong.com/hong-kong-chinese-new-year-shopping-mall-display-decoration/#new_town_plaza

Transcript 2

- 1 I 如果你要说什么事情你就说
if there is anything you want to say you should just say
- 2 (2s)
- 3 X ((looks at camera)) 这个不是和我们在((looks back into setting)) 在哪里我们在
沙田 那个商场里差不多有这种的就是一个新年快乐的, 不过可能香港人特别喜欢这种的 flower
Is this not like- we were at er at where we were at Shatin in that mall had more or less this kind of thing just one a Happy New Year one but maybe Hong Kong people really like this kind of flower
- 4 I 我也觉得
I also think so



FIGURE 10 | X gestures at the entrance to the archway. (A) Tracing the outline of the archway. (B) Repeated pointing gestures.



FIGURE 11 | The "Happy Cherry Train Station" display visited by our participant at a different mall in the city.

Joining the Setting

An overview of our participant's exploration of the setting is offered in **Figure 12**, which shows her path through the store with white arrows, reconstructed from our video recording and notes. This figure reproduces the milieu, which, thanks to the behavior setting study, we know to be a set of interdependent behavior-milieu parts (see section 3.1.2.1 above). As can be seen from each point of the white arrow, X's path brought her to (1) the cherry blossom archway, (2) the photography stage, (3) the animated video kiosk, (4) the manned display counters, (5) the printed animated photo station, back to (6) the cherry blossom archway, and, upon my request, (7) back to the animated video kiosk.



FIGURE 12 | X's path through the store and the synomorphs she visited.

In addition to showing the research participant's trajectory around the store, this simple reconstruction of X's path illustrates the population interdependency that was discussed earlier, offering an example of the high degree to which this inhabitant entered different parts of the setting.

The archway is decked out with pink cherry blossom and lit up by several powerful floor lights. As shown in **Figure 13**, when X enters, she extends her arms, skimming the blossom with her



FIGURE 13 | Entering the cherry blossom archway (00:31–00:35). **(A)** Enters, **(B)** pirouettes, **(C)** poses and giggles, and **(D)** fondles and exits.

fingers (**Figure 13A**), then spins around to face the camera and giggles (**Figures 13B,C**). She fondles a roof flower on her way out (**Figure 13D**).

X's embodied action as she enters the cherry blossom archway is remarkable and strikingly different to both the assured pace with which she first approached the setting (cf. **Figure 8A**) and her explicit reflections on the setting while waiting to enter (Transcript 2 and **Figures 10A,B**). For one, she has slowed her pace down to a leisurely gait or saunter. She seems to be no longer walking to get somewhere or waiting to enter, but partaking in a "passage through the archway," meaning exploring the material features of this new environment, responding to and engaging with its affordances. Her hands skim the bloom with each step, which is left twitching as she moves by. Two seconds after entering the archway, X pirouettes, smiles, and audibly giggles for the camera (**Figures 13B,C**), appearing to delight in the experience.

X emerges from the archway into a congested space where a group of three women are queuing in front of the photography stage. She compensates, doubles back, and finds an alternative route, navigating the store's infrastructure to a place where she can view the stage. Having established a clear view on this stage, she momentarily stands still and watches a woman posing for photographs. She then turns to the camera and initiates a dialogue (Transcript 3). Smiling, she points at the stage where the woman is posing for pictures (**Figure 14**) and says "oh这里可以拍照" (*oh here we can take a picture*). I ask her if she would like to take

a picture (line 2). After a pause (2 s), she says: "我::不喜欢拍这个" (*I: don't like taking photos of this*; where the "::" symbols indicate prolongation of the vowel), then turning and walking away from the stage (and visibly no longer smiling), she says "这个太粉红色的我不喜欢" (*this is too pink, I don't like it*) (line 3).

This short interchange sheds light on further sense-making behaviors. For instance, conversation analytical work has shown that the linguistic marker "oh" can indicate "that its producer has undergone some kind of change in his or her locally current state of knowledge, information, orientation, or awareness" (Heritage, 1984, p. 299). This would seem to be a coherent interpretation of the current usage, given that X produced her "oh" after a period of silently observing the setting. Judging by her smile and the upbeat prosodic contour of her utterance, the change of state displayed by "oh" seems to have been experienced as a pleasant one. I was wrong to assume X would want to take part in the activity proposed by this part of the setting though. Based on the linguistic and embodied details of X's response, my offer to take a photograph seems to have triggered quite a negative emotional outburst. In addition to the repeated, direct rejections, by pausing and adding contrastive stress to the pronoun "I" (elongated vowels are attested stress markers in Mandarin conversation; Li, 2014), X resists the assumption implied by my suggestion. As with X's backward lean, pointing gestures, and frown at the entrance to the cherry blossom archway, the linguistic design of X's response and her

Transcript 3

- 1 X oh 这里可以拍照
oh here can take a picture
- 2 I 那你要不要去?
do you want to go then?
- 3 P (2s)我::不喜欢拍这个((turns and walks away))这个太粉红色的我不喜欢
I:: don't like taking photos of this, this is too pink I don't like it

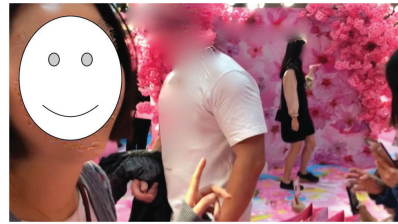


FIGURE 14 | Arrival at the photography stage (00:46–01:00).

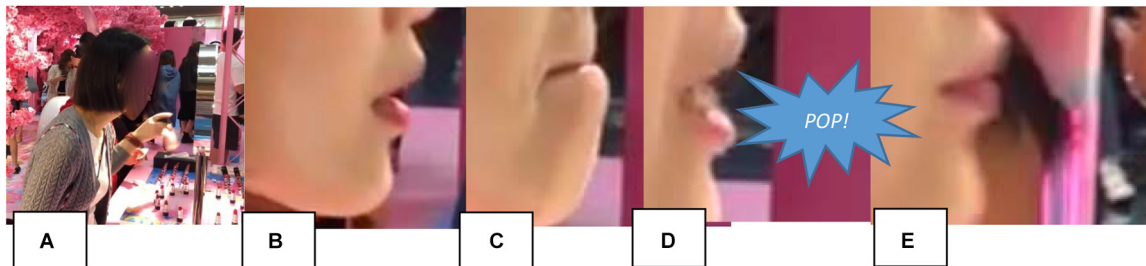


FIGURE 15 | Evaluating lipstick application at display stall (01:44). (A) Approach, (B) open, (C) pinch, (D) pop, and (E) purse.

subsequent walking away are behaviors with which she regulates her ongoing relation to (and distinguishes herself from) the immediate environment.⁷

After a quick look into the animated video kiosk (where we will return later), X arrives at one of the stalls displaying the store's product range of cosmetics. Recall that these stalls are equipped with brightly lit mirrors and manned by beauty consultants. In the video, we see several people around the stall using the mirrors to apply lipstick, which they have selected from a range of testers. When a space frees up, our participant approaches the stall, scans the product display, then looks into one of these mirrors for a duration of 4 s. Slowing the video of this mirror-looking episode down, a smooth sequence of actions can be identified. **Figure 15** shows how X first cranes her neck to bring her face within 6 inches of the mirror (**Figure 15A**), opens mouth (**Figure 15B**), purses lips, uses bottom lip to push the top lip up, uses the bottom lip to pull the top lip down (**Figure 15C**), which she releases with an audible pop (**Figure 15D**), then retracts from the mirror with a final lip purse (**Figure 15E**) before continuing to browse the product display.

The participant's evaluation of lipstick application at the display stall invites a discussion of the interplay between functional and affective aspects of sense-making behaviors. Recalling the oft-quoted passage on "double sensations" from Merleau-Ponty (1945/2012, p. 95) and Lehtinen (2014) has discussed the lips "as an alternative to the figure of the two hands

in the double touch" (p. 80)⁸. While the hands in double touch are often "accounted for in terms of intentionality of conscious acts" and "operative intentionality (the 'I can')," Lehtinen (2014) argues that the mode of experience of the lips in double touch "belongs instead to the relations of enjoyment and affective perception" (p. 80). The addition of lipstick and a mirror at the pop-up store problematizes this distinction, however, as we clearly see a task-directed use of the lips to evaluate and improve the appearance of lipstick, which is part of a sociocultural practice. That said, such a functional explanation would leave parts of this action or "sensorimotor scheme" underdetermined (Di Paolo et al., 2017) because X's lip-smack (*pop!*) seems functionally unnecessary. Unless it is a biomechanical consequence of moving the lips in that way, the lip-smacking might index the relations of enjoyment and affective perception mentioned by Lehtinen. It could also simply mark the ending of the episode. After this pop, X seems satisfied with the appearance of her lips and returns to browsing the products on display.⁹

After spending a few minutes at the cosmetics display stall, X continues to explore the store and eventually arrives back in front of the cherry blossom archway, which is somewhat congested (**Figure 16**). Rather than entering again, X stops and peers in.

⁸Lehtinen (2014) is introducing the work of Luce Irigaray's phenomenology of the feminine being.

⁹An affective reading of X's lip-smack would be supported by the popularity of lip-smacking in autonomous sensory meridian response videos on YouTube. Furthermore, when I showed this clip to the research participant and asked her what she was doing, she replied "if you don't know, it is because you have never worn lipstick." Her response recalls Wittgenstein's *reason for not having a reason*: "This is simply what I do" (cited in Rietveld, 2008, p. 983).

⁷I am grateful to multimodal interaction researcher Xiaoting Li for discussing the morphosyntactic, phonetic, and interactive details of this example with me.



FIGURE 16 | Full-bodied leaning-sideways gesture in front of the archway (05:36–05:48). (A) Peering in, (B) walking away, (C) eye contact with camera, (D) posture and pucker, (E) lean left, and (F) lean right.

Her hands are clasped behind her back, and she is craning slightly toward the archway (Figure 16A). As the congestion begins to clear, X starts to walk away (Figure 16B). But in doing so, she makes mutual gaze with the camera (Figure 16C). She stops, turns her gaze back to the archway, leans away from it, and begins to pucker her lips (Figure 16D). She then leans the full body first to her left (Figure 16E) then to her right (Figure 16F), each time raising a foot off the floor and extending her arms slightly.

Our participant's return to the cherry blossom archway is revealing. When seen for the second time, the cherry blossom archway presumably still affords the action of entering, but X does not engage with that affordance on this revisit. Instead, she first adopts another posture that projects an observer stance (Streeck, 2018). Although she then starts to walk away, as she makes eye gaze with the camera, she abandons her trajectory and begins to exploit the archway as the backdrop for a photo opportunity. In doing so, X reveals her perception of an affordance in her own creative way, which triggers an unexpected act (Jensen and Pedersen, 2016).

As for the posing action itself, X's full-bodied, leaning-sideways-with-pout gesture is very common among the poses for photos in China, belonging to a number of stock gestures that get reproduced on such occasions. According to the research participant X, her leaning-sideways pose imitates the posture of a waddling duck and is supposed to be "cute." Puckering the lips with this gesture is also according to her "just being cute," but could be recognized as a manifestation of the more conventionalized "duck-face" gesture or meme.¹⁰

¹⁰For a discussion of this leaning-sideways pose, I am grateful to Enhua Guo, who helped me to informally survey several Chinese women for their opinion on its meaning. None of these women mentioned the pose being related to ducks, however. Summarizing their views, the pose might have originated with a Chinese Internet celebrity, whose attractive or cute performance of the pose began circulating online, which led to the pose going viral. For a discussion of how gestures are embedded in global cultural and capitalist flows, as would be the case in the uptake of a celebrity pose, readers are pointed toward chapter 4 of Fleming and Harrison (2020) where they will find analyses of a K-Pop dance move appearing in the classroom of a British university campus in China.

Before leaving the store, I ask X to return to the animated video kiosk. After a short wait, the beauty consultant manning the kiosk invites X in. Immediately upon entering, X encounters herself on the big screen. After a moment's inspection, she says “哇!太高了好像” (*wow! too tall it seems*), and smiling, dips to put herself in the frame (Figure 17).

As a marker of assessment (Schegloff, 1982, p. 85), X's exclamation “哇” (*wow!*) is further evidence that she has been invited to assess her appearance, with which she seems astonished. Her dip is an immediate solution: “expert craftsmen will normally immediately distinguish the relevant possibilities for action in situation within their familiar practices” (Rietveld, 2008, p. 981). The beauty consultant now counts X down “Three, two, one,” and as the camera begins recording, X does a hair-flip dance that is well-known on 抖音 (Chinese TikTok). X's performance is automatically replayed on the screen. As she watches herself, she starts to smile and tilts her head (Figure 18).

X's smile and head tilt while watching herself dance can be interpreted as affect-laden sense-making behaviors. “Holding the head in a lateral tilt, or head-cock” writes semiotician Calbris (1990), “is a sign of tenderness, arising from fondness or from a desire to be touching” (p. 55). Calbris (1990, p. 55) also offers evidence that the gesture is used when “indicating a particular point of view.” X's smile suggests she is pleased by this view, but she nevertheless does a rerun and includes a “V” gesture at the end of her dance. Interestingly, this V gesture is the same gesture that X observed being performed by somebody posing on the photography stage. This V gesture is drawn from the same class of “cute” stock gestures as the “shush” gesture by the model in the advertisement being projected on the screens outside the store (cf. Figure 3). X's rerun dance and added gesture can be seen in the post-processed video, which has also been edited, enhanced, and framed with the corporate logo (Figure 19).

As the research participant exits this video kiosk and heads away from the store, leaving the behavior setting, her smartphone pings. An e-mail from Pink Cosmetics has arrived containing her video and a link to the company's shopping platform online.



FIGURE 17 | X makes herself smaller to fit on the screen.



FIGURE 18 | X watching herself, smiles and tilts her head (05:36–05:48).

DISCUSSION

This paper has examined an intersection between ecological psychology and the enactive approach brought about by investigating embodied action as sense-making within the confines of a behavior setting. With a case study selected from a video corpus being built to study embodied interaction and urban environments in China (see Fleming and Harrison, 2018, 2020; Harrison and Fleming, 2019), I first described a Pink Cosmetics pop-up store in a Hong Kong shopping mall with the definitions and criteria from behavior setting theory (Barker, 1968). My findings revealed a highly structured environment embedded within the mall, where several behavior–milieu parts (Barker’s “synomorphs”) were interwoven with image-making technologies, including a photography stage, brightly lit mirrors, a printed holograph machine, and an animated video kiosk. Manned by beauty consultants and makeup artists, these machines invariably functioned to capture and augment a person’s self-image, inviting the store’s inhabitants to behave and act by posing, evaluating, and improving their appearance in ways conducive to the application and purchase of makeup.

Having used Barker’s (1968) theory to establish the pop-up store as a behavior setting (describing its structural attributes

and identifying salient measures of interdependency between its behavior–milieu parts), I zoomed in to the analysis of a person’s moment-to-moment discovery and perception of this setting. In previous experimental research, people were found to perceive the identity of behavior settings (e.g., a bank, library, basketball game) based on schematic animations of activity patterns shown to them on a computer screen in the lab setting (Heft et al., 2014). For my perception study of the Pink Cosmetics pop-up store, I analyzed visible embodied actions in the actual setting of my key participant, who I had followed at close range with a video recorder as she first encountered then joined the environment of the pop-up store. Adopting a micro-ethnographic approach to embodied communication that draws on both ecological psychology and enaction theory (Jensen and Pedersen, 2016; Streeck, 2017, 2018), I described this person’s gait, posture, eye gaze, gesture, and situated language use as she explored different parts of the store, taking this descriptive work as an empirical basis to identify and analyze her sense-making.

Analysis of this participant’s embodied activity revealed the range of thoughts, feelings, memories, and attitudes that she experienced upon encountering the setting. These included a series of multimodal utterances with which she (a) identified the product on sale (“lipstick, cosmetics”) and its associated action patterns (gesturing the application of makeup), (b) judged the store’s brand (“not one of those very good ones”), (c) experienced feelings of familiarity from the settings in a different time–space locale (“more or less this kind of thing,” the word “this” being accompanied by a gesture singling out a salient design feature of the setting), and (d) evoked cultural explanations for the appearance of the setting (“maybe Hong Kong people really like this”), while her facial expression and gestures marked distinctions from her own preferences. As she then entered and toured the store, her visible bodily action (including language) manifested a roller-coaster ride of dispositions and emotions, ranging from disapproval and aversion to amusement, surprise, delight, then dismay and astonishment. Gallagher (2017) stresses that “one’s beliefs and values, as well as one’s affective states and cultural perspective... can shape the way that one quite literally sees the world” (p. 19). By extension, the sense-making activities



FIGURE 19 | The video sent to the participant's social media account.

of an individual—embodied micro-adaptations in relation to the ecological environment that are dependent on her values, beliefs, history, affect, and culture—showed how this individual perceived and experienced the behavior setting studied here.

Focusing on activities occurring in relation to specific structural parts of the setting (what I referred to as “stations”) and moving beyond the analysis of the participant’s multimodal utterances, several patterns of behavior in the data could be identified that involved more kinesically complex sequences of embodied actions patterned in relation to structures in the environment. These occurred more specifically in response to the activities invited by different behavior–milieu parts of the store (its “interjacent synomorphs”; Barker, 1968) and can be seen to highlight further relations between sense-making activities and the specifics of a behavior setting.

Several such behaviors occurred upon encountering different stations in the setting. In addition to behaviors such as standing in line, rerouting upon encountering a congested space, and scanning the display stalls, we also saw the participant twirling through the cherry blossom archway, remaking her lipstick in the brightly lit mirror (*pop!*), and gesturing/dancing for the different cameras (full-bodied leaning, head tilts, hair toss, V gesture, etc.). Perceiving such behaviors as sensorimotor schemes (Di Paolo et al., 2017), enactivists attribute them to “a rich repertoire of ready-made, highly organized ways of engaging the world” (p. 81) that people bring to a behavior setting, or rather will begin to *enact* “when coupled to the right environmental circumstances” (p. 82). While some sensorimotor schemes in the current data “are rather widespread across the species” and across different environments, such as our participant’s standing in line, back-tracking, etc., “others are acquired as part of our sociocultural milieu,” which would be the case for the archway-twirling, posing, and evaluating/improving of one’s appearance invited by this setting (Di Paolo et al., 2017, p. 81).¹¹

The sensorimotor schemes which are most closely related to the sociocultural milieu seem crucial to understanding the sense-making/behavior setting relation. They highlight what Rietveld (2008) describes, following Merleau-Ponty (1945/2012), as the participant’s “unreflective performance” or “form of *embodied* intelligence or cognition that is ‘motivated’ by the situation. . .” (p. 975). Rietveld’s (2008) account of embodied, situated, and lived normativity helps to recognize actions such as twirling through the cherry blossom archway, remaking lipstick in the brightly lit mirror, and gesturing/dancing for the different cameras as the participant’s adequate perception, recognition of, and response to the settings relevant functional affordances. Her “unreflective” performance of these actions also points to the overall (or interdependent) “*potentiating*” and “*affective allure*” of the setting’s structure and dynamics (p. 977). The behavioral objects, mechanisms, and action patterns in this particular setting (which were shown to be based around the making, evaluating, appreciating, and enhancing of self-image) exaggerate both the normative dimension of sense-making actions within a behavior setting and the embodied know-how required of inhabitants to fully join or “penetrate” a setting’s standing pattern of behavior.

Finally, this case study shows what specialists in the design and implementation of pop-up stores like those in *Jubilee Plaza* must already know: “Retail is no longer about buying products but rather it’s about providing an experience that consumers delight in”¹². Notwithstanding the limitations of my case study, I offer the Pink Cosmetics pop-up store as an example of the cognitive and technological environments being shaped by novel forms of consumerism and screen culture and the sociocultural specificity of the sense-making behaviors that such environments invite. If Roger Barker and the inhabitants of 1950s Midwest were suddenly

together reflect the history of each particular body” that enters a given behavior setting (p. 81).

¹²See www.storefront.com. Storefront markets itself as “the world’s largest marketplace to book short-term retail space” <https://www.whub.io/startups/storefront>.

¹¹In addition to species-wide and sociocultural, Di Paolo et al. (2017) state that other sensorimotor schemes are idiosyncratic. The point is that “all of them

introduced to the behavior setting studied here, we might wonder how their sense-making behaviors would differ.

DATA AVAILABILITY STATEMENT

The datasets generated for this study will not be made publicly available. The video recordings on which the analysis is based contain material that would be inappropriate to make open access.

ETHICS STATEMENT

The study of video recorded interaction sampled here was reviewed and approved by the University of

Nottingham Ningbo China. The research participant gave informed consent.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Agency From a Radical Embodied Standpoint: An Ecological-Enactive Proposal

Miguel Segundo-Ortin*

School of Liberal Arts, University of Wollongong, Wollongong, NSW, Australia

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Edited by:

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*Correspondence:

Miguel Segundo-Ortin
miguel.segundo.ortin@gmail.com

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Explaining agency is a significant challenge for those who are interested in the sciences of the mind, and non-representationalists are no exception to this. Even though both ecological psychologists and enactivists agree that agency is to be explained by focusing on the relation between the organism and the environment, they have approached it by focusing on different aspects of the organism-environment relation. In this paper, I offer a suggestion for a radical embodied account of agency that combines ecological psychology with recent trends in enactive cognitive science. According to this proposal, while enactivism focuses primarily on describing how our acquired sensorimotor schemes and habits mutually equilibrate, affecting our tendency to act upon some affordances instead of others, ecological psychology focuses on studying how perceptual information contributes to the actualization of the sensorimotor schemes and habits without mediating representations, inferences, and computations. The paper concludes by briefly exploring how this ecological-enactive theory of agency can account for how socio-cultural norms shape human agency.

Keywords: agency, ecological psychology, enactivism, affordances, habits, sensorimotor schemes, information

INTRODUCTION

Enactivism and ecological psychology are the two main schools of thought in the radical embodied cognitive sciences. They have much in common. Both approaches reject that cognition is confined to the head, and prompt for explanatory strategies that break away with the idea that cognition is based on the manipulation of mental representations. Likewise, both approaches stress the active role of the body and the environment in the processes that bring about cognitive activities.

In light of these affinities, a number of authors have already suggested the possibility of a unified approach to cognition that combines both theoretical frameworks (Chemero, 2009; McGann, 2014; Baggs and Chemero, 2018; Kiverstein and Rietveld, 2018; Heras-Escribano, 2019). Inspired by these proposals, this paper aims to contribute to this unification by focusing on the issue of agency. In a minimal sense, we can understand agency as the capacity of individual organisms or systems to execute goal-directed or intentional actions. So conceived, agency is manifested whenever an individual “acts on its own behalf in an environment” (Kauffman, 2000, p. 8), or when she does “something by itself according to certain goals” (Barandiaran et al., 2009, p. 369). In what follows, I will focus on this basic form of agency, and I will not discuss other forms, such as collective agency.

The dominant account of agency in philosophy – also referred to as “the standard theory” of agency (Schlosser, 2019) – assumes that a particular event *x* is an *action* just in case it has been appropriately (non-accidentally) caused by a series of mental states which represent both my goal

and the actions intended to pursue that goal¹. There are nonetheless reasons to think that the standard theory does not provide a satisfactory account of agency. For one thing, it has been pointed out that the standard theory is “too demanding,” for there might be organisms “that are capable of genuine agency and that do not possess representational mental states” (Schlosser, 2019). Besides, the fact that we currently lack a convincing story of how mental states can be causally relevant to behavior in virtue of their representational content undermines the credibility of the standard theory. These and other related problems have motivated defenders of 4E (embodied, embedded, extended, and enactive) theories of cognition to articulate alternatives to this standard account, emphasizing embodied and situated aspects of action (see, e.g., Juarrero, 1999; Malafouris, 2013).

Interestingly, even though both ecological psychologists and enactivists agree that agency must be explained by focusing on the relation between the organism and the environment instead of the individual's representational states, they have evolved their own individual (and largely independent) approaches to it, focusing on different aspects of the organism-environment relation. Taking stock of this, the purpose of this paper is twofold. Firstly, I highlight the limitations of both the ecological and enactive approaches to agency, showing why they can't offer a satisfactory account of it. Secondly, I show how ecological psychology and enactivism can complement each other to explain agency, overcoming their theoretical limitations. The complementarity approach I envisage can be summarized as follows: While enactivism focuses on investigating how the history of interactions of an organism gives rise to a series of sensorimotor schemes and habits that in turn play a causal role in determining how she interacts with the affordances of the environment, ecological psychology, through the notion of ecological information, explains how the individual can access to the environment's affordances without mediating representations and inferences. It is argued that the existence of ecological perceptual information is essential to understand the organism-environment coupling that, according to enactivists, gives rise to action.

The structure of the paper is as follows. In section “The Issue of Agency in Ecological Psychology,” I analyze the most significant theories of agency proposed by ecological psychologists – Reed's (1993, 1996) theory of intentions and Withagen et al.'s (2012, 2017) theory of affordances as invitations – and offer reasons as to why these proposals are unsatisfactory. Then, following the suggestion of Baggs and Chemero (2018) that ecological psychologists should adopt the theory of agency of enactivism, section “Enactive Agency” focuses on analyzing the enactive accounts of biological and sensorimotor agency. However, I argue that enactivism does not offer a satisfactory theory of agency either, for it leaves undetermined how the organism can access to the environmental structures that are relevant to agential behavior – an aspect that, we shall see, is essential to enactivism. Consequently, in section “Steps Toward the Unification”; I propose a dual approach to agency that combines

the tools provided by enactivists and ecological psychologists. Nonetheless, it is well-known that the relation between ecological psychology and enactivism has not been an easy one. This could lead us to think that such a unified theory of agency is untenable. Section “Bridging the Uncanny Valley” confronts this view by addressing the most significant disagreements between enactivists and ecological psychologists. These disagreements pertain to, for instance, the notion of information at use in ecological psychology, or the nature of “sense-making” coined by enactivists. As I shall argue, most of the tensions between enactivists and ecological psychologists are based on reciprocal misinterpretations. To finish up, section “Conclusions and Directions for Future Research” concludes by briefly exploring the potential of this ecological-enactive approach to agency to explaining how human agency can be shaped by socio-cultural norms and conventions.

THE ISSUE OF AGENCY IN ECOLOGICAL PSYCHOLOGY

The ecological theory of perception was first introduced by psychologist James J. Gibson in two seminal books published in Gibson (1966) and Gibson (1979/2015), respectively. The main ideas of this approach are: (i) that perception is direct; (ii) that perception is active; and (iii) that perception is action-oriented.

First of all, ecological psychologists are famous for arguing that perception is direct. To say that perception is direct is equal to saying that it is not mediated by representations. Instead, perception is conceived of as information detection. Perceptual information is given by higher-order properties of spatial-temporally extended patterns of stimulation – the so-called “invariants”². According to ecological psychologists, since the invariants specify (lawfully correspond to) the properties of the environment that give rise to them, they provide non-ambiguous information about these environmental properties. Therefore, detecting these invariants is enough to be aware of the environment without the need for representations and inferences.

The second principle states that perception is active. Ecological psychologists reject the standard view of perception as a passive, sub-personal process that takes place inside the organism. Instead, perception is conceived of as “an achievement of the individual” (Gibson, 1979/2015, p. 228). The reason for this is twofold. On the one hand, the detection of information requires that the agent actively modulates its attention to detect the invariants that are relevant to their goal. In this sense, perception is not something that happens in the animal, but something the animal *does*. On the other hand, it is often the case that the information needed to carry on a particular perceptual task is not available in the array, but needs to be produced by the organism itself. To see this, think of motion parallax – the continuous and

¹ Exactly what counts as “appropriate causation” is a matter of discussion. However, this qualification aims to rule out cases of deviant causation (see Wu, 2016).

² In the ecological literature, it is common to distinguish between structural and transformational invariants (see, e.g., Michaels and Carello, 1981). In short, whereas structural invariants refer to the properties of the sensory stimulation that remain unchanged, underlying other variations, transformational invariants are the “modes of change” of perceptual objects.

regular transformations of the apparent position of the objects from the starting point to the endpoint of the movement. Because the objects that are closer to the organism appear to move faster than those that are located further away, detecting the different speeds at which the objects “move” allows the organism to be aware of the different distances she holds regarding them. Moving as to produce motion parallax is thus an efficient strategy for perceiving depth.

Third perception is action-oriented. According to ecological psychologists, not only does action serve perception (as in the case of motion parallax), but perception is primarily for the control of the action. This idea is best captured by the claim that the main objects of perception are the affordances – this is, the opportunities for interaction that an environment (including other organisms) offers to an individual. Accordingly, when we detect information relative to the properties of an object (its rigidity, its size, etc.) we are primarily aware of its affordances – the possibility of grabbing it, throwing it, and so on. Hence, it is by directly detecting information that organisms can make their way in the world.

Some Gibsonians, however, have argued that the main explanatory target of ecological psychology is not perception, but agency. This idea is captured by Reed when he claims that “the goal of ecological psychology is to explain agency scientifically, not to explain it away or simply offer a discourse about it” (Reed, 1996, p. 19; see also Gibson, 1994). Three reasons justify the importance of agency for ecological psychologists (see Brancazio and Segundo-Ortin, 2020). Firstly, since perception requires the active and purposeful exploration of the environment by the animal, perception is already infused with our goals. Secondly, because affordances are opportunities for action, not causes of behavior, perception of affordances is not enough to regulate action. Rather, the organism must act upon these affordances (Gibson, 1967/1982, p. 411). Thirdly, because a single object offers multiple potential affordances to an animal, how she behaves is unconstrained by the affordances of the object. The animal must *select* what affordance to actualize at each moment (Cutting, 1982). Following this reasoning, I agree with Wagman (2019) that to adequately explain how perception contributes to action, we need a theory of agency, which is a theory of how individuals “select, perceive, and actualize affordances appropriately based on intention” (p. 148).

In what follows, I shall examine the two most significant attempts to explain agency from the ecological side: Reed’s (1993, 1996) theory of intentions, and Withagen et al.’s (2012, 2017) theory of affordances as invitations.

Reed’s Theory of Intentions

At the beginning of his *Encountering the world*, Reed (1996) complains that “psychologists have persisted in modeling animal and human behavior on mechanical principles, thus neglecting perhaps the most fundamental problem of their field – autonomous agency” (p. 10). Reed (1996) characterizes agency as the capacity to put attention and action at the service of one’s current intentions (see also Gibson and Rader, 1979). As he explicates, “in any situation, an individual’s intentions serve to select a small number of the potential affordances available

in that situation. This selection is reflected in the organization of the individual’s attention and activity” (Reed, 1993, p. 46). He nonetheless rejects the mainstream view of intentions as mental states that cause actions, and proposes the following characterization instead:

From an ecological point of view, intentions are not causes of action, but patterns of organization of action; they are not mental as opposed to physical, but are instead embodied in the kinds of performances most likely found in cognitively capable creatures. . . . The development of intention is thus the development of the ability to nest bouts of exploratory and performatory behavior so as to achieve desired outcomes (Reed, 1993, p. 62).

But, how do intentions emerge, if not in the mind of the perceiver? According to Reed, an intention can only emerge whenever there are multiple affordances available for the organism to choose. To explain how an organism selectively acts upon some affordances instead of others, Reed takes inspiration from Darwinian evolutionary biology. He hypothesizes that intentions, just like any other biological entity, emerge out of processes of variation and selection. For him, the minimal units of analysis for a theory of intentions are perception-action cycles (PACs). Each PAC is specific to a particular affordance or, to be more precise, to the information which specifies a particular affordance. Then, Reed suggests that in situations where the organism is offered multiple affordances, the PACs enter a sort of competition, and this competition results in goal-oriented or intentional behavior – namely, the actualization of an affordance. As he himself writes, drawing a clear parallelism with Darwin’s theory: “Intentions are thus the “species” that emerge out of competition among perceptual and action processes for utilizing affordances” (p. 65).

Reed’s account nonetheless suffers from significant shortcomings. To begin with, Reed provides no clue about the conditions under which the PACs compete. All we know is that intentions to actualize particular affordances emerge out of the competitions between PACs, but it is not clear what the selection pressures that define this competition are.

Reed (1996) is famous for sketching a selectionist approach in which affordances, conceived as environmental resources, exert selection pressures and give rise to species equipped with action systems – systems that are specialized in taking advantage of particular affordances. The same proposal can be rehearsed here to explain the emergence of intentions. Indeed, Reed (1996, p. 18) tells us that “the relative availability (or non-availability) of affordances create selection pressures on the behavior of individual organism.”

Reed’s selectionist approach is under attack by current neo-Gibsonians (see, e.g., Withagen and van Wermeskerken, 2010). The reason for this is that his account is markedly adaptationist, thus conflicting with the current trends in evolutionary biology. In this adaptationist view, environmental pressure and natural selection shape organisms’ evolution by favoring some genetic mutations over others, while organisms remain as passive receptacles of genes. This asymmetric approach to evolution is deemed too simplistic by current evolutionary biologists, who emphasize the active role of the organisms in altering the

selection pressures to which they are exposed (see Lewontin, 1983; Laland et al., 2016)³. In addition, Turvey has recently argued that adaptationism is incompatible with ecological psychology, for it perpetuates the dualism of organism and environment (Turvey, 2018, p. 16).

Moreover, we can think of actions that are either irrelevant for our survival (e.g., nail-biting) or harmful (e.g., smoking), but that nonetheless belong to our common behavioral repertoire. This is a problem for Reed's account, since if the PACs that give rise to these intentional actions are either irrelevant or detrimental (mal-adaptive) for the organism, then it is hard to see how we can make sense of some people's tendencies to bite their nails or smoke from the adaptationist approach⁴.

Another possibility, also sketched by Reed (1993, 1996), is that social interaction contributes to the development of particular intentions. In this view, the competition between PACs is influenced by the actions of others who instruct and correct the behavior of the individuals, teaching them "*what* affordances can be utilized by *whom* and *when*" (Reed, 1993, p. 52, emphasis original). Although appealing, this second possibility is quite limited, for it only applies, as Reed himself acknowledges, to animals with complex societies and sociocultural norms. Surely, human agency is constrained by the social norms that rule within the communities we inhabit, but a theory of agency based *solely* on social norms cannot pay the entire bill, for there are non-human animals that are capable of agency and do not have social norms. These shortcomings have led other neo-Gibsonians to formulate alternative accounts of agency.

Affordances as Invitations

Whereas Reed (1993, 1996) attempted to explain agency by drawing from Darwinian evolutionary biology, Withagen et al. (2012, 2017) try to do so by relying on contemporary phenomenology (Dreyfus and Kelly, 2007). Withagen et al. begin by rejecting the notion of intention put forth by Reed. Then, they argue that if we want to understand agency in ecological terms, we must think of affordances not just as opportunities for action, but as invitations to act as well:

If we recognize that affordances can also invite behavior, we are forced to a conception of agency that puts the animal-environment relation much more central. When actively exploring the environment, the agent is attracted or repelled by some of its affordances, and the ensuing behavior is partly the result of these invitations. This means that to understand how animals make their way in the world, the inviting character of affordances should be taken central (Withagen et al., 2012, p. 257).

According to this view, the environment does not simply offer a neutral manifold of possibilities for acting. Rather, some of its affordances can also invite us to act a certain way, "with us bodily responding to these callings" (Withagen et al., 2017, p. 12).

Importantly, this is not to equate affordances with invitations. Instead, the hypothesis is that, under certain conditions, some affordances can invite action, whereby the invitational character of the affordances "depends on the agent-environment relation" (Withagen et al., 2012, p. 256)⁵.

If phenomenology is called upon to provide the theoretical inspiration for this proposal, Withagen et al. (2012, 2017) look at industrial design and architecture to provide real examples of affordances as invitations. For example, Norman (1988/2013) demonstrated years ago that the design of an object affects the individuals' usage of it, making some affordances more easily perceivable and, consequently, more likely to be seized⁶.

Withagen et al. (2012) mention other organismal factors that can contribute to making affordances invitations. These factors include the action capabilities of the agent, the evolution of the species, the cultural background of the individual, and, finally, the history of interactions of the individual. As they explicate, "this inviting character of the affordances depends on the agent-environment relation, arguably in a multidimensional way . . . This suggests that whether an affordance invites is an animal-relative property of the environment as well" (p. 256).

Nonetheless, even if we can find the characterization of affordances as invitations suggestive and theoretically valuable⁷, the issue remains as to see how this characterization helps us to advance in our understanding of agency. Two main issues remain to be solved. First, invitations to act are not causes of behavior either. In fact, Withagen et al. go on to characterize agency as "the animal's capacity to modulate the coupling strength with these affordances – the agent can influence to what extent each invitation influences him or her" (Withagen et al., 2017, p. 14). Therefore, thinking of affordances as invitations does not fully resolve the problem of how to explain agency, for we still have to make sense of the capability of the individuals to

³Gibson is ambiguous regarding the notion of "invitation": "The concept of affordance is derived from these concepts of valence, invitation and demand but with a crucial difference. The affordance of something does *not change* as the need of the observer changes. The perception of its affordances should not be confused with the temporary special attraction it may have" (Gibson, 1979/2015, p. 130, emphasis original).

⁶For instance, Norman suggests that by changing the design of a door, namely, by adding an easily reachable flat bar instead of a knob, we can "indicate" the user that she needs to push the door to open it (Norman, 1988/2013, p. 10). A first-pass objection to this idea is that it is not clear how industrial design proves that affordances may also be invitations. In short, making some affordances more easily perceivable is not the same as making these affordances *invitations*.

⁷Other authors have further expanded the connection between the notion of affordances-as-invitations and agency. For instance, Rietveld and Kiverstein (2014) include invitations as a crucial element of their Skilled Intentionality Framework, and assert that "[i]n acquiring a skill the individual becomes increasingly expert at responding adequately and appropriately to the actions a particular situation invites" (p. 334). In a similar vein, Crippen (2019) incorporates invitations to discussions in aesthetics, emotional perception, and action, suggesting that "[m]ysterious smiles and settings likewise can be understood in terms of affordances because both suggest something worthwhile is hidden, thereby inviting approach, exploration and deeper penetration" (p. 11). Some others strongly disagree with this view, however. For instance, Heras-Escribano argues that "the alleged invitational character of affordances adds nothing to our understanding of the epistemic and ontological aspects of affordances *per se*. On the contrary, this inviting character might make affordances even more obscure to understand" (Heras-Escribano, 2018, p. 111).

³Even though this idea has been popularized by Lewontin, it is already present in the work of American Pragmatist John Dewey (see Crippen, 2016, p. 235).

⁴Some evolutionary biologists have nonetheless suggested that there might be factors, other than bestowing adaptive advantages to a species, that cause a genotype to be favored by natural selection (see Dawkins, 1976). I thank a reviewer for the pointer.

modulate their relation to the inviting affordances⁸. Second, and more importantly, this account presupposes agency instead of explaining it. To see this, consider the following passage:

An affordance can invite behavior if and only if an agent perceives it. If affordances are not perceived (or even have not been discovered) they do not have the potential to attract (or repel) the according behavior of the agent. Hence, a prerequisite for affordances to invite is an actually present observer that actively explores the affordances of its environment (Withagen et al., 2012, p. 257).

Whereas the affordances of the environment exist independently of being perceived by the individual, for an affordance to invite it, needs to be perceived. This means that for affordances to invite, we need an organism that is already capable of exploring its environment, actively focusing its attention in some informational patterns instead of others. This is, for affordances to invite, we already need an agent.

In conclusion, even though a theory of agency can incorporate invitations (namely, to make sense of actions that we perform in an unconscious or pre-reflective way), conceiving of affordances as invitations leaves untouched core aspects of the notion of agency. Motivated by this, some defenders of ecological psychology have come to propose that Gibsonians should look for a theory of agency in the other main school of thought in the radical embodied cognitive sciences: enactivism. To quote Baggs and Chemero (2018):

Ecological psychology focuses on the nature of the environment that animals perceive and act in; enactivism focuses on the organism as an agent. Combining the two would seem to provide a complete picture of cognition: an enactive story of agency, and an ecological story of the environment to which the agent is coupled (p. 2).

Unfortunately, Baggs and Chemero do not elaborate on this proposal, and do not explain how the enactive theory of agency can fit into the ecological picture. In section “Enactive Agency,” I shall analyze what enactivists have said about agency⁹. Can enactivism provide an account for how different individuals selectively perceive and act upon the affordances of the environment?

ENACTIVE AGENCY

One of the most important ideas presented in *The Embodied Mind* (Varela et al., 1991/2016) is that cognition arises out from the active and reciprocal coupling between the agent and its environment. The enactive framework emphasizes the role of the agent in enacting, or bringing about, their own cognitive life, but rejects that it needs to be done through representations and

internal computational operations. Like Gibsonians, enactivists put agency at the center of their research program.

In an attempt to clarify what the notion of agency amounts to, Barandiaran et al. (2009) provide the following working definition. According to them, a system qualifies as an agent if it meets three necessary and jointly sufficient conditions. First, individuality: For a system to be an agent, there must be a distinction between the system and its environment. This is not to say that the system must be completely detached from the external world, but that it must be able to maintain itself as something distinguishable from the latter. Second, interactional asymmetry: Even if the environment can cause the individual to act a certain way on particular occasions, for an individual system to be an agent, it must be able to modulate the coupling with the environment, initiating some processes and resisting the tendencies exerted by the medium when needed. Finally, normativity: According to this condition, an agent must have intrinsic goals, and these goals provide a normative reference against which an action can be considered a success or a fail. This last condition is crucial, for it allows us to distinguish actions, properly speaking, from other bodily phenomena such as trembles or spasms.

According to Di Paolo et al. (2017, 2018), these three conditions provide the basic characterization for a notion of agency, and they can be used to investigate the different forms in which agency can be manifested: biological, sensorimotor, social, and linguistic. In what follows, I will focus on the biological and sensorimotor forms of agency, as I take them to be the most directly relevant to ecological psychology.

Biological Agency

Arguably, the official story of enactivism begins with the notion of “autonomy.” This concept was first introduced by Varela (1979; see also Barandiaran, 2017) to capture the peculiar dynamics of living systems. In Varela’s view, living systems owe their existence to what he dubs “organizational closure.” A system is organizationally closed when it is composed of a number of internal dynamical processes such that (i) they recursively depend on each other (each process is simultaneously a causal enabling condition for, and an effect of other processes), and (ii) they constitute the system as a unity that is recognizable and identifiable against its medium. Autonomy is regarded by enactivists as a necessary and sufficient condition to speak of an individual system.

The most basic form of autonomy can be seen in autopoiesis. Autopoiesis, also referred to as “material self-production,” refers to the capacity of living systems to generate and maintain their own identity as something distinct from the environment. According to Weber and Varela (2002), an autopoietic system consists of:

A network of processes of production (synthesis and destruction) of components such that these components:

1. Continuously regenerate and realize the network that produces them, and
2. Constitute the system as a distinguishable unity in the domain in which they exist (p. 115).

⁸Bruineberg and Rietveld (2014) have proposed to explain this modulation by appealing to the Free Energy Principle in neurodynamics.

⁹In what follows, I will focus exclusively on the enactive approach first developed by Varela et al. (1991/2016), and extended in the works of Thompson (2007) and Di Paolo et al. (2017, 2018), as it is the branch that most prominently has focused on the issue of agency.

According to the theory of autopoiesis, living beings preserve themselves in virtue of being organized as a network of metabolic processes that generate their own components. So conceived, autopoiesis differs from other dynamical processes because of its reflexivity: “the autopoietic system is organized so as to produce that very organization” (McGann, 2007, p. 469).

To say that autopoietic systems are autonomous is not to say that they are self-sufficient. Crucially, it is because all living beings need to interact with the world to preserve their autonomy that they develop an individual perspective of the environment. At the very least, a system must be able to distinguish those aspects of the environment that are valuable or meaningful to its autopoiesis. The appearance of this individual perspective from which features of the world are perceived in relation to the autonomous system’s viability is what enactivists call “sense-making.” This capacity for sense-making is, according to enactivists, what distinguishes cognitive from non-cognitive systems, and it is key to understanding biological agency.

Thompson (2007) illustrates this view through bacterial chemotaxis. Because the bacterium exploits sucrose as a source of nutrient, it is attracted to sugar concentration, whereas other chemicals are neutral or repulsive. Crucially, although sucrose is a real entity of the bacterium’s environment, its status or meaning as food is not. Rather, the latter is linked to the bacterium’s metabolic needs. This is the sense in which enactivists claim that the meaningful or cognitive environment is “brought forth” by the organism’s activity. As Thompson (2007) explicates, for the sense-maker, “the environment becomes a place of valence, of attraction and repulsion, approach or escape” (p. 158). Thus, according to the enactive picture, being a sense-maker implies being ready to selectively act upon the affordances of the environment that are relevant to maintain autonomy.

Nonetheless, Di Paolo (2005) argues that autopoiesis alone provides a very thin understanding of sense-making and agency. The reason for this is that autopoiesis provides an “all-or-nothing norm” (Di Paolo, 2005, p. 436), according to which environmental features are relevant only in relation to their *direct* impact on the system’s autopoiesis. Two undesired consequences follow from this. First, autopoiesis leaves no space for the possibility that organisms act to actively avoid or seek situations on the basis of physical encounters that are not inherently lethal/non-lethal. Think, for instance, about the footprint left by a prey. This environmental encounter is relevant for the organism, if only as a reliable proxy for future autopoietically relevant affordances (nutrition). However, because the footprint does not physically affect the organism’s metabolism, it is deemed meaningless for the point of view of the theory. Second, autopoiesis does not conceive of the possibility that organisms actively seek to improve the conditions for self-production, e.g., by swimming up the sugar gradient.

To overcome these limitations, Di Paolo proposes to combine autopoiesis with adaptivity. A system is deemed adaptive when it is able “to regulate itself with respect to the boundaries of its own viability” (p. 430). To do so, the system must implement a set of

second-order processes¹⁰ that allow it to actively monitor internal and external perturbations, putting environmental encounters in relation to the whole spectrum of its viable states and thus recognizing in these encounters the tendencies that can lead to the loss or improvement of its autopoiesis. Adaptive systems are thus a subclass of autopoietic systems that can recognize environmental features as meaningful in virtue of their virtual consequences, thus perceiving “graded differences between otherwise equally viable states” (p. 437).

Autopoiesis and adaptivity are thus said to provide the bedrocks for a theory of agency at the biological level (Di Paolo et al., 2017, 2018; Heras-Escribano, 2019). Whereas autopoiesis (and, more generally, autonomy) provides the basic norms, or goals, for the system, e.g., to maintain its precarious individuality, adaptivity provides the means by which otherwise irrelevant environmental features are meaningfully identified, increasing the system’s sensitivity to the affordances of the environment and enabling it “to distinguish a situation as a risk or an opportunity, to tell the difference between good and better, bad and worse” (Di Paolo et al., 2018, p. 33). Therefore, an adaptive autopoietic system will be able not only to perceive the footprint as an opportunity to feed, but will also appreciate whether following the track of the prey is the best option given the circumstances. Investigating the species-specific mechanisms that give rise to this “graded perception” is a crucial step to understand how different organisms asymmetrically regulate their action in environments with multiple competing affordances (Reed, 1993)¹¹.

Yet, in a sense, biological agency is very limited. Since the kind of norms that arise out from biological autonomy concern to our self-individuation only, if we were *just* biological agents, the only affordances of the world that we would care for would be those that are related to our survival. Anything that is not directly relevant to being alive would be non-significant to us. At the same time, we would always avoid taking any action that could entail a risk to our biological integrity (actions such as drinking alcohol, smoking, and so on). As both conclusions are obviously false, we can safely infer that, at least for human beings, biological agency cannot be the whole story.

Sensorimotor Agency

Recently, Di Paolo et al. (2017) have attempted to complement the previous account with a theory of what they call “sensorimotor agency.” This kind of agency is present in sophisticated organisms capable of learning and acquiring new behavioral repertoires, and while it is enabled by biology, it is underdetermined by it.

The hypothesis that justifies the extension of agency beyond the biological realm is that we can find a form of autonomy at the level of perception and action. Two notions are crucial for this idea. The first one is “sensorimotor scheme.” These are organized, mutually adjusted sequences of sensorimotor

¹⁰I deem these processes “second-order” because they are not constitutive of the system’s autopoiesis.

¹¹Whereas the general notion of adaptivity is made operational through concepts from dynamical systems theory (“state trajectories,” “attractor landscape,” “viability set,” etc.), Di Paolo (2005, p. 440) offers suggestions about what the mechanisms that give rise to adaptivity in bacterial chemotaxis might look like.

coordination patterns that the individual deploys in carrying out a specific task and have been established as preferable in light of some normative framework, be it internal or external to the individual (namely, considerations of efficacy, timing, precision, and so on)¹². To understand what sensorimotor schemes are, think, for example, of the activity of cooking a recipe. If the recipe requires that we chop the zucchini to a specific thickness, I will need to coordinate the movements of my hands in order to keep the appropriate distance between the knife and my fingers. However, this coordination is only possible on the basis of the continuous perceptual experience, and then requires the establishment of a task-oriented sensorimotor pattern. In normal conditions, this sensorimotor pattern will not be enacted in isolation. On the contrary, while I am chopping the zucchini, I shall pay attention to the onion that I put on the pan, either by looking directly at it or by smelling it, to prevent it from getting burned. Hence, the task of cooking a meal requires the enactment of multiple sensorimotor patterns. At the beginning, these patterns are not well integrated (my hand coordination is rather clumsy, I cannot identify when the onion in the pan is burning, etc.), but as long as I get proficient in cooking this meal, these patterns get intertwined in the form of a scheme: a task-related, mutually supporting relation of coherent sensorimotor patterns. Next time I cook this meal, I will have the disposition to execute (“enact”) the same sensorimotor patterns I successfully enacted in the past.

It is important to realize, however, that the execution of a scheme is not innocuous. Rather, when a particular scheme is executed, it has an effect on other schemes, either preventing them from occurring or increasing the likeliness they will be enacted. This leads us to the realization that sensorimotor schemes, just like individual coordination patterns, can be organized in “clusters,” or networks of mutually coherent and enabling sensorimotor schemes. Drawing a parallelism with autopoiesis, these networks of schemes are regarded as the “individuals” that give rise to sensorimotor agency: “the behavioral analog to biological agency is a network of precarious but interactively self-sustaining sensorimotor schemes, i.e. a *self-asserting sensorimotor repertoire*, whose adaptive regulation is directed at the preservation of internal coherence and consistency” (Buhrmann and Di Paolo, 2017, p. 219). According to this picture, a network of schemes constitutes a particular autonomous system that “is reasserted by every successful act and challenged by every breakdown” (Di Paolo, 2019, p. 15).

Thus, whereas the study of biological agency requires that we focus on understanding how metabolic and adaptive processes give rise to a selective engagement with the biologically relevant affordances of the environment, the study of sensorimotor agency requires that we focus on understanding how sensorimotor schemes intertwine with others, forming mutually consistent networks. The network of sensorimotor schemes an organism embodies determines how she deals with the world – her sensorimotor “style” or “identity.” As such, when we face the world, most of the time we are already “equipped with a

rich repertoire of ready-made, highly organized [sensorimotor schemes]” (Di Paolo et al., 2017, p. 81), some of them widespread across the species, and others acquired in our previous history of interactions. These schemes condition what affordances we perceive and act upon, making some actions natural, while others feel awkward or unfamiliar. Therefore when considered at the sensorimotor level, the affordances of the environment become relevant not only because they contribute to our survival, but because they bestow “the stability and coherence of [our] sensorimotor repertoire” (p. 39).

The other important notion is “habit,” where habits are regarded as “self-sustaining precarious sensorimotor schemes” (Di Paolo et al., 2017, p. 144). A sensorimotor scheme is deemed precarious whenever the elements that support it depend for their structural stability on the regular enactment of the scheme. It means that “if the habitual scheme is not enacted with sufficient frequency, the structures supporting it starts to lose the properties that enable it. Eventually, the capability to enact the scheme degrades and disappears” (p. 144).

Enactivists oppose to the traditional reading of habits as rigid patterns of behavior that get automatically activated in the presence of the right environmental cues. As explained by Barandiaran and Di Paolo (2014), this conception spans from Descartes and Locke to modern behaviorism, and regards habits as units that result from the association of ideas or between stimulus and response, thus opposing habits to intelligent actions. By contrast, enactivists take the notion of habit from Phenomenology and Pragmatism, and picture them as behavioral routines that can be flexibly changed or customized if the context requires it. Indeed, pretty much in line with Dewey (1922), Egbert and Barandiaran (2014) go as far as to suggest that habits are essential to cognition, thus breaking the dichotomy between habitual and intelligent actions¹³.

But, what do habits have to do with sensorimotor agency? The key lies in the idea that habits are “self-sustaining.” As Di Paolo et al. (2017) explicate, this means that “a habit “calls” for its exercise and its exercise in turn reinforces its durability” (p. 144). According to this view, the fact that a particular sensorimotor scheme is habitual entails that it is more prompted to be enacted. As such, while different sensorimotor patterns can be as effective as others to reach a particular goal, some of them “are preferred because they are habitual and comfortable” (p. 143). Acquired sensorimotor habits thus guide the way we relate to the external world, normatively defining a set of viable actions (affordances) that can contribute to their preservation:

According to the enactive approach, habits are self-sustaining networks of bodily, neural, and interactional processes that become a source of [non-metabolic] normativity for an agent, in such a way that the preservation of her habitual identities guides much of her perception, thoughts, and behaviors (Ramírez-Vizcaya and Froese, 2019, p. 7).

¹²The conditions under which different coordination patterns cohere are referred to as “sensorimotor norms.”

¹³Habits are pivotal in the way Dewey understand human cognitive live. For example, he argues that “[r]eason pure of all influence from prior habits is a fiction” (Dewey, 1922, p. 31). Elaborating on this view, Crippen (2016, p. 247) suggests that the Deweynian notion of habit could be the basis of an enactive theory of morality.

Enactivists thus propose to investigate sensorimotor agency by studying how sensorimotor schemes and habits develop and relate to each other forming complex ecologies that in turn affect the way we interact with the world. In fact, following the enactive lead, Kiverstein and Rietveld (2018) understand habits as “interrelated states of action-readiness that coordinate to multiple relevant affordances” (p. 154). To complement this approach, enactivists have proposed a theory that attempts to explain how habits couple and mutually stabilize, as well as the conditions that determine how sensorimotor schemes become habits. Admittedly, the enactive theory of sensorimotor learning (Di Paolo et al., 2017; Di Paolo, 2019) is still to be further developed and tested upon, but it constitutes a significant milestone in the radical embodied cognitive sciences.

STEPS TOWARD THE UNIFICATION

Now that we have a thorough picture of the enactive theory of agency, it is time to come back to the suggestion made by Baggs and Chemero (2018). Can enactivism *alone* provide ecological psychologists with a theory of agency? My answer to this question is no. The reason for this has to do with the way enactivists characterize sensorimotor schemes.

According to the enactivist characterization, sensorimotor schemes (and networks of these) are grounded in the complex dynamical arrangement of certain properties within the agent (namely, musculo-skeletal structures and neural networks) that in turn give rise to specific sensitivities and dispositions to act. Despite this characterization, Di Paolo et al. (2017) are clear that sensorimotor schemes are not something a body possesses. Rather, they claim that these are “modes in which structures in the agent and structures in the environment meet and mutually stabilize” and that they “constitutively involve both the organismic body and its environment” (p. 152). But if the environment is constitutive of the organism’s sensorimotor schemes, it follows that agency is not a property that belongs to the organism or a system, but “a property of a *relation* between that system as its surroundings” (p. 110).

This means that in order to explain agency and account for how sensorimotor schemes and habits unfold, selectively exploiting some affordances of the environment instead of others, we have to account for how the organism can access to the environmental structures that complement and stabilize her sensitivities and dispositions. Without this complementary story, the enactive theory of sensorimotor agency remains incomplete:

Having powers and sensitivities required for action, in other words, is only half of the story. The other half is access to suitable accompanying conditions surrounding the agent, which in our world-involving perspective must themselves be active and concrete and not merely formal (Di Paolo, 2019, p. 212).

My claim is that ecological psychology can provide enactivists with this complementary story and then that it can contribute to explaining agency. According to this idea, what enables the organism to access the environmental structures that are relevant to its goals is the existence of perceptual information.

This information is given in the form of spatial-temporally extended patterns of stimulation that lawfully correspond or specify the environmental properties that are relevant for the system’s sensorimotor repertoire. This point is rather important because, according to the Gibsonian tradition, it is the existence of ecological perceptual information what makes possible the coupling between the individual and the affordances of the environment, and then the coupling of perception and action, without the necessity of performing inferences upon mental representations¹⁴. Thanks to this lawful correspondence, the organism can directly perceive the possibility of passing by an aperture if she detects the structured energy distribution this aperture generates. Remove the specific information, and you will be back to the old problem of having to explain how organisms can access the environment based on ambiguous and impoverished stimuli.

I therefore propose a dual approach to agency that combines the tools provided by enactivists and ecological psychologists. While enactivists focus primarily on describing how our acquired sensorimotor schemes and habits mutually equilibrate, affecting our tendency to act upon some affordances instead of others, ecological psychologists focus on studying how perceptual information contributes to the actualization of sensorimotor habits without mediating representations, inferences, and computations. Thus, we can replace the rather unspecific claim made by Di Paolo et al. (2017) for something more concrete: agency is a property of the relation between the organism and its environment, where this coupling is made possible by the existence of ecological perceptual information the organism can directly detect and exploit in guiding its action.

The contribution of ecological psychology to the enactive theory of agency can be seen in the following two examples. First, ecological psychology can bring to the enactive theory of agency a series of well-tested theoretical and empirical methods that allow us to identify what informational patterns need to be detected to enact a particular scheme, carrying out its associated task. For example, thanks to Lee (2009), we know that the information required to control braking is “time-to-contact,” and that this information is present in the optical looming pattern produced by the approaching obstacle. The crucial aspect here is that since the optical looming specifies the time remaining until driver and object collide, it provides unequivocal information to the driver about the actions she can perform: namely, whether braking is still possible, or she should prepare herself for an imminent collision. Experimental evidence shows that the same information is exploited to intercept moving targets (Fajen et al., 2008) and that it can be detected by dynamic touch as well (Cancar et al., 2013). The literature on time-to-contact shows that ecological psychology provides both a formal (mathematical) characterization of the informational variables required to successfully perform different tasks and a series of concrete examples of the sensory patterns where these variables are manifested, as Di Paolo (2019, p. 212) demands.

¹⁴As Withagen and Chemero write: “Direct perception is a coupling between the perceiver and the environment, via information in the array” (Withagen and Chemero, 2012, p. 532).

Moreover, this unified approach allows us to advance a new characterization of sensorimotor mastery. In this picture, sensorimotor mastery depends on embodying habitual sensorimotor schemes that integrate action patterns with the appropriate task-specific ecological information. Coming back to the example of cooking, sensorimotor mastery in this context requires that I coordinate my actions with the information of the environment, enacting action schemes that are well attuned to the information that is relevant to the task I am performing – namely, the olfactory information that specifies that the onion is burning in the pan. The process of coming to detect this task-relevant information is what Gibsonians call “education of attention” (Jacobs and Michaels, 2007). However, since the perceptual information needed to perform a task is not always present in the immediate environment, sensorimotor mastery also requires that we learn how to act in order to produce it. For example, the lion can learn that an efficient strategy to perceive whether the prey is reachable is to produce motion parallax, and can incorporate this act within its broader hunting-related sensorimotor schemes. Similar examples can be found in the literature about “dynamic touch,” where perceivers actively and skillfully manipulate objects in order to perceive their affordances (see Turvey and Carello, 2011).

In conclusion, rather than simply taking the enactive theory of sensorimotor agency from enactivism as Baggs and Chemero (2018) propose, I hold that ecological psychologists, through the notion of ecological perceptual information, can contribute to explaining it.

BRIDGING THE UNCANNY VALLEY

In the previous section, I have proposed an approach to sensorimotor agency that combines enactivism and ecological psychology. However, it has been recurrently pointed out that there exist essential tensions between both research programs. Di Paolo et al. (2017) nicely captures this view when he claims that “the relation between the schools of thought [enactivism and ecological psychology] is one of strange familiarity, as if their respective practitioners were staring at each other across an uncanny valley” (p. 18, ff. 3). In what follows, I shall attempt to bridge this valley. To do so, I will address the most significant reasons that ground the tension between these schools of thought. My purpose is to show that these tensions are based on reciprocal misinterpretations.

To begin with, it is well-known that Varela et al. (1991/2016) conceived of enactivism in opposition not only to classical cognitivism, but also to ecological psychology. Whereas they agree with Gibsonians that perceptually guided action need not be explained by positing mental representations, they disagree with the explanatory strategy put forth by ecological psychologists. As they argue, the ecological picture gives no explanatory relevance to the organism’s own activity, and instead tries to explain perception entirely from the side of the environment:

For Gibson, these optical invariances, as well as the environmental properties they specify, do not depend in any way upon the perceptually guided activity of the animal (though Gibson’s

followers do relativize them to a given animal niche). . . . In a nutshell, then, whereas Gibson claims that the environment is independent, we claim that it is enacted Thus the resulting research strategies are also fundamentally different: Gibsonians treat perception in largely optical (albeit ecological) terms and so attempt to build up the theory of perception almost entirely from the environment. Our approach, however, proceeds by specifying the sensorimotor patterns that enable action to be perceptually guided, and so we build up the theory of perception from the structural coupling of the animal (p. 204).

Varela et al.’s diagnosis that ecological psychology neglects the structural coupling of organism and environment can also be found in the work of current enactivists. Consequently, they keep presenting enactivism as opposed to ecological psychology:

We agree with ecological psychologists when they highlight that real environments are rich enough to access directly their relevant meaningful aspects. We think they are in fact too rich, and that sense-making always involves a massive reduction of all the environmental energies that might affect the agent, to those within the dimensions of biological, sensorimotor, and social historically contingent meaning (Di Paolo et al., 2017, p. 227).

I hold that this position is based on a misreading of ecological psychology. For one thing, we must note that affordances – the primary objects of perception for ecological psychology – are organism-dependent. For example, that the glass I have in front of me is *graspable* is not a property of the glass alone, but a property that holds in virtue of the relation between the glass and myself. It is because I am equipped with hands of a certain size and opposable thumbs that the glass affords *graspability* to me, but it will not afford the same action to my cat. This is why J. J. Gibson always insisted that affordances point two ways, to the environment and to the observer (Gibson, 1979/2015, p. 121, 132). Moreover, the affordances do not depend on physical relations alone, but need to be related to the observer’s capabilities as well (Chemero, 2009). For example, studies have shown that the perception of the *climbability* of a step is susceptible to change as the perceiver ages or gets physically tired (Konczak et al., 1992).

Yet it is not only the affordances that imply the complementarity of animal and environment but the information too. At the beginning of *The Ecological Approach to Visual Perception*, Gibson (1979/2015) introduces a crucial distinction between the environment and the physical world. As he explicates, while the physical world comprises everything “from atom to galaxies” (p. 4), the environment refers only to those aspects of the world that can be detected and interacted with by a particular organism. Ecological information is said to be in the environment, not the world *per se*, meaning that the notion of information is relational as well (Segundo-Ortin et al., 2019). For example, whereas electromagnetic fields constitute information for sharks in the sense that sharks can detect and exploit them, they do not have the same status for human beings. Even though electromagnetic fields are real physical properties of the world, their status as perceptual information is determined at the ecological scale – the scale of the perceiver.

On the other hand, although Gibsonians put the emphasis on the environment when explaining perception-action, they do not claim that the environment alone suffices to cause it. By contrast, as we mentioned before, ecological psychologists conceive of perception as a sort of activity – something the animal does. It requires that the organism actively forages for information, sometimes moving in order to give rise to and perceive the required invariant patterns. This clearly shows that ecological psychologists do not obviate the role of the individual in bringing about or “enacting” its own perceptual world, as enactivists claim¹⁵.

Therefore, we can conclude that it is wrong to assert that ecological psychologists aim to explain perception only from the side of the environment. In fact, several Gibsonians have held that the correct unit of analysis for an ecological theory of perception is the organism-environment system, emphasizing the structural coupling, or “mutuality,” of both relata (see, e.g., Michaels and Carello, 1981; Richardson et al., 2008; Turvey, 2018).

Di Paolo et al. (2017) advance a complementary reason to feel unease about ecological psychology. According to them, even though ecological psychology rejects representationalism, it keeps committed a “functionalist general approach to cognition” (p. 18, ff. 3) that is incompatible with enactivism. For them, this is shown by the fact that ecological psychology explains perception in terms of information gathering, use, and transformation. The same idea has been coined by Hutto and Myin (2017, p. 86), for whom ecological psychologists’ use of “information pickup” reveals “an underlying commitment to an information processing story.”

Once again, I hold that this reading is misguided. Even though ecological psychologists use “information pickup” and “information detection” interchangeably, it does not follow that they hold that perception requires internalizing and processing information. Instead, an organism is said to pick up information whenever she tracks the dynamic patterns that are present in the topology of her sensory array, perceiving what this information affords. Reed makes this point clear when he claims that “ecological information cannot be transmitted: it is ambient and available, not something put over a channel; it is something to be detected or used (or not) in regulating action. . . . Information pick up is not a process of “internalizing” information” (Reed, 1996, p. 155). And the same idea is expressed by J. J. Gibson:

I do not believe that the visual system is a channel for transmitting signals from the retina to the brain. I believe it is a system for sampling the ambient array. . . . And that means that the observer’s brain cannot be compared to a computer, or to a processor of information delivered to it Gibson (1970/1982, p. 86).

Perception, in ecological psychology, does not consist of coding and passing messages from the sensory organs to the brain to be further decoded and computed, but on tracking properties in the sensory array and exploiting them to coordinate

action *in situ*. Therefore, we can conclude that the reasons advanced by Di Paolo et al. (2017) to attack ecological psychology are misguided.

Yet enactivists are not the only ones to have expressed doubts upon the possibility of a unified framework. Attacks have come from the ecological side as well. For example, it is a common assumption among the Gibsonians that enactivists subscribe to a kind of mental constructivism that is radically incompatible with ecological psychology. Fultot et al. (2016) situate this problem in the way enactivist use the notion of “sense-making.” For them, because enactivists are “in favor of interpreting the activity of perceptual agents as a kind of construction of perceptually meaningful world” (p. 298), enactivism “is germane to the representationalist, not ecological, theory of cognition” (p. 304; see De Jesus, 2016; Hutto and Myin, 2017 for similar claims). Elaborating on the same issue, Heras-Escribano (2018) asserts that “if enactive agency emphasizes subjectivity, it cannot be compatible with ecological psychology” (Heras-Escribano, 2018, p. 136).

I nonetheless think that a more charitable reading of enactivism is possible. Consider, for example, the way Di Paolo et al. (2018) characterize sense-making:

Sense-making is the capacity of an autonomous system to adaptively regulate its operation and its relation to the environment depending on the virtual consequences for its own viability as a form of life. Being a sense-maker implies an ongoing (often imperfect and variable) tuning to the world and a readiness for action (p. 33, emphasis original).

As we can see, Di Paolo et al. steer clear of the constructivist interpretation of sense-making. On this view, sense-making does not consist of the creation of subjective meanings by the individual, but on the discrimination of what in the environment is relevant for its survival and potential actions. I take this reading to be totally unproblematic with ecological psychology, and perfectly compatible with the view of perception as the selective detection of information about affordances.

Admittedly, more work is needed to build up a general ecological-enactive approach of the sort Baggs and Chemero (2018; see also Heras-Escribano, 2019) seek. However, it seems clear that some of the most well-known reasons for the tension between ecological psychology and enactivism are based on misunderstandings. I hope that once these misinterpretations are clarified, the possibility of building an ecological-enactive theory of agency looks more plausible.

CONCLUSION AND DIRECTIONS FOR FUTURE RESEARCH

Explaining agency is a major challenge for those who are interested in the sciences of the mind, and non-representationalists are no exception to this. In this paper, I have examined how the two most important schools of thought in the non-representational cognitive sciences, ecological psychology and enactivism, address the issue of agency. I have proposed

¹⁵Based on this idea, Baggs and Chemero (2018) introduce a distinction between “habitat” and “umwelt.” Whereas “habitat” refers to the environment for a species, the *umwelt* refers to the environment for a particular behaving organism. According to them, this distinction helps fostering our understanding of the active role of the organism in perception (and cognition).

that there is a mutual fit between enactivism and ecological psychology, and that both theories can complement each other to explain sensorimotor agency. According to this view, the environment, as conceived of by ecological psychologists, contributes to the emergence of agential behavior by providing the organism with information about affordances, and agential behavior depends on the enactment of habitual patterns that integrate structures at the level of the organism with action-specific ecological information. Therefore, while enactivists explain how the history of interactions of an organism gives rise to a series of sensorimotor schemes and habits (a “sensorimotor repertoire”) that in turn play a causal role in shaping its current perception and action, ecological psychology helps us make sense of the environmental informational patterns that contribute to the emergence of agential behavior. Remarkably, this proposal is not in conflict with the idea that some affordances can be perceived as invitations in certain situations (Withagen et al., 2012, 2017), but rather contributes to explain how different individuals, by means of embodying different sensorimotor repertoires, regularly perceive and exploit certain affordances instead of others.

Besides, I argue that this ecological-enactive approach can provide a more comprehensive account of agency than the one previously provided by ecological psychologists alone. To see this, consider the problem of explaining how our individual agency can be modulated by socio-cultural norms. Gibsonians have largely noted that our relationship with the affordances of the environment does not only depend on our capability to detect information. Rather, this relation is often influenced by the social pressures and norms that rule within the communities we inhabit. As explained by Heras-Escribano: “Our social norms and conventions share their space with our individual perception of affordances, and sometimes our norms exert some pressure for not taking certain affordances given some social conventions” (Heras-Escribano, 2018, p. 175).

Gibsonians have nonetheless gone into great pain when trying to explain how social norms can influence perception-action in a way that is consistent with the core tenets of ecological psychology (see, e.g., Costall, 1995, 2012; Heft, 2007, 2017, 2018; Heras-Escribano, 2018; Rietveld and Kiverstein, 2014). I suggest

that an ecological-enactive approach to sensorimotor agency can provide us with new theoretical resources to address this challenge. A hypothesis that is consistent with this approach is that individuals, by interacting and collaborating with peers, learn and acquire particular sensorimotor schemes and habits (see Adolph and Hoch, 2019). If these schemes and habits already encode (albeit implicitly) the social norms that are distinctive of their community, then we have a way to understand how these norms can have an influence on the affordances we perceive and act upon.

Whether or not the ecological-enactive theory of agency fully takes off is yet to be seen. If we aim to fully explain human agency, we must be shown whether an ecological-enactive theory of agency can explain complex phenomena such as group action (Marsh et al., 2009) or long-term planning (Brancazio and Segundo-Ortin, 2020). Nonetheless, it seems that a combined approach along the lines I have suggested here can be mutually beneficial and opens up new and promising lines of research. Let us keep exploring the possibilities of an ecological-enactive cognitive science.

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The author confirms being the sole contributor of this work and has approved it for publication.

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Enactivism and Ecological Psychology: The Role of Bodily Experience in Agency

Yanna B. Popova^{1*} and Joanna Rączaszek-Leonardi²

¹ Polish Institute of Advanced Studies (PIAS), Warsaw, Poland, ² Human Interactivity and Language Lab, Faculty of Psychology, University of Warsaw, Poland

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Ezequiel A. Di Paolo,
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*Correspondence:

Yanna B. Popova
yannapopova7@gmail.com

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This paper considers some foundational concepts in ecological psychology and in enactivism, and traces their developments from their historical roots to current preoccupations. Important differences stem, we claim, from dissimilarities in how embodied experience has been understood by the ancestors, founders and followers of ecological psychology and enactivism, respectively. Rather than pointing to differences in domains of interest for the respective approaches, and restating possible divisions of labor between them in research in the cognitive and psychological sciences, we call for a deeper analysis of the role of embodiment in agency that we also undertake. Awareness of the differences that exist in the respective frameworks and their consequences, we argue, may lead to overcoming some current divisions of responsibility, and contribute to a more comprehensive and complementary way of dealing with a broader range of theoretical and practical concerns. While providing some examples of domains, such as social cognition and art reception, in which we can observe the relative usefulness and potential integration of the theoretical and methodological resources from the two approaches, we demonstrate that such deeper synergy is not only possible but also beginning to emerge. Such complementarity, as we envisage, conceives of ecological psychology that allows felt experience as a crucial dynamical element in the explanations and models that it produces, and of an enactive approach that takes into consideration the ubiquitous presence of rich directly perceived relations among variables arising from enactments in the social and physical world.

Keywords: ecological psychology, enactivism, embodiment, experience, social cognition, art reception, kinaesthesia, agency

INTRODUCTION

This article aims to consider some foundational concepts in enactivism and in ecological psychology, and how they have come to shape the past and current concerns of the main theorists in these respective frameworks. Both theories are currently described as positions of “radical embodiment” (Baggs and Chemero, 2018) in that they both reject a representational view of human cognitive processes and see being and acting in the world as a foundational capability of the mind. This suggests, we think, more than simply an accidental convergence of ideas, and indicates a common historical ancestry of a kind, one which remains largely unexplored, namely, the radical empiricism of William James on the one hand and a broadly phenomenological understanding of the activity of the body as foundational for perception and cognition on the other. As some researchers have already discussed (Glottzsch and Heft, 1982; Heft, 1989;

Chemero and Käufer, 2016), despite coming from different traditions, Gibson was familiar with the work of Merleau-Ponty and used some related ideas in his own research. Radical empiricism, as developed by William James, was also a significant influence on Gibson, and the common threads between James and key phenomenologists still remain a point of intense historical and theoretical debate. Enactivism has openly and repeatedly acknowledged its links with phenomenology and thinkers such as Husserl, Jonas, and Merleau-Ponty. Nevertheless, our aim here is not merely looking for direct influences but, rather, highlighting a certain creative confluence and a commonality of ideas that shaped and continue to inform these two influential positions in current research in psychology, philosophy, and cognitive science. We propose that in order to examine the similarities and differences between the two approaches and seek the points of possible mutual support, a deeper analysis is needed of the crucial notion of experience, which, in turn, determines how embodiment and agency are understood. This is driven in part by the fact that a lot of current work that ventures outside of narrowly understood cognition into areas such as architecture, art and art reception, or media and narrative in general tends to use enactivist approaches and Gibson's theory of affordance interchangeably, without much precision. A similar situation exists in relation to discussions about social cognition, where the process of perceiving "social affordances" and the enactivist concept of "participatory sense-making" appear to be used as analogous. It is our aim in this article to show how through careful considerations of the notions of embodied experience and agency certain choices of applications to diverse fields such as social cognition, art reception, or psychopathology, to name but a few, can become better understood and perhaps more thoroughly evaluated and differentiated. The complementarity of the approaches that is increasingly often being pointed to and/or called for (Baggs and Chemero, 2018; Heras-Escribano, 2019) has, we claim, to rest on a clarified common conceptual core in order to have the potential of becoming a strong alternative to representational approaches. At present, within cognitive and psychological sciences, the applicability of ecological psychology seems to be more in the broadly understood action-perception and motor-coordination field, providing multiple methodologies and tools for empirical research, while enactivist approaches seem to be especially helpful in the domain of social interaction, including psychopathology and art reception, as well as in setting up the philosophical frame for researchers. Perhaps a more nuanced understanding of the relation between experience, embodiment, and agency would lead to pooling of the respective expertise and methods so that they can be applied in a broader range of common domains. In the second part of the article we attempt to show such advantages on the example of early social interaction and art reception.

SOURCES AND DEVELOPMENTS

It is important to address briefly the issue of how particular ideas developed in reaction to accepted views at the time of conception in both the early enactivism of Varela et al. (1991) and in Gibson's ecological theory of perception (1966, 1979), and

how these positions of carving a particular intellectual response to dominant views gave rise to subsequent emphases on specific aspects that led to divergences as well as commonalities in the two theoretical approaches under consideration.

Enactivism

As acknowledged by Varela et al. (1991) and Thompson (2007), early enactivism was mainly formulated as a reaction against classical, first-generation Cognitivism, which was based on the prevalent-at-the-time computational theory of mind (Thompson, 2007, pp. 4–8). Early enactivism therefore was explicitly framed as a rejection of information processing and symbolic representations that dominated cognitive science, and sought ways to reconcile the scientific study of the mind with the lived experience of an organism. One main criticism was aimed at the cognitivist failure to account for such subjective experience, providing instead a model of the brain as a "stimulus-driven, sequential processing computer" (Thompson, 2016, p. xix). Another major point of contention was the evident lack of interest, shown by cognitivists, in the role of not just bodily but also environmental and social dynamics in cognition and lived experience. To that extent, enactivism came as a position of radical change in our understanding of mind and life in cognitive science, and as such it reached to phenomenology in order to emphasize the role of embodiment, embeddedness, and enactment for understanding cognitive processes. As Evan Thompson acknowledges, many things have changed since those early days of enactivism. Embodiment has become a central concern for cognitive science, as has the self-organizing and distributed nature of brain processes, and "the deep continuity in the principles of self-organization from the simplest living things to more complex cognitive beings" (Thompson, 2016, p. xix).

For our purposes here it is crucial to highlight the lessons from phenomenology that have shaped the past and continue to contribute to current work within enactivism. Phenomenology studies pre-reflective as well as conscious lived experiences, and respects the centrality of the first-person point of view. It is best understood as a strictly defined commitment to the role played by subjectivity in the constitution of everything that we do, including scientific projects (see Moran, 2000; Sokolowsky, 2000). The core term of phenomenology is "intentionality," understood as the claim that all acts of consciousness, be it perceptions, feelings, moods, decisions, memories, or imaginations, are experiences of something. Our awareness is inescapably linked with the world of things and other people. Phenomenological description is therefore always an intentional description, revealing the inherent relationship of the world with subjectivity¹. This is precisely how the initial formulation of enactivism as "the emergence of mind as entailing the emergence of a world" can be properly understood. It can be

¹The term *intentionality*, as a distinctive feature of consciousness, stems from the Latin verb *intendo* and means "to aim" or "to stretch" and therefore describes how consciousness can be directed to objects that are internal, such as memories or anticipations, and also external, such as things and events in the world. Husserl borrowed the term from his teacher Franz Brentano, although he considered Brentano's understanding of it misleading. Its use in phenomenology indicates the necessity to bridge a dichotomy between lived experience and the way it always points beyond itself.

argued that because phenomenology is primarily understood as a philosophy of experience, its influence filters directly into preoccupations in early and contemporary enactivism with issues such as individuation, autonomy, and agency, as we will discuss below. For example, the five principles, highlighted by Thompson (2007, p. 13) as the main ideas behind the theory, show explicitly that enactivism foregrounds the constitutive nature of subjective experience in relation to an external realm that is “brought forth by a living being’s autonomous agency.” Importantly, subjective experience is not seen as “an epiphenomenal side issue, but central to the understanding of the mind” (Thompson, 2007, p. 13). It needs to be emphasized, however, that with its commitment to the biological study of the self-organization of all living beings, enactivism goes beyond the object matter of phenomenology in its preoccupation with the constitutive nature of subjective experience, as seen in more recent work in enactivism (e.g., Di Paolo et al., 2017). This is to say that the self-organizational nature of biological structure and the foundational role of embodied subjectivity are equally important tenets of enactivism (see also Stewart et al., 2010)².

So, how are the lessons from phenomenology manifested in enactivism? What are the contributions of a phenomenological description of subjective experience to enactivism as a cognitive science discipline? Husserl understands *experience* or *lived experience* (a translation of the German verb *Erleben* and noun *Erlebnis*) as “something that one lives through,” “the conscious state as personally lived through and experienced in the first person” (Moran and Cohen, 2012, pp. 115, 195). It includes perception, imagination, memory, emotion, and many other aspects of conscious life. Each intentional act, such as judging, perceiving, wishing, and so on, has a particular quality to it, which is given in experience. Husserl also distinguishes between *lived experience* and the properties of the *mind-transcendent object* (Moran and Cohen, p. 169). This is because in lived experience we can only know the particular object in an incomplete way, as it presents itself to us in a certain aspect, from a particular angle, etc. However, it is the experience of an object that fundamentally underlies our encounter with it. As a well-known commentator on Husserl has described it, “[w]e are never conscious of an object *simpliciter*, but always of the object as appearing in a certain way; as judged, seen, described, feared, remembered, smelled, anticipated, tasted, and so on. We cannot be conscious of an object (a tasted lemon, a smelled rose, a seen table, a touched piece of silk) unless we are aware of the experience through which this object is made to appear (the tasting, smelling, seeing, touching)” (Zahavi, 2005, p. 121).

One fundamental aspect of lived experience is “embodiment,” understood most basically as the view that our knowledge of the

world is inseparable from the experiences of the bodies that we are³. Preoccupation with the body is a major characteristic of phenomenology, but it is important to stress that the body for phenomenologists, such as Husserl and Merleau-Ponty, is not the body seen as any other object in the world, but precisely the felt and animated body experienced by a particular first-person perspective, in other words, the body-as-experiencer, the body-as-lived (*Leib*), and in contrast to the physical body (*Körper*) (Husserl, 1989). The lived body’s main characteristic is that it is always given as “my own body” in such a way that “I experience myself as ‘holding sway’ over this body” (Moran and Cohen, p. 194). The lived body, then, is not just a center of experience but a center of agency, or “willful self-movement.” As Husserl has described it, “the living body is never absent from the perceptual field” (quoted in Moran and Cohen, p. 194). This is clearly mirrored by Merleau-Ponty when he says: “[I]t is, therefore, quite true that any perception of a thing, a shape or a size as real, any perceptual constancy refers back to the positing of a world and of a system of experience in which my body is inescapably linked with phenomena. But the system of experience is not arrayed before me as if I were God, it is lived by me from a certain point of view; I am not the spectator, I am involved and it is my involvement in a point of view which makes possible both the finiteness of my perception and its opening out upon the complete world as a horizon for every perception” (Merleau-Ponty, 2002, pp. 353–354).

What enactivism takes from phenomenology (particularly from the philosophy of Husserl, Jonas, Merleau-Ponty) can be summed up by the statement that human experience is inherently incarnate (embodied) and the study of embodiment revolves around questions of action, perception, and motility. In current enactivist thinking cognition is thus defined as “the exercise of skillful know-how in situated and embodied action” (Thompson, 2007, p. 13). As discussed, both Husserl and Merleau-Ponty give special importance to the role of bodily motility in perception, and both emphasize the implicit, usually pre-reflectively functioning bodily intentionality that underlies everything that we do. The body is the sole vehicle for having a world, and this very aspect of incarnate existence is what is at the core of enactivist concern with experience. According to Thompson (2005, p. 11), any scientific account of the body as a locus of convergence of perception and action requires an account of not just selfhood or agency but also an account of a pre-reflectively known embodiment. In current enactivist work (e.g., Buhrmann and Di Paolo, 2015) this avowed preoccupation with embodiment has given rise to a complex understanding of what constitutes agency, which includes both a phenomenologically derived embodied

²It needs to be noted that the branch of enactivism that we are discussing is the one developed from the original work by Varela et al. (1991, 2016), and evidenced in subsequent work by Thompson (2007); Di Paolo et al. (2017), De Jaegher and Di Paolo (2007), and Buhrmann and Di Paolo (2015), among others. “Sensorimotor enactivism,” as it is sometimes termed, is a variety of enactivism that concentrates on the study of environmental interactivity and sensorimotor contingencies and does not undertake to explore issues of subjectivity to the same degree. Representative theorists in the latter include Hutto and Myin (2012); Nöe (2004), and O’Regan and Nöe (2001). For a description of varieties of enactivism, see Ward et al. (2017).

³It is important in a paper concerned with influences and historical connections of ideas to emphasize that it was Husserl’s own phenomenology that can be considered a first true phenomenology of embodiment. As Moran (2017, p. 28) observes, this fact is still not appreciated fully by researchers, with some notable exceptions (e.g., Taipale, 2014, the work of Dan Zahavi), due to the fact that Husserl did not publish the work contained in *Ideas II* (1989) in his lifetime. As a result, Merleau-Ponty, who had access to Husserl’s manuscript as early as 1939, is usually credited with initiating the phenomenology of embodiment in his *Phenomenology of Perception*.

selfhood and a biologically based view of the organism as a “self-organizing system.”

Within the perceptual world the body can appear as just another object to be perceived and examined, an “object body,” or *Körper*. Yet, inescapably, this is always accompanied by the experience of the body-as-lived, the body from within. For Merleau-Ponty human existence is thus “doubly” embodied, and this dual perspective between the physical body and the lived body provides a way to escape dualism in the description of embodied experience and even a way of reconciling a more scientific third-person stance and a first-person phenomenological one⁴. As first noticed by Husserl and later emphasized by Merleau-Ponty, it is intrinsic to lived embodiment to be both a subject of experience and an object available to one’s own as well as the other’s gaze. The body (*Leib*) thus performs a key role in the formation of intersubjectivity since the simultaneity of my experience of my body as both subject and object gives rise to the recognition of the subjectivity and lived embodiment of another. This feature of “embodiment” becomes particularly relevant in relation to “social affordances” and how an agent becomes, through her own spontaneous actions, a possibility for participatory action for others, as we will discuss below.

Another major theme from phenomenology that is evident in enactivism is the relational nature of the subject and world connection. Both embodiment and such relationality between organism and world are aspects of what constitutes experience, in other words, of how we perceive and act in the world, engage with other people, or, simply, live as an individual biological system. Embodiment, or having the body we do, determines not only what we perceive and how we act and think, but how the world appears or feels. With respect to relationality, as already mentioned in connection with intentionality, the mind and the world are not understood as two pre-given and discrete entities, but as “mutually constituted” in a dynamic and active relationship. Husserl first addressed the enworlded nature of experience, “the world as the ever present horizon of experiences” (Moran and Cohen, p. 189), and this theme was taken up by his followers in concepts such as “being-in-the-world” (Heidegger, 1962) and “being-to-the-world” (Merleau-Ponty, 2002). For both of these philosophers the subversion of classical dichotomies between subject and object, or subject and world, constitutes a substantial aspect of their respective projects in philosophy. For Heidegger, the very insertion of hyphens between the words of his key concept “being-in-the-world” (*In-der-Welt-sein*) serves as a graphic illustration of the conceptual disintegration of the dichotomy he seeks to overcome. In this mode of their thinking both philosophers can be seen as clear precursors of enaction. For example, E. Rosch’s own description captures this co-constitution of self and world, “[t]he environment of a given living body of whatever degree of complexity can only be what is knowable and known to its sense organs and cognitions, and that environment

is in its turn constantly changed by the organism’s action on it – . . . neither side is pre-given” (Rosch, 2016, p. xxxviii). The same two themes of (i) embodiment and (ii) the relational nature of the subject/world connection are also dominant features of ecological psychology. Yet the role of felt experience in embodiment is different in ecological psychology, as is the emphasis on the direct perception of relations between subject and world and within the world itself, as we will show below.

Ecological Psychology

Ecological psychology, an approach developed by J. J. Gibson, grew out of the radical empiricism of William James and the philosophical behaviorism of Edwin B. Holt. Although we recognize the complex, multithreaded nature of ecological psychology’s background (see Heft, 2001, for an excellent introduction to this background and history of the approach), including Gestalt psychology, and phenomenology, we focus on these roots as most closely linked to the issues we will pursue⁵. Following radical empiricism, it was a reaction against the mediated, inference-based theories of perception by a passive viewer (Heft and Richardson, 2013). While often thought to be mainly a theory of perception, ecological psychology, which followed from Gibson’s and his followers’ work, was based on redefining the organism/environment relationship, which meant a redefinition of most key concepts to cognition. As Heft points out, “there is hardly a topic in psychology for which considerations of the nature of the environment and an individual’s relation to it do not play an essential role” (Heft, 2001, p. 9). Thus, although Gibson’s and his followers’ interests are often linked to research on perception-action cycles in the domain of motor control, profound changes followed in thinking about such issues as the sources of meaningfulness of perception and action, the ways knowledge is gained and used, and the role of values in this process, thus making ecological psychology a comprehensive theoretical view and research framework (Gibson and Crooks, 1938; Gibson, 1966; Reed, 1988, 1996; Hodges, 2007). This broader engagement as a theory of cognition is evident in the scope of the theoretical debates that ecological psychologists initiated, for example, with the advocates of representational and modular versions of cognition (see, e.g., Fodor and Pylyshyn, 1981; Turvey and Carello, 1981; Turvey et al., 1981).

Ecological psychology is based on the assumption of an essentially active organism, where the coherence and adaptivity of action both shape and drive the cognitive processes. Perception is direct, continuous, and unmediated, and it involves the agent’s movement. The lack of the necessity for inferential processes stems from this directness and from the fact that perception provides rich and highly structured relational information, which is sufficient to specify behavior. The researcher’s task is to

⁴ An example of such an attempt is Varela’s project of neurophenomenology (also known as the project of *naturalization in phenomenology*), which aims to combine the experimental subject’s 1st-person account of her experience with neuroimaging data. See Varela (1996) and Varela and Sheer (1999) for descriptions of the whole research project.

⁵ The relation of Gibson’s work to phenomenology reflects well this complexity, which is one of the main points in this paper article. He might have been influenced by Merleau-Ponty on a general level, and it is true that the general assumptions of his theory, especially about the relation organism/environment, can be seen to parallel the work of Merleau-Ponty (Heft, 2001; Chemero and Käufer, 2016). On the other hand, as we will claim below, some threads present in James’s work, congruent with the phenomenological approach, seemed to not have been picked up by Gibson.

discover the properties of such relational dynamical structures and account for how they are meaningful for an agent, and how the agent's actions are coupled to them, resulting in adaptive behavior.

The philosophical roots of Gibson's theory lie in William James's radical empiricism, which, as some theorists have claimed, served to pave the way also for phenomenology (Edie, 1970; Heft, 2001, p. 114). The core of radical empiricism is a refusal to acknowledge the distinctiveness and independence of organism and environment, knower and known, subject and object that we later find both in Husserl and in Merleau-Ponty. For James, the world possesses an inherent discoverable structure, which is directly apprehended and present in experience. The "radicality" of James's empiricism stems from the proposal that what is present in the world and apprehended directly by experience is more than mere elements of the world, of which then the mind must make sense. Reality and the capacity to be experienced (experienceability) are granted also to relations and structures, which therefore do not have to be cognized in a separate cognitive feat: "Order is an intrinsic quality of encountering the world" (Heft, 2001, p. 36).

Although it is easy to see in these ideas the precursors for Gibson's theory of direct perception, it is likely that influences from behaviorism made him emphasize only some of the consequences of such understanding of the relation between the world and an organism. In the ecological psychology framework, direct apprehension of the structures of the environment retains predominantly a functional value, serving to guide the organism's actions⁶. The felt, subjective quality of the relational experience, it seems, has not been capitalized on or factored in the explanations of activities as an important feature. Thus, it can be safely stated that even though other influences on Gibson (such as Koffka or MacLeod) made him employ phenomenological description as a propaedeutic for experimental work, he was not a phenomenologist (Heft, 2001, pp. 114, 117).

The key concept in the ecological psychology view of cognition, which is presently proving itself increasingly useful both for the mainstream cognitivist approaches (see, e.g., Norman, 1999, for discussion) and certain newer enactivist/ecological hybrid approaches (e.g., Rietveld and Kiverstein, 2014), is the notion of *affordances*. In an often quoted definition: "[t]he *affordances* of the environment are what it offers the animal, what it *provides* or *furnishes*, either for good or ill" (Gibson, 1979, p. 127). The role of the concept in the framework is to retain the action-relevance and organism's subjectivity when talking about the perception of the world. Even though some understandings of affordances tend to objectivize them as features of the environment (Hutto and Myin, 2017), it seems rather clear that in most of Gibson's writings they are a relational concept, in which both the environment and the organism are implicated (Chemero, 2003). Employing this concept realizes the tenets of James's radical empiricism in a twofold way: first, affirming the subject/object inseparability, and second, granting

reality and direct capacity to be perceived (experienceability) to relations. It is thus important to underscore the complexity of this notion. Affordances are relational in a double sense: (i) of unifying the organism and the environment, the knower and the known, but, also, (ii) of being based on complex, often non-obvious relations, which can be directly perceived. In later works in ecological psychology we witness further development and clarification of this unifying role of the concept of affordances.

One such important theoretical move, which served to make an explicit connection between ecological psychology and Merleau-Ponty's phenomenological understanding on intentionality, was Heft's (1989) consideration of the intentional nature of affordances and therefore of perception. It is misleading, he claimed, to treat affordances simply as causes for behavior. They should be thought of, rather, as constraints on actions that an animal is capable of producing, and is actually producing. Affordances thus scale not only to the action abilities or sizes of the animal's bodies. Having a body is not having some average action vehicle but, as Heft reminds us, quoting from Merleau-Ponty: "having a body is [...] to identify oneself with certain projects and to be continually committed to them" (Merleau-Ponty, p. 82, quoted in Heft, 1989). This allows us to understand affordances in relation to intentional acts. They are those environmental features that are implicated in ongoing projects, and it is from these intentional acts that they derive both their meaning and their capacity to be perceived. This seems to be a step toward explaining what it is to experience the sense of oneself as the author of one's actions. This also alleviates the critique of the Gibsonian approach regarding culturally based affordances: adding to an intentional repertoire (e.g., via engagement in new routines, imitation, learning, or spontaneous behavior) brings about new affordances.

The embodied nature of the cognitive processes in ecological psychology thus stems from cognition understood as being for the action of a body and from taking activity as the starting point for cognition. It is the active body that shapes perceptual categories. The complexity of intentional acts in which an organism is involved can provide for the complex, relational, and multilayered nature of the perceivable and perceived properties of the world. However, it seems that Gibson's approach focuses on merely a subset of projects and intentional acts in which we can be engaged, i.e., those connected to a goal-directed activity in the environment. The role of the body is thus mainly a functional role, and the embodiment of action does not refer to the felt experience this body possesses while acting. To be sure, the "I," the self of an agent, is important: As described by Heft (2001, p. 120), "[a]ccompanying the experience of optical flow, and perception of the environment generally, is the experience that it is 'I' who is moving through the environment. This is not a Cartesian experience of the 'I,' a disembodied entity that is self aware as it thinks. This 'I' is much more concrete than that; it is the source of action and it can literally be seen by the perceiver. It is 'I' as purposive agent." However, the indications of one's bodily presence are not the felt bodily experiences but rather "persistent features in the field of view," such as occluding edges. For example, the movements of the head are perceivable in visual information as "sweeping of the field of view (...) and

⁶Note that we use "functional" here in its psychological sense, as it applies to the psychological approach of James (1890); Dewey (1934), and others. This is distinct from "philosophical functionalism" as used in contemporary cognitive science. See also note 8, below.

the wheeling of the field,” but not, again, as felt motions, with which the visual experiences can enter into relations. As Heft writes, this means that “accompanying exteroception is always ego- or interoception,” or in Gibson’s own words: “The optical information to specify the self, including the head, body, arms and hands, accompanies the optical information to specify the environment. The two sources on information co-exist” (Gibson, 1979, p. 116). This, however, also refers to the body as an object; its movements, specified by the optical flow, are considered in terms of coupling to the processes in the world, but the body as experiencing, lived one, the proprioceptive or kinaesthetic information of felt body motion (which does not have to be specified by optical flow) does not seem to be a discernible element of experience and, for example, cannot be coupled to the experienced visual flow. This Gibsonian understanding of the body, in other words, is not equivalent to the felt, bodily presence that dominates the Husserlian notion of *lived experience*.

It can be argued that both ecological psychology and enactivism reject a mentalist version of agency and recognize the inseparability of agency from bodily activity. Yet, as we have shown, the body seems to be playing a different role in constituting experience for the two approaches, and this necessarily leads to distinct understandings of agency, to an analysis of which we turn in the next section.

EXPERIENCE, EMBODIMENT, AND AGENCY IN ENACTIVISM AND IN ECOLOGICAL PSYCHOLOGY: DISCUSSION

For both approaches, in the first instance, agency can be understood in the context of action and goal-directed movements. For phenomenologists, and enactivist too, our ordinary way of being in the world is primarily practical, which means that it is not only driven by practical concerns but is best described in those terms too (Gallagher and Zahavi, 2008, p. 153). The preoccupation with the “lifeworld,” i.e., with the daily, bodily, pre-theoretical world of experience, is there in Husserl, Heidegger, and Merleau-Ponty, and it aims to describe human experience as it is lived, that is, in terms of the actions and movements that having a body allows. But agency cannot be understood as linked exclusively with practical goals or given in intentional action. A phenomenological understanding of agency distinguishes between “an experiential sense of agency” and “an attribution of agency” that can be made when one is asked about one’s own actions (Gallagher and Zahavi, 2008, p. 160). The former is precisely a bodily-given sense of agency and is more basic than the latter, which depends on it. It combines a bodily given kinaesthetic experience of movement and a sense of control of one’s own actions. The lived body is, according to Husserl, originally given in the awareness that I can move, although this awareness often remains implicit (Husserl, 1989, see also Taipale, 2014, p. 43). More specifically, Husserl (1989) describes our awareness of our own bodies as a field

of sensing (*Empfindnisse*) whose role is to constitute our perceived body as our own. As commentators have noted, “Husserl rarely invented new terms, so this shows he was struggling to express something not captured in ordinary language. The term appears to bring together two other terms: *sensation* (*Empfindung*) and *lived experience* (*Erlebnis*)” (Moran and Cohen, 2012, p. 299). Sensings (*Empfindnisse*) are sensations in their immediate manifestation to the lived body (Husserl, 1989, Taipale, p. 44) but which also “communicate further some other object” (Moran and Cohen, p. 299). Thus, for example, seeing the blue of the sky is a way of “living-through” the experience of blueness and, at the same time, acknowledging the perceived object: the color of the sky as blue⁷.

This is best demonstrated on the example of the sense of touch. On the one hand, touch, as shown by David Katz, an experimental psychologist, uniquely among the senses utilizes agency, as when with our hands we produce the various tactile qualities that we experience (Katz, 1989, p. 242). Thus, Husserl maintains that active touch is critical for the very experience of having a body; the felt body (*Leib*) is “constituted originally only in tactuality” (Husserl, 1989, p. 158). On the other hand, touch also allows for experiential duality: sensing is doubled in touch, as it allows the experience of touching and being touched in the same act of experience (Husserl, 1989, pp. 153, 155; see also Taipale, 2014, p. 48). Uniquely, in the sense of touch, Husserl claims, I can produce a sensation by moving and also localize it in my own body, i.e., I can touch myself touching in a way that I can never see myself seeing. This also makes possible the experience of the dual nature of the body – as both subject and object, a state of affairs that further allows us to understand sociality as a kind of bodily intersubjectivity (Husserl, 1989, p. 311). Kinaesthesia, on the other hand, does not constitute a separate field of sensing for Husserl because the sensation and the sensing cannot be separated. As Taipale (p. 29) says, “the kinaesthetically sensed is nothing other than the kinaesthetic sensing itself.”

As already noted, in phenomenology an implicit awareness of one’s body and of its motility constitutes a basic sense of agency, summarized in the Husserlian unproblematic “I can move” (Husserl, 1989). Before anything else the lived body is the expression of this original capacity for motility, which accompanies all feelings and sensations given within the somaesthetic field of experiences and is manifested in the non-purposive movements of stretching, breathing, yawning,

⁷It is thus very important here to differentiate a phenomenological, and particularly Husserlian, understanding of “sensation” from a more traditional and widely used in psychology notion. For Husserl sensation constitutes the incarnate relation of the self with the world, while for psychology, especially as criticized by ecological psychology researchers, it is a momentary, and “anatomically specific product of sensory receptor stimulation” (Heft, this issue, see also Turvey, 2019). Enactivism, as we show below, follows the Husserlian tradition in its insistence on the necessity of both a dynamic sensorimotor account of perception and a phenomenological account of bodily consciousness (Thompson, 2007). There are important differences in how sensations are treated in enactivism and ecological psychology, respectively, and our article focuses on one element of this issue, namely, the role of felt bodily experience in agency. As raised by one reviewer, the broader issue of sensations deserves further analysis, and the article by Harry Heft (this issue) is a very good starting point for such a debate.

or running. These are movements that can be passive or pre-intentional, or simply involuntary and reflexive, such as twitching, but are nevertheless always experienced as one's own. As commentators have noted, with respect to what is meant by "kinaesthetic," "Husserl is not referring to the physiological movements of the body (the physical range of movements of which the body is capable) but rather our first-person experiential sense of the moving of our eyes, tilting and turning the head, looking up or down and so on, especially in so far as these movements are *freely* undertaken" (Moran and Cohen, 2012, p. 181). When it comes to perceiving and acting in the world, this kinaesthetic experience, accompanying everything that one does, is not merely secondary to the given perceptual object. On the contrary, it is what makes possible the very constitution of the perceived world (Husserl, 1989). What is crucial in this context, as already discussed, is to acknowledge the fact that Husserl speaks of the mutual codependency existing between the world and the lived body that perceives it. In the words of Dan Zahavi, "we are aware of perceptual objects by being aware of our own body and how the two interact, that is, we cannot perceive physical objects without having an accompanying self-awareness, be it thematic or unthematic" (Zahavi, 2002, p. 18). So, while the reciprocity of subject/world relations is clearly evident here, as it is in ecological psychology, what seems emphasized in Husserl is precisely the bodily experience of the subject.

Husserl is preoccupied with the lived body as both an active doer involved in intentional acts and as a subject that is pre-reflectively or reflectively aware of itself. Depending on the type of movement it performs, the body is more or less present to awareness. Thus, everyday activities such as walking or eating are practiced without explicit awareness, and so are habitual actions or practical skills, such as writing or playing an instrument with fluency. These acquired capacities for movement are agentive but not to the same extent as when one is first learning to drive, for example. Thus, as other phenomenologists have also discussed, the body recedes in experience and attention moves toward the objects of perception. The agency of the body thus becomes experientially absent, or, as Husserl would call it, "passively active," "an unthematized substratum from which the world is acted upon" (Leder, 1990, p. 19). But this *anonymity* or transparency of the body is not to be interpreted as the absence of agency, or the lack of bodily self-awareness. It is, rather, a different mode of agency and self-awareness, a *body schematic awareness* (Merleau-Ponty, 2002), or *operative intentionality*, a term used initially by Husserl but also adopted by Merleau-Ponty. The important point to be made here is that any form of agency is supported and ultimately made possible by a constantly present bodily-given experience, realized in the ability to move. In the context of this, we agree with Sheets-Johnstone's (1999) assessment that Merleau-Ponty in his use of *operative* or *motor intentionality* neglects Husserl's emphasis on the qualitative character of self-movement, i.e., on the quintessential role of "kinesthesia," and prefers to think of movement as "a way of access" to the world (p. 243). According to Sheets-Johnstone, bodily intentionality, defined only in terms of a pragmatically given activity, cannot be a necessary or sufficient basis for embodied agency. We believe that enactivism does take this

suggestion on board, when it comes to its proposals as to what constitutes agency.

It is fair to say that the question of agency represents a foundational and definitional concept for enactivism, both in the early work of Varela et al. (1991) and in subsequent developments (Thompson, 2005, 2007; Barandiaran et al., 2009; Buhrmann and Di Paolo, 2015; Stapleton and Froese, 2016). Agency, in the enactive approach, is defined under three main topics: *self-individuation* (*autonomy*), *interactional asymmetry*, and *normativity*. As a feature of agency, *autonomy* points out to the fact that enactivism defines only living beings as cognitive systems⁸. As Thompson describes it, "living structures are ontologically emergent with respect to mere physical structures. They constitute a new order of nature that is qualitatively distinct from the merely physical order" (Thompson, 2007, p. 75). Living beings are thus "autonomous selves," which are "not merely self-maintaining, like a candle-flame," they are also self-producing, "including an active . . . boundary that demarcates inside from outside and actively regulates interaction with the environment" (p. 64). Such a formulation does not mean that an organism is understood as detached from its environment but that the interactions with the environment are seen to serve the purpose of the organism's own self-individuation. Enactivist have borrowed a phrase from the philosopher Jonas (1966) to describe precisely the nature of that self-sustaining relationship with the environment: *needful freedom* (Di Paolo et al., 2010, p. 38). "Needful" explains the organism's dependence on the environment for its sustainability, while "freedom" expresses its agentive autonomy in this very process. The enactive approach and phenomenology can be seen to converge on the issue of autonomy or self-individuation, despite the more encompassing level of description provided by enactivism. Autonomy is a fundamental characteristic of biological life, expressible through the capabilities of the lived body. Hence, agency in enactivism is clearly understood as being reliant on biological embodiment: "a genuine agent is biologically embodied" (Stapleton and Froese, 2016, p. 113), but it includes a conceptual shift toward a teleology of sense-making, of "enacting a world of significance and valence" (Thompson, 2007, p. 158) for an individual. Autonomy can be seen then as suggesting a strongly embodied sense of agency and an explicit sense of subjectivity, which puts its proponents firmly in the phenomenological camp. At the same time it allows for a discussion of biological, yet non-human, kinds of agency under

⁸From what has been said so far it should be evident that enactivism in the form discussed here is not to be equated with existing formulations by philosophers and cognitive scientists of what has been termed "extended cognition" (Clark, 1997; Clark and Chalmers, 1998). This position is most simply described as the belief that the environment and its resources can, under certain conditions, be considered as legitimate constituents of cognitive processes. In this view, cognitive processes are understood as functional and can be realized on human brains or any other "thinking" devices. As Chemero and K  ufer (2016) note, "the hypothesis of extended cognition is a natural corollary of philosophical functionalism" (p. 56). It needs to be pointed out, however, that with its emphasis on experience, enactivism is not a theory that can embrace philosophical functionalism in any form. The co-constitution of body and world, as defined by Di Paolo, Thompson, and other enactivists, does not entail that objects outside the biological body are parts of the cognizing organism. Thus, the relational character of the cognitive processes is not taken to presuppose any kind of ontological claim about the boundaries of the mind.

the same umbrella, thus grounding human subjectivity in more basic forms of life and organic development⁹. Living organisms thus achieve autonomy through a precarious dependence on a world that is always experienced as value-laden for them. When the world is experienced as changed or deficient in some way, an organism can be seen to be in danger of losing its self-maintaining function, i.e., its autonomy, unless it adjusts its relationship with the environment in some way. It can be shown, therefore, that autonomy, thus understood, plays a crucial role in theoretical and practical work in, for example, psychopathology and bioethics. Treatment of patients as autonomous beings, and not as a set of symptoms, or considering psychiatric illnesses within their social and cultural contexts, are explicit attempts to think of patient autonomy in enactivist terms, i.e., in terms of a heterogeneously understood and phenomenologically grounded accounts of agency (for representative treatments, see Ratcliffe, 2008; Fuchs, 2010).

Another important distinction in the enactivist understanding of agency is *interactional asymmetry*. This notion describes the fact that organisms do things, they explore and perform with some regularity, and do not merely react to the world. “[F]or agency it is not sufficient for an individual system to just be a moving system, nor to merely be in interaction with the environment or other systems” (Stapleton and Froese, 2016, p. 118). It is the agent that drives the interaction, and it is the living, perceiving, and acting organism that at all times balances an openness to the environment with an agential relation to it. The key issue here is that agency is seen as regulated by the agent and not as a passive response. Furthermore, the enactive theory of participatory sense-making shows that both this openness and this agency are intersubjectively achieved (De Jaegher and Di Paolo, 2007). Participatory sense-making thus explains how regulating one’s relation to the environment often is a matter of joint endeavor involving other agents. Sense-makers in interaction can then be seen to navigate two orders: that of their own agency and that of the interactive order itself (Popova and Cuffari, 2018). In this view, social interactions are seen as co-regulated processes between autonomous agents whereby relational dynamical patterns acquire their own autonomy (De Jaegher and Di Paolo, 2007, p. 493).

Finally, *normativity* in enactivism describes “the biological norms that guide adaptive behavior” (Stapleton and Froese, 2016, p. 119). This notion concerns the fact that organisms can either succeed in their dealings with the world or fail. Normativity thus expresses the need to acknowledge that there exists an optimal level of engagement between an organism and its world, one that the organism as an agent seeks but also, at times, fails to achieve. Normativity is fundamentally understood as a biological norm that guides adaptive behavior (Stapleton and Froese, 2016, p. 119)

but can be seen to be operative in the form of values in not strictly biological terms, but, more specifically, in affective terms and at socio-cultural levels (see Colombetti, 2010). With this notion the enactivists come closest to a phenomenological sense of felt embodiment and to a Husserlian bodily subjectivity. Although often expressed in the language of adaptive dynamics, and norms geared toward some biological advantage, normativity should not be understood in strictly physiological terms but as a step toward a self-felt subjectivity.

It can be argued that with the notion of the interaction asymmetry enactivists can be seen to address the criticism voiced by Sheets-Johnstone toward Merleau-Ponty. An organism’s agency (both pragmatically and kinaesthetically available) is given a certain priority in relation to this organism’s own goals or norms and this is revealed in experience. As far as the authors of the present article could gather, this kind of experience of one’s own felt movement rarely features in the dynamical models of perception within ecological psychology, perhaps due to Gibson’s legacy described above.

We have already argued that an understanding of experience as “purely relational” in Jamesian radical empiricism gave Gibson’s ecological psychology the impetus to consider the relational aspect of organism/world engagement as primary. As Heft points out in his chapter on William James’s radical empiricism as a foundation for ecological psychology, “this analysis of the multiplicity of potential structures in pure experience, and of the selective function of knowing as the process by which some of these structures are realized, establishes the basis for James’s philosophy of radical empiricism as an alternative to metaphysical dualism” (Heft, 2001, p. 30). James’s understanding of the relation between the perceiver and the world embraced a kind of “phenomenal monism” (Edie, 1970), which, in turn, supports the pluralistic nature of “orders of reality.” This is a strong fundament on which the research program of ecological psychology is built.

Recognizing the richness of experience, its dependency on self-generated activity, and, most importantly, its relational character allowed ecological psychology to reach a deep and nuanced understanding of the embodied nature of cognition that mainstream cognitive science is still struggling to achieve. Moreover, the radical empiricist acceptance of direct perception of relations allowed for discoveries of complex relational variables that directly control our actions (Lee, 1976) and the unprecedented development of ecologically valid models of behaviors (see, e.g., Haken et al., 1985; Warren et al., 2001; Turvey and Carello, 2011), including behaviors in relation to brain activity (e.g., Jirsa et al., 1998; Kelso et al., 2013). The dynamical structures underlying action control are being uncovered, with due attention both to self-generated movement and to the affording character of the environment. Combined with dynamical systems tools for modeling behavior, this approach is presently advancing as one of the very promising scientific alternatives to the information processing approach in the cognitive sciences. Its strength lies both in a coherent theoretical background and in highly developed methods for dealing with complexity of the relational nature between an active body and the rich structures of the environment.

⁹As some theorists have claimed, some of the foundations of the enactive theory of agency can be traced to Maturana and Varela’s (1987) work on the biological roots of cognition and particularly to the concept of *autopoiesis*. The latter literally means “self-creation,” and describes a form of organization of the living system, the most minimal of which is the living cell, that is both self-sustaining and self-generating. It has led, however, to some disagreements regarding the equivalence of autopoietic, living, and cognitive systems (Thompson and Stapleton, 2009; Froese and Di Paolo, 2011), which so far remain unresolved.

However, the same clearly expressed Jamesian provenance does not present itself readily when it comes to ecological psychology's approach to felt experience as a basis for agency. As already noted, it seems that not all, often crucial, threads present in James's account and later picked up by phenomenologists (see, e.g., Edie, 1970) are also present in Gibson's work. For James, embodiment seems to be the origin of the multiplicity of experiences, including both the functionally oriented origin of physical activity, relating the changes in the environment to the experienced changes in the body and, at least with equal validity, the self-identifying "nucleus of our personal identity" (James, 1890, I, p. 341), "the fons et origo of all reality" (II, p. 296). The latter constitutes one of the aspects that was later developed in the philosophy of Husserl, Sartre, or Merleau-Ponty (Edie, 1970, p. 515). This richness does not seem to be fully reflected in the Gibsonian approach, where the emphasis on action in the world turned researchers' attention to this outward function of bodily experience. Gibson recognizes the importance of proprioception (Gibson, 1966; Hamilton, 2013), but it is treated primarily as knowledge of body position and movement, to which the other senses can be related, and less as the reflection of a bodily-experienced selfhood.

These distinct ways the body is known will determine the way agency is understood. For James the origins of activity are in the experiences of the body: we experience the environment through our bodies and also experience our bodies through the environment (Heft, 2001, p. 55). The experience of motion provides the feeling of ownership present in all self-initiated action. It is this experience that, as Heft rightly notes, "was laying some groundwork for the significant philosophical analyses of later philosophers such as Merleau-Ponty" (Heft, 2001, pp. 55–56). This central self, the "self of selves," as James called it, is to be found on empirical grounds and can be identified with the movements of the body (Heft, 2001, p. 56), envisaged as an intra-specific flow of bodily events, not with the body as perceived. This leads to experience being understood as consisting of the relation between two different dynamic dimensions that contribute to the ongoing stream of experience in James. One is the intra-specific flow of bodily events that we identify with the self, and the other is extra-specific flow of environmental features as we move through the world (Heft, 2001, pp. 56–57). Such a source of body knowledge is distinct from just knowing the optic flow caused by one's own body movement (sweeping and wheeling of the field) or from specifying one's own body as occluding edges (persistent features in the field of view), as we see later in Gibson.

Following James's understanding of "pure experience" as neither subjective nor objective, it is possible to trace back Gibson's definition of affordances to a congruent conception, expressing the implication of the perceiver in the very act of perceiving. To the extent that the lived body is seen as complicit in the act of perception and action in the world, the theory of affordances bears certain similarity to a phenomenological understanding of the body. But this is the phenomenology of action and behavior, of tool usage and pragmatic living, not the phenomenology of bodily selfhood, of pre-reflective embodiment and implicit, intransitive (passive) experience of bodily self-awareness. Agency in ecological psychology is thus

understood in the context of this more pragmatic sense of embodiment, in relation to undertaken action.

In the context of our discussion of agency, it is helpful to mention Sheets-Johnstone's critique of Gibson, specifically in relation to the notion of agency. She argues that "he transforms the phenomenon of movement into a phenomenon enmeshed in the global phenomenon of 'perceptual affordances'" (Sheets-Johnstone, 1999, p. 235). Movement (kinaesthesia) does not constitute a perceptual system for Gibson, the way the other five senses do, and therefore remains purely instrumental to them. For him movement is only the way we possess of "picking up information" that is there in the environment, not an experiential aspect of bodily existence (Gibson, 1979, p. 238, quoted in Sheets-Johnstone, 1999, p. 235). Ultimately, for Sheets-Johnstone, because Gibson chooses to focus exclusively on the five senses, and not on proprioception or kinaesthesia, he restricts his account of perception. Interestingly, Sheets-Johnstone sees the commonly observed focus on the environment that many commentators have pointed in Gibson's work as stemming directly from his preoccupation with the senses, with "what we see, hear, smell, taste, and touch," rather than with the living organism itself (Sheets-Johnstone, 1999, p. 236). Therefore he completely misses an opportunity to describe "the affordant kinetic power of the organism" as a system in its own right. The phenomenon of movement, that is, of self-movement, "as a phenomenon in its own right is elided" (p. 236). As she claims, "movement is something both more and other than instrumental, and . . . kinesthesia may afford something both more and other than information" (p. 238). Consequently, Thelen and Smith have later argued that "movement must itself be considered a perceptual system" (Thelen and Smith, 1994, p. 193). The kinesthetic experience is experience on its own right, at the core of constituting the agent (Sheets-Johnstone, 1999, p. 119).

To be sure, agency is one of the key notions for ecological psychology: grounding perception in self-controlled activity in the world has successfully changed the perspective not only in research on perception but in cognition in general. As Edward Reed notices, Eleanor Gibson lists agency as "the core phenomenon for psychology to explain" (Reed, 1996, p. 12), linking it to the key issues of autonomy and control. Yet the aspects of agency are analyzed here mainly as a capacity for action and defined in the context of actions' properties: prospectivity, retrospectivity, and flexibility (Gibson, 1994; Reed, 1996; Turvey, 2019, p. 305). Even though the importance of spontaneous motion is recognized, especially for development of adaptive action (Turvey, 2019), it is discussed in terms of muscle activity, rather than felt motion. Edward Reed echoes Eleanor Gibson's emphasis on the centrality of the notion of agency, which allows the organism to use opportunities for action rather than being fully determined by external causes: "The goal of ecological psychology is to *explain* the agency scientifically, not to explain it away, or to simply offer a discourse about it" (Reed, 1996, p. 19). But perhaps the stress on the "scientific" might have reduced the perceived explanatory potential of the felt, subjective, bodily experience, which rarely enters the theories of ecological psychology, despite Reed's evident quest for the opposite (Reed, 1997). The question remains, however:

Would involving bodily experiences, including kinesthetic self-perception, indeed make the explanation less scientific?

The aspects of agency important for the enactive approach described above, i.e., autonomy, interactional asymmetry, and normativity, would require recognizing self-felt experience, as they build not only on situated action but also crucially involve bodily experience of self and self-felt motion. Perhaps it is the lack of relating the perception-for-action in ecological psychology to the Jamesian stream of felt experience that diminishes the theoretical value of autonomy and asymmetry in the approach. Those aspects of agency that are set in inner experiential terms do not seem to be clearly defined. Agency of an organism, a basic premise for the ecological approach, on which natural selection and generic activity in the world are based, appears to be constituted more by environmental energy constraints than a drive, or a need, for self-maintenance. It can be argued that Varela et al. (1991, p. 203) were at least partly right when they criticized the ecological approach for not giving enough attention to how structural autonomy of an organism arises. It seems that only such structural autonomies can have experiences in the first place. Gibson explicitly said that he strives to build a psychology of values rather than a psychology of the stimulus (Hodges and Baron, 1992; Hodges, 2007) and understood values as ingrained in the perceptual fields of the organisms, indeed as directly perceived and guiding actions [see, e.g., fields of values in driving (Gibson and Crooks, 1938)]. It is difficult to see, however, how such experience of values could be based on picking up relations in the environment, even if such relations would include perceptions of one's own movement when this movement is devoid of what Sheets-Johnstone calls the "ongoingness of primal kinetic liveliness" (p. 212).

It has been our aim in this article, through pointing out differences in conceptual understanding of the two frameworks, to argue not for a neat division of labor along existing lines, but for an integration of methodologies and mutual enrichment. From the discussion it should be evident that the ancestry of the two frameworks, respectively, the work of James and Husserl, had a lot of commonalities. Later developments, as shown in Gibson's writings and the work of early enactivism, appeared to move away from each other, with different emphases and quite distinct research trajectories. Perhaps only now, with the later generations of both ecological psychologists and enactivists, we can observe not only a growing and far-reaching mutual interest, but an increased scope for compatibility, to which the current issue is a testament. Two good examples of the feasibility of this aim already exist, evidenced in the two steps toward each other made by an ecological psychologist and an enactivist, respectively.

The first is an attempt by a prominent ecological psychologist to capture felt experience and relate it to the origins of agency. Kelso (2002) laid the conceptual grounds and later developed a concrete dynamical model of activity in a baby-mobile paradigm setting (Kelso and Fuchs, 2016). The model is based on a phase-locking synchrony, relating self-generated and self-felt movement to the perceived movement of the objects in the environment. It is these dynamical couplings that become relevant or meaningful and not just the relational variables in the environment *per se*. The systemic landscape for such couplings is usually multi-stable,

with several possible coordinations, which can be selected according to tasks or other factors. The model is briefly described below in our analysis of agency in social coordination.

On the enactivist side, Ezequiel di Paolo and colleagues extend the work on sensorimotor contingencies (e.g., Nöe, 2004) to account for agency (Buhrmann and Di Paolo, 2015). The account is closely related to ecological psychology's non-representational approach to perception as based on "skillful use of the regularities governing active exploration of the world." Experience of oneself as an agent "derives from the ways in which we establish, lose, and re-establish meaningful interactions between ourselves and our environment." This depends on a skillful control of the sensorimotor contingencies. Recognizing this relational nature of agency opens the way to ecological-psychology-like analyses of the structure of the environment in relation to structures of experience, with the self-felt bodily experience as an indispensable part of it. The dynamical systems tools, used and developed within ecological psychology to deal with complexities of multi-relational structures in terms of their global-local, multi-stable dynamics, are acknowledged as especially useful by the authors. This unlocks the way to identifying the dimensions of the contingencies, which themselves might be relational and non-obvious, thus opening the approach to the richness of structure present in the environment and within the organism/environment system.

In the next two sections we present two examples of domains in which we can observe the relative usefulness and potential integration of theoretical and methodological resources from the two approaches.

SOCIAL AFFORDANCES AND SOCIAL AGENCY IN EARLY INTERACTIONS

Neither enactivism nor ecological psychology at their beginnings took account of the social reality that humans are constituted within. For ecological psychology the interest concerned mainly the social nature of artifacts (see, e.g., Costall, 1995) and socially constructed environments (Reed, 1995, 1996), with a stronger acknowledgment of the active, engaging nature of the social realm in which actions of humans take place in the work of Hodges and Baron (1992), where they flesh out Gibson's understanding of affordances in terms of values. Perceiving and acting upon affordances was considered a value-realizing activity, which was illustrated in situations of social interaction. The abovementioned work by Heft (1989), which linked the notion of affordances to intentionality, opened interesting avenues for accounting for social interaction. In the empirical work within ecological psychology, social factors were considered in how social situations change affordances (Marsh et al., 2009), and how other people's behaviors can be treated as opportunities for interaction (Valenti and Gold, 1991; Rączaszek-Leonardi et al., 2013). In enactivism, the crucial value of the social came with the notion of participatory sense making (De Jaegher and Di Paolo, 2007), although social concerns have always been a prominent part of phenomenology, commencing with the notion of *intersubjectivity* in Husserl.

The importance of the social realm is perhaps most evident while researching developmental processes. From an ecological perspective, developmental processes are understood as the tuning of the infants' perception to the important information in the environment, which is dependent on the activity of an infant. One quickly realizes that the infants' surroundings consist predominantly of other people in interaction with a child, constituting a kind of reliable and highly structured "social physics" (Rączaszek-Leonardi et al., 2018). Unlike the physical world, though, the actions of others most often engage the infant as a vital actor within the events.

Drawing on ecological psychology and especially its later developments, mentioned above, which linked perception of affordances to intentional action, researchers have shown how a social agent develops, tuning to the perception of social affordances (Rączaszek-Leonardi et al., 2013). It has been shown how the sensitivities of the child can be shaped, in a sense, "movement first." On the one hand, almost every action performed with a child is an enaction of an interactive event, in which an infant is given a particular role that has to be filled with a particular action (e.g., smile) at a particular place of a sequence (e.g., after a gaze at an infant and calling her name), and with particular timing (otherwise repetitions and repairs follow). This way, infants learn that the particular movements of others are affordances for their own actions. On the other hand, infants' spontaneous actions can become affordances, in the sense of being parts of an intentional act, also "movement first," without developing "theories of mind" or other complex representational schemas. This happens when a random movement of a child is picked up by a caregiver and enveloped as an element of a sensible interactive event. Reliable enaction of such causal structures around infants makes them agents, who, with time, realize that their own movements afford actions for others. This is a story told within the ecological approach, showing how others' movements become affordances for a baby and how baby's own movements become affordances for others. It shows the dependency of perception on action and the immersion of action in socially reenacted intentional episodes, which give them meaning. Yet it seems that something is missing in the transition from merely perceiving contingencies of infant's own movements with those of others to becoming an agent, realizing the affordances-creating potential of one's own behavior.

It seems crucial for the development of agency in such situations that it is shaped not only by immersing an infant in structured interactive episodes, but that this structure is related to the felt experience of the moving body. Those are infant's own movements, not abstract behaviors, that are embedded, enveloped by enactments of con-specifics, and thus this felt experience of the body can enter in relation with the perceived movements of the infant's body and of the movements of others. The caregivers respond to the spontaneous movements of the baby with "the other part of the story," or they demand a particular activity, co-creating sensible episodes with the child, which then leads to educating perception in purposeful intersubjectivity, but the foundational kinesthetic perceptual consciousness never ceases to underlie them. It should be mentioned that such education of movement and perception is

not only instrumental: this would be underappreciating the kinds of constraints that are passed in the infant-caregiver enactions. The structures of events are such that the joint dynamics of acting bodies become not only functional or efficient but, above all, preserving crucial values for co-existence and co-action, such as mutual respect and relative agency in a situation (Rączaszek-Leonardi and Nomikou, 2015). These seem especially strongly guarded by the felt bodily experiences, the kinesthetic feelings in relation to unfolding events, and these, in turn, can be experienced as feelings of connection and joy, disconnection and despair, surprise, awkwardness, adequacy. These are felt experiences that can well become crucial parameters, e.g., in explaining the timings and intensities of joint enactions and, therefore, in guiding agents' behaviors.

As already mentioned above, this kind of experience of one's own felt movement is usually absent from dynamical models of perception within ecological psychology. Recent attempts, however, seem to capture them within a precise mathematical model of empirically studied phenomena (Kelso and Fuchs, 2016). In the model, agency is seen as emerging from spontaneous activity, movement first, relating in self-organized couplings both the internal feelings of one's own bodily movements, the perceived self-movements, and contingent movements in the environment. In this complex relation "we discover ourselves in movement" (Kelso, 2002, after Sheets-Johnstone), see ourselves as agents, capable of effectuating the changes. "[T]he sense of self emerges as an explicitly *collective effect*" (Kelso and Fuchs, 2016, p. 51), spanning the infant and the movement of objects in the environment. Coordinative dynamics drives patterns of coordination, following the general pattern-formation principles in nature. This can be modeled by a system of differential equations relating in a bidirectional, informational way the oscillatory movement of the infant to the oscillatory movement of, in this case, a baby mobile. The thing that seems crucial and that opens the possibility for the felt motion to impinge on the resulting dynamics is that the coupling between the two oscillatory movements depends on a parameter, which seems to relate the mobile salient motion to both kinesthetic information from leg movement and haptic information from the baby's body. Kelso calls the parameter attentional ("baby's attention to self-generated movements and the kinesthetic, visual and auditory consequences they produce," p. 51) but it is crucial that the attention relates what is the sensed experience of the moving body to the body as perceived (haptic information), and to the movement in the environment. A critical value of this parameter leads to the "eureka" effect, a discovery that it is "I" who makes the mobile move. What is shown in other experiments is that the sense of one's own body movement is crucial for the couplings to emerge, while the haptic information is less so. The coordination of the felt, experienced, movements of the baby and the movements of the mobile that are in a co-regulating positive-feedback loop leads to the emergence of agency, in which the baby, within several minutes, discovers the effects of the kicks and triples their frequency with visible delight.

Returning to the early interaction situation, the picture of learning to perceive and act upon social affordances "movement first" is enriched by noting that these are one's own felt

movements that are met with the enactions of caregivers. This feeling of movement becomes enfolded in an enacted project. In social situations we thus learn not only how our body should move in a given point of a social event, we learn how our body should feel in such movements. As Sheets-Johnstone has argued, movement comes before behavior: a behavior (instrumental) is “a kinetic episode that we, as adults, partition off from the global phenomenon of animation” (1999, p. 212), while what is constitutive to our conscious self is the “ongoingness of primal kinetic liveliness,” which leads to a “foundational kinesthetic perceptual consciousness.”

Shaping the infant's perception for social interaction thus in a sense relies on the baby having particular bodily kinesthetic experiences, and makes them social through relating them to enacted events. This felt kinaesthesia in enaction with others provides for the emergence of the baby as a social agent: the infant not only feels that she moves and how this feels but also that she becomes a mover, also in connection to the inner feelings. Lived bodily experience thus gives access to the direct feeling of the valence of a particular engagement with the world, which one's own perceptions of external events only does not provide.

AFFORDANCES, AGENCY, ART

There is an area of profound and significant human experience that lies beyond the perception/action cycles, as described in ecological psychology. This is the area of art production and reception. In the brief space we have here we will only suggest some ways in which enactivism can be seen as being able to enrich ecological psychology in the study of this irreplaceable aspect of human life. When speaking about art, we will not be providing a definition of art, a consensus on which is still forthcoming after centuries of discussions, and talk instead of “artful practices” that include a broad spectrum of activities, such as dance, theater, painting, sculpture, video installations, and the like. In a similar vein, the study of aesthetics has grappled with the question of what is the essence of all things we call “beautiful,” without much agreement, and this discussion will not detain us here. It is sufficient to mention that Alexander Baumgarten introduced the term *aesthetics* as early as 1735, and defined it to mean “a science of how things are to be known by means of the senses” (*scientiam sensitive quid cognoscendi*) (quoted in Guyter, 2004, p. 15). Aesthetics is then a scientific study of sense perception in relation to the fine arts and other objects of beauty, and, importantly, it provides knowledge that is understood to be both thought and felt. Another way to say this is to acknowledge that aesthetic reception is undoubtedly “a refined and intensified form of experience,” as Dewey (1934) has claimed. Indeed, aesthetic reception is about perceiving the world and its objects, but it is nevertheless a particular kind of perceptual process. We have argued that ecological psychology and Gibson's notion of *affordances* describes perception in terms of action and everyday engagements with the environment. Yet, practical interests in an object do not exhaust our ways of engagement with it. Art objects, whether they are pictures, sculptures, installations, or dance performances, are unique. While the act of looking at

a painting, for example, with its specific processes of moving the eyes, fixating and focusing them, and the repetition of these processes, might be compared with how we look at an object in the world, the aesthetic artifact remains somehow an autonomous and alien entity, removed from the ordinary world, and able to produce a distinct experience that nevertheless brings us back to the world. For Dewey works of art are not objects or events designed for observation but, rather, “the actual work of art is what the [art] product does for experience” (Dewey, 1934, p. 9). In both making and engaging with art works, Dewey says, “we are carried out beyond ourselves to find ourselves” (p. 199).

The uniqueness of the art object or art practice can be described in at least two ways. First, in the terminology of Russian formalism, they contribute to “defamiliarization” of everyday experience: they work against habituation to uncover forgotten, sensory aspects of “being in the world.” As Victor Shklovsky, one of the main theoreticians in this area, has put it: “[t]he technique of art is to make objects ‘unfamiliar,’ to make forms difficult, to increase the difficulty and length of perception because the process of perception is an aesthetic end in itself and must be prolonged” (Schklovsky, 1917, p. 12). The operative word here is “ostranenie,” or “making strange” precisely that which appears ordinary in experience. Second, as described by Bence Nanay, a philosopher of perception, art objects require a distributed form of attention: because the aesthetic object and event is removed from everyday experience (i.e., is perceived as framed differently), we are both focused on the object and paying attention to everything that this object is or, potentially, can be (Nanay, 2016, pp. 24–25). Importantly, in both these descriptions, subjective experience underlies the process of aesthetic reception. On the side of production, art is commonly associated with strong expressions of subjectivity. As a receiver of art one also experiences a strong sense of being an agent who feels the “strangeness” of the given art form at the same time as trying to make sense of it.

The concept of affordances has been used on a few occasions to describe human engagement with architectural design and even art objects. For example, Withagen et al. (2012) argue against the view that “affordances are mere action possibilities” and propose instead that affordances are understood as potential invitations for actions, providing examples from industrial design and architecture. Baron et al. (2008) offers a new term, *tentativeness*, which describes a shift toward a more active and participatory way of engaging with particular examples of visual art, sculpture, and architecture. This is a solid argument against automaticity in perception and for a more bodily response to art that is by its very nature inviting not just visual but also kinesthetic reception, such as Serra's sculptures and the architecture of Arakawa and Gin. Kadar and Effken (2008) use paintings by Cézanne and Hokusai to show how active participatory perception can be enhanced by the use of particular drawing techniques. They argue that classic linear perspective relies on static and passive perception on the part of the viewer, while Chinese (parallel) perspective mirrors somewhat the dynamics inherent in visual perception. Similarly, they argue that Cézanne uses visual distortion in both still lifes and landscapes, thus aiming to enhance the affordance structure of the painted objects. These are valuable

contributions linking visual perceptual knowledge with certain aesthetic values, and with questions about how sense-making of pictorial artifacts happens. The suggestion that the point of view in the visual arts can be understood as an affordance for the viewer is not, however, unique to ecological psychology and has been proposed as a comprehensive relation between the viewer and particular developments in the history of Western visual art by, for example, art psychologist Ciaran Benson. Thus, a medieval artwork presents a flat pictorial space that does not require a particular perspective, while the geometry of linear perspective used in the Renaissance requires a particular “entry point” into the work (see Benson, 2001). This particular point of view becomes significant and often carries a symbolic meaning expressed by a particular pictorial arrangement and mirrored by the viewer’s eye. The question of the viewer’s point of view turns out to be a lot more complicated when we get to modern and experimental art, where no particular way of looking is required by the spectator, and viewing art becomes, rather, a matter of personal choice of a way of engagement. This is where the subjective experience of perception, with no specific, pre-defined point of entry or even way of interaction with the artwork, takes the lead. A case in point is art where subjective visual perception itself (how I experience myself seeing) becomes the object of artistic presentation (as in the experimental work of James Turrell), as well as other kinds of art, like sculpture, physical theater, or improvisational dance, where self-felt embodiment necessarily accompanies reception.

To that extent, attempts by ecological psychologists to highlight the active and participatory perception of art objects are at best partial explanations of why certain visual properties (e.g., perception of point of view in a painting, or patterns of activity in moving through a building) constitute a part of aesthetic reception. Heft has described the relationship between an affordance and behavior as that of “fittedness and compatibility”: while affordances do not elicit behavior, they can still prompt an act (Heft, 1989, p. 10). The question that arises here is one of an alternative scenario, namely, when such “fittedness and compatibility” do not happen readily, or provide a multiplicity of options to be taken. When, in other words, an observer is faced with an object or event that they cannot comprehend immediately, after a prolonged exploration, or not at all. So, while applicable to certain aspects of visual art and architectural design, using the terminology of affordances in relation to art remains so far only an incomplete account of how we make sense of it, as it does not touch on topics such as self-movement, affectivity, or intersubjectivity in processes of art creation and reception.

With their emphasis on human experientiality and the complexity of human agency involved in art practices, enactive theories are better placed to explain not just how we perceive art but also how we experience it. There have been attempts to provide enactive accounts of reading a fictional narrative, albeit in quite distinct ways (Caracciolo, 2014; Popova, 2015; Popova and Cuffari, 2018), reading poetry (Popova, 2016), the movement-based pedagogy of Jacques Lecoq (Murphy, 2019), and of human communication broadly conceived (Di Paolo et al., 2017), to mention just some examples. A particular feature of the enactive approach to cultural forms is the heterogeneous notion of agency that is taken into account. In engaging with

art, the individual agency of the viewer, listener, or participant is balanced by an autonomous dynamic interaction with the art object that arises in the very exchange with it. As discussed, a characteristic of art works and practices is both the experience they initiate and the non-instrumental nature of the engagement they provoke, discernible in a constantly modulating sense of “being in control,” of knowing and making sense of the particular encounter. Such engagement is normative and asymmetric for the viewer, yet, making sense of an art object invariably has a participatory character, which involves a distributed attentional effort (agency on the part of the experiencer) and lies outside of immediately situated space, time, and instrumentality, i.e., is detached in some way. It is also constituted intersubjectively: in art we engage not just with the object but in some way also with the creative agency of the artist, embodied, so to speak, in that particular artifact. Di Paolo (2016) has argued persuasively for “participatory object perception,” where even immediate instrumental use should be seen as secondary to a dynamic of social practices, involving those objects. As Di Paolo has described it with respect to object perception generally, but, as we see it, with potential wider applicability to art, “it is a social skill that I enact individually” (Di Paolo, 2016, p. 253). The intersubjective aspect of any form of art, given in the dual constitution of materiality (of the body, the canvas, the stone), shaped by the agency of another, and in concretization brought about by the agency of a perceiver (or participant) is particularly well-suited to enactivist treatment. The valuable lessons from ecological psychology about, for example, the spatial organization of pictorial space and active perception can only be enhanced by considerations of affectivity and experientiality that enactivism can bring to the table in discussions about art.

CONCLUSION

What can be learnt from such comparison, as we have offered, between the two frameworks under consideration and where to go from here? Perhaps it can be claimed that James’s radical empiricism played for Gibson’s ecological psychology the role that a phenomenological understanding of the body played for enactivism. Thus, for Gibson radical empiricism enabled direct perception and took away the necessity of information processing by allowing relations to be directly apprehended. For enactivists, a phenomenological understanding of the body led to a heterogeneous notion of agency that includes a felt sense of movement and bodily action, yet is consistent with a broader subjectivity linked to a defined perspective and self-generated normativity.

In the two approaches, ecological psychology differs from enactivism in how it understands cognition to be linked to the body (i.e., is embodied), namely, through a functional link to activity in a complex, structured world, rather than to the felt, qualitative self, discovered in movement. This is visible in how Gibson, for example, describes perception of self, or ego- or intero-ception, not as proprioception but as perception of one’s nose, arms, hands, torso, etc. It is an important perception for establishing relational variables, including the movement of the

subject, but it is not the same as the felt subjectivity of movement. On the other hand, enactivism differs from ecological psychology (or at least seems to be less specific about it) about what embodiment includes. As we have shown, ecological psychology carefully specifies the relational nature of the world, the rich structure, which can be directly picked up by the organism. The key point of the relational nature of the Jamesian structured and still directly experienced environment might not be capitalized on in phenomenological and thus enactive thought, and the non-obviousness (for experience and for description) of the complex relations that govern action in the lived world might thus be underappreciated. An important aspect of this might be the lack of sufficient concern for the relations the body itself enters in perception, i.e., the scope of how the body is implicated in the much criticized “information pick-up” from the world that enactivists generally describe ecological psychology to be about.

It seems that this rich relationality and careful consideration of the environmental structure could benefit immensely from including, as a backbone for all other relations, the stream of human presence, with its directly felt quality. On the part of ecological psychology this would require admitting that direct perception is also a direct access to felt kinesthesia, and the relations it enters into with both perception of one's own movement and the movements of the world. A heterogeneous notion of agency, such as has been developed in enactivism, with the notions of autonomy and asymmetry, might be beneficial for recognizing different kinds of engagements within the environment in ecological psychology. Yet, the importance of agency has to be complemented by attention to how this environment is richly structured and ubiquitously present.

For joining the efforts of the two respective fields, more is needed than an acknowledgment of an existing apparent division of labor, which would seem natural given the respective histories of the fields (Baggs and Chemero, 2018), namely, that ecological psychology takes on the identification of the complex and relational structure of the environment, and specification of its informational value and coupling to the organism, while enactivism develops an increasingly elaborate

study of kinds of human experiences and embodiment. This apparent division is not a result of “a major philosophical barrier to unification” (Baggs and Chemero, 2018), as the above discussion of the radical empiricism of William James clearly demonstrates, but stems from specific understandings of the role of embodiment in experience. Rather than continue a divide along established lines and accept specializations, what is needed, we claim, is a careful analysis that will make explicit how the two frameworks approach the relation between the contents of experience, especially experience of one's embodied self, and the kinds of embodiment and agency that an organism commands. Thus, instead of continuing with their own tasks to solve, each approach requires a push for a better awareness of their conceptual core and, if necessary, for a change in concept definitions and terminology. The key to integration, we believe, is a reconciliation of the importance of felt experience with the structured ecological information available in the environment. Despite some complementarity of efforts already in evidence, the project of integration remains a strong challenge for the future.

AUTHOR CONTRIBUTIONS

YP and JR-L contributed equally to parts introduction and conclusion. YP wrote parts enactivism and affordances, agency, art of the manuscript. JR-L wrote parts ecological psychology and social affordances and social agency in early interactions. YP wrote a substantial part of experience, embodiment, and agency in enactivism and in ecological psychology: discussion. Both authors contributed to the article and approved the submitted version.

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The Ecological-Enactive Model of Disability: Why Disability Does Not Entail Pathological Embodiment

Juan Toro^{1,2*}, Julian Kiverstein^{3,4} and Erik Rietveld^{4,5,6}

¹ Center for Subjectivity Research, Faculty of Humanities, University of Copenhagen, Copenhagen, Denmark, ² The Enactlab, Copenhagen, Denmark, ³ Amsterdam Brain and Cognition, Amsterdam, Netherlands, ⁴ Amsterdam University Medical Center, Amsterdam, Netherlands, ⁵ Department of Philosophy, University of Twente, Enschede, Netherlands, ⁶ Institute for Logic, Language and Computation, Faculty of Science, University of Amsterdam, Amsterdam, Netherlands

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Emmanuel College, United States

*Correspondence:

Juan Toro
juan.toro@hum.ku.dk

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In the last 50 years, discussions of how to understand disability have been dominated by the medical and social models. Paradoxically, both models overlook the disabled person's experience of the lived body, thus reducing the body of the disabled person to a physiological body. In this article we introduce what we call the Ecological-Enactive (EE) model of disability. The EE-model combines ideas from enactive cognitive science and ecological psychology with the aim of doing justice simultaneously to the lived experience of being disabled, and the physiological dimensions of disability. More specifically, we put the EE model to work to disentangle the concepts of disability and pathology. We locate the difference between pathological and normal forms of embodiment in the person's capacity to adapt to changes in the environment. To ensure that our discussion remains in contact with lived experience, we draw upon phenomenological interviews we have carried out with people with Cerebral Palsy.

Keywords: disability, medical model, ecological psychology, enactive cognitive science, normality, lived body, affordances, pathology

INTRODUCTION

According to the influential but widely criticized medical model, disability can be understood in terms of functional limitations of a disabled person's body caused by a clinically observable pathological condition. Disability is something to be diagnosed, treated and cured through rehabilitation or normalization (cf. Moore and Slee, 2012, p. 228). Many theorists in the field of disability studies claim however, that this conception of disability as an individual pathology is the outcome of a medicalization of physical impairments that mistakenly locates the disability within the body of the individual person taken in isolation from the social world (Oliver, 1996; Thomas, 2007; Beresford, 2012). In the last years, disability movements in the United Kingdom and North America have emphasized the social situation of disabled people and the way in which disabled people are excluded or stigmatized because of their different forms of embodiment (see McRuer, 2006; Shildrick, 2009; Davis, 2017). The social model claims that disability is not an individual physical condition, but is the outcome of "socially produced inequality and dependency" (Beauchamp-Pryor, 2012, p. 178). Disability so-conceived is a social category: a means of classifying and treating people in ways that lead to discrimination and oppression comparable to that experienced by ethnic minorities (see UPIAS, 1976; Shakespeare, 2006).

Both the medical and social models of disability are premised on concepts of embodiment that fail to adequately recognize how disabled bodies are lived bodies that have their own first-person perspective on the world. The medical model understands disability in terms of the body of the disabled person as described objectively and scientifically. At the same time this model of disability fails to recognize the lived embodiment of disabled persons¹. The social model is arguably guilty of a similar neglect of the embodied lived experience of the disabled person. In distinguishing disability from physical bodily impairment, the social model leaves in place a medicalized understanding of the disabled person's bodily impairment. The social model has good reasons for foregrounding the marginalization, exclusion and oppression of disabled people from full participation in wider society. However, such a focus threatens to eclipse attention to how the disabled person's lived experience of the world is shaped by their bodily impairment (Shakespeare, 2006; Scully, 2008; Beaudry, 2016). In line with the social model, we will question the medical model's conflation of disability with the impairment of the physical body of disabled persons. Nevertheless, unlike the social model, we do so on the basis of how the disabled person experiences the world through their embodiment in it.

We propose a model of disability which we will call *the Ecological-Enactive (EE) model of disability*, that takes into account the valuable contributions of both the medical and the social model, without being reducible to either of them. The EE model draws upon enactive cognitive science to offer an account of how a person's body can be both a *lived body* that has its own first-person perspective on a meaningful world, and at the same time a *living body* whose biological organization can be understood and explained from a third-person scientific perspective (Thompson, 2007; Di Paolo et al., 2017; Gallagher, 2017). From ecological psychology we borrow the conception of the environment as furnishing *affordances* – possibilities for action the person can make use of because of the bodily skills and abilities they have developed (Gibson, 1979; Stoffregen, 2003; Chemero, 2009; Rietveld and Kiverstein, 2014). The EE model

proposes to understand disability in terms of a person's embodied skills for responding to the affordances of their environment².

The EE model of disability aims to do justice to how a disabled person experiences the world through the medium of the lived body. At the same time the EE model aims to integrate such a first-person account of the difference in embodiment the disabled person can experience with a third person perspective on embodiment. In doing so it avoids pathologizing the disabled person's living body.

To ensure our discussion remains in contact with lived experience, we draw upon interviews and experiments we have carried out with people with Cerebral Palsy (CP). CP is an umbrella term covering “a group of disorders affecting the development of postural and motor control and occurring as a result of a non-progressive lesion in the developing central nervous system, causing activity limitation” (Bax et al., 2005; see also Rosenbaum et al., 2007). CP is an especially interesting disability for our purposes, since it disrupts the often taken for granted control a person exerts on their body. The “magic” that seems to link the person's decisions to their bodily movements is disturbed, generating in the person a different way of being-in-the-world (Merleau-Ponty, 2012).

We conducted an experiment in which people with CP interacted separately with a stranger, a relative, and a physiotherapist. They were given six simple tasks to perform: (1) shaking hands, (2) passing and receiving an empty cup, (3) passing and receiving a cup with water, (4) passing and receiving a small coin-shaped object, (5) playing patty-cakes, and (6) lifting up a tray with a cup of water on it.³ We recruited the participants in collaboration with a healthcare institute working with CP. The participants were chosen according to their location and degree of CP, so that all participants with CP ($n = 11$) had limited bodily functionality in one or both hands. The participants with CP correlated with level I to III in the gross motor classification system (GMFCS) (Palisano et al., 1997)⁴.

¹We follow Barnes (2012) in using the term ‘disabled people’ rather than ‘people with disabilities’. She writes:

“I use ‘disabled people’ rather than ‘people with disabilities’ because ‘disabled people’ mirrors our usage of other terms which pick our minority social groups – for example, we say ‘gay people’ not ‘people with gayness’. It is sometimes suggested that we should say ‘people with disabilities’ because ‘disabled people’ suggests that disability somehow defines the person. But I simply don't think that's true. Saying that someone is a disabled person doesn't mean that disability defines who they are anymore than saying that someone is a gay person means that sexuality defines who they are.”

The term ‘people with disabilities’ is often associated with the medical model. However, it should be noted this is not the case in Denmark for instance. There the disability movement has fought for the term ‘people with disabilities’, to avoid being objectified as ‘disabled’, and to call attention to the fact that the person's identity goes beyond disability. Our thanks to Jacob Nossell and Kristian Martiny for discussion of this issue.

²We assume here that enactive cognitive science and ecological psychology can be smoothly integrated (see Kiverstein and Rietveld, 2018 for an argument for this assumption). It should be noted, however, that such an integrative project is not without its conceptual tensions. In their ground-breaking work *The Embodied Mind* Varela et al. (1991) expressed doubts about the realism of Gibson's ecological psychology. They argued that Gibson's ecological theory of perception was premised on a one-sided view of the animal-environment relation. Varela et al. (1991) argued instead for a view of the animal-environment relation in terms of a structural coupling and codetermination. Ecological psychologists for their part have objected that the enactive notion of sense-making implies a view of the physicochemical environment as meaningless until it is given meaning by the agent. Enactive cognitive science from their perspective fails to do justice to the pragmatically structured environment, and the role of the environment in constraining and enabling behavior. These traditional tensions notwithstanding we pursue the possibility of a collaborative and integrative research program in this manuscript. The task of smoothing these conceptual tensions will have to await another occasion [but again see Kiverstein and Rietveld (2018) for first steps in this direction]. We focus here instead on putting such a program to work to show how to avoid pathologizing the experience of being disabled, an urgent ethical and political matter of concern.

³This experiment was designed and performed by an interdisciplinary team of researchers affiliated with the University of Copenhagen – Center for Subjectivity Research, the Technical University of Denmark, the Elsass Institute, and the Enactlab.

⁴All measurement procedures contributing to this work comply with the ethical standards of the relevant Danish committees on human experimentation and

Here, we will draw upon the phenomenological interviews we carried out with the participants following their performance of the tasks.⁵ Phenomenological interviews are second person semi-structured interviews that use open ‘how’ questions, intended to make the participants aware of specific, phenomenologically relevant aspects of their experience. We describe phenomenological interviews as “second-person” to emphasize how the interview is open-ended. The knowledge coming out of the interview is the joint product of the intersubjective interaction of the interviewer and the interviewee. Among the aspects that participants reflect on are how they experienced their own bodies, the other person, the level of difficulty of the task, and so on.⁶ In these interviews, of around 20 min each, we find that many people with CP are able to adapt to the challenges that arise in their practical engagement with the environment just as well as people that are not disabled. Not all people with CP experience a pathological form of embodiment. Disability should not be conflated with pathology. These phenomenological reports will be complemented throughout this article with reports found in the literature of disabilities and pathologies, in order to make evident important contrasts between pathological and non-pathological forms of embodiment.

Our article will be divided into six parts. In section “The Medical and Social Models of Disability” we offer a brief overview of the medical and social models of disability. We show how both models of disability risk pathologizing the embodiment of disabled persons by understanding the embodiment of the disabled person solely in terms of physical impairment. In section “The Embodiment of Disability” we provide an ecological and enactive account of the lived body in terms of the dynamics of the living body’s selective engagement with a landscape of affordances (Rietveld and Kiverstein, 2014). Section “Normal and Pathological Embodiment: Toward an Ecological-Enactive Model of Disability” puts this account to work to understand the difference between healthy or normal, and impaired or pathological forms of embodiment. We use our ecological-enactive model to question an understanding of the bodily restrictions and limitations of the disabled person in terms of impairment. In section “Pathological and Normal Embodiment in People with Cerebral Palsy” we offer contrasting reports from people with CP we take to illustrate this difference. Some of these reports, we suggest, are best interpreted as indicating pathological embodiment, while others are illustrative of how CP does not

necessarily lead to pathological embodiment. Section “Normality as optimality and the tendency toward an optimal grip” deepens our claim that a person with disabilities can nevertheless be considered to be normally embodied. Our article closes in section “How to understand the ‘dis’ in ‘disability’?” by reflecting on the question of how to understand the ‘dis’ in disability. In our article we stress what disabled people are still able to do in their everyday engagement with the world, but we in no way wish to downplay the severity of the daily challenges they face. Despite the limitations they experience in their own abilities, and their vulnerability, disabled people are often skillfully able to find a way to the affordances needed to meet these daily challenges.

THE MEDICAL AND SOCIAL MODELS OF DISABILITY

A model of disability aims on the one hand to account for what it means to be disabled, and on the other to identify the causes of disability (Silvers, 2010). A model should identify for instance why it is that a person experiences the limitations associated with disability. The medical and social models have returned competing answers to this question. The medical model has tended to emphasize biological defect and dysfunction in answering the question of what disability is. On this model the limitations disabled people experience are accounted for by reference to some biological pathology – a clinically observable impairment in bodily structure or function (Boorse, 2010). The medical model recognizes that functional limitations are dependent on a myriad of environmental factors. However, disability is understood as essentially a health problem that requires medical treatment aimed at enabling disabled persons to adjust to society⁷.

The social model by contrast understands the limitations disabled people experience in terms of their social isolation, oppression and exclusion from participation in social life. Its proponents have distinguished *impairment* as understood in the medical model as a natural, biological fact, from *disability* conceived of as an artificial social classification (see Barnes, 2012). The limitations disabled people experience are caused by

with the Helsinki Declaration of 1975, as revised in 2008. Ethics approval is not obtained for this experiment because, according to the Danish ethics committee law §2, no. 1, only health scientific research that includes biological material and clinical trials needs approval, whereas qualitative interviews and non-health scientific measurements (eye-tracking and motion capture) do not need approval. The treatment of data complied with the General Data Protection Regulation. The participants filled out a form providing informed consent, and the Elsass Institute, where the experiment took place, approved of it.

⁵We explain in detail the conceptual framework and the methodology of the experiment in Martiny et al., Unpublished.

⁶For a detailed account of the methodology and the theory behind the phenomenological interviews, see Høffding and Martiny (2016). See also de Haan et al. (2013, 2015) for an application of phenomenological interviews with OCD patients treated with Deep Brain Stimulation.

⁷Work in the philosophy of psychiatry has shown that to do justice to the complexity of mental illness will require eschewing a simple reduction of mental illness to biological dysfunction, and similar arguments could be made for disability. We thank a reviewer for this suggestion. Murphy (2006) shows for instance how a scientific psychiatry will have to make reference to many different physical, psychological, and social factors. The explanation of the causal etiology of mental illness will have to advert to many different variables – biological, psychological, and social – to account for illness symptoms. What is distinctive about a medical approach to mental illness according to Murphy is that it aims for a causal understanding of mental illness through constructing a causal model of the illness. The medical models of mental illness and disability share a view of people with mental illness as being “worse-off” in some way as a consequence of their bodily impairment. They are disadvantaged relative to the non-disabled population as a consequence of “the failure of their physiology or psychology to perform a natural function” (Murphy, 2020). The dispute between the medical and social models is thus not about the role of social and cultural factors in causing disability. It is instead about whether disabled people are intrinsically worse off because of their bodily and functional impairments. The social model denies this and claims instead that disabled people are worse off because of how society treats them (see e.g., Barnes, 2016).

factors that come from outside of the person, not from their impairment. The real problems disabled people face come from “the surrounding social, institutional, and physical environment with which persons with disabilities must deal” (Asch and Wasserman, 2006, p. 166).

We agree with the social model that it is important to disentangle impairment from disability. A model of disability should, at minimum, account for the difference between bodily impairments that are normal, and those that are disabling. Everyone is impaired with respect to some functions (Boorse, 2010). People are unable to see ultraviolet light for instance, or swim across the Pacific Ocean. These examples of limitations in a person’s abilities do not count as disabilities because they are within the range of what is considered normal. What makes the difference between an impairment that is classified as normal, and one that is agreed to be disabling of a person?

The question of what it means to be normally embodied is central to understanding disability. As Davis notes in his introduction to the *Disability Studies Reader*: “To understand the disabled body, one must return to the concept of the norm, of the normal body” (c.f. McRuer, 2006; Davis, 2017, p. 16). According to Davis, the concept of normality as we use it today has a relatively recent history. It first emerged alongside the field of statistics in the middle of the 18th century. Notions like average and standard deviation were initially applied to astronomical observations, but they were applied to the human body in the work of Adolphe Quetelet (see Canguilhem, 1991/2015, p. 154–159; Davis, 2017). By identifying the average with the normal, the physiologist could determine objectively (i.e., quantitatively) whether a specific function or parameter such as height, weight, intelligence or strength was normal or deviant. Furthermore, based on such a statistical conception of normality, a ranking could be formed from what is normal in a population to what is above or below average. Variations from what is normal can be either good and socially desirable – better than average intelligence – or bad and undesirable – a physical defect or disease to be treated and cured. As Davis notes: “When we think of bodies, in a society where the concept of the norm is operative, then people with disabilities will be thought of as deviants.” (Davis, 2017, p. 17).

Disabled people clearly deviate from what is the average or typical body. The person with CP will differ in their movement capacities from the average person, but such a restriction in their movement capacities shouldn’t, we believe, be taken to entail that they are pathologically embodied. Thus consider as one example how CN, one of the participants in our experiment, with spastic CP that affects her left arm and hand, describes her experience of horse riding:

“It’s dangerous doing this specific thing with the horse, because it demands two hands, but I don’t think about not having two hands. And then I get mad because my dad is overprotective, because I can easily do it.”

The inference from statistical deviance to pathological embodiment fails to take into account the lived experience of the person. CN’s experience of horse riding is that she can do things

with the horse that a non-disabled person would typically do with two hands. Her embodied experience of the horse is comparable to that of any non-disabled person that knows how to ride a horse. CN may not share all of the movement capabilities of people that do not have CP but this difference does not license the conclusion that she is pathologically embodied.

The medical model understands the embodiment of the disabled person primarily in terms of physical impairment caused by some underlying pathology. One of the many problems with such an understanding of disability is that it conceptualizes the body of the disabled person from the outside in terms of clinically observable impairments or loss of function relative to some normal or pre-existing state. Such a third-person understanding of the body of the disabled person fails to recognize their lived embodiment.

This understanding of the disabled person’s embodiment from a third-person, objectifying standpoint is shared by the social model. Thus the British-based disability movement, the Union for the Physically Impaired Against Segregation (UPIAS) defined impairment as “the lack of a limb or part thereof or a defect of limb, organ or mechanism of the body.” Disability is distinguished from impairment as “a form of disadvantage imposed on top of one’s impairment.” But as Hughes and Paterson (1997) noted this leaves in place a pathological and medical understanding of impairment. According to the social model, disabled people embody certain biological properties that are classified as physical impairments. The social model claims that based on such a classification disabled persons are then subjected to social forms of prejudice, exclusion and oppression. The limitations disabled people experience are thus traced to their social circumstances while the lived experience disabled people have of the world through their embodiment in it is at best sidelined and ignored⁸. But as Silvers (2010) has noted: “to ignore experiences of being weak, enervated, in pain and vulnerable in

⁸To respond to this line of criticism, many theorists influenced by the social model have developed accounts that include the disabled person’s body understood in terms of its impairment. In doing so, some of them have taken distance (to different degrees) from the social model, aligning themselves with critical disability studies (Shildrick, 2009) feminist philosophy of disability (Tremain, 2017, 2019), crip theory (McRuer, 2006), social constructionism (Barnes, 2016) among other movements, with evident overlap between them. Tremain, for instance, develops a feminist account of disability based on Foucault’s notion of apparatus, which, she claims, is not vulnerable to the objection leveled against the social model that it “denies impairment and the body” (Tremain, 2019, p. 144). Tremain (2019) describes how the body and its material experiences cannot be dissociated from discourses, institutions, architectural forms, laws, scientific practices that bring this body into being as an impaired body. Notice, however, that the material experiences of the body she aims to accommodate are the experiences of a body brought into being by historically contingent practices as a kind of thing – an impaired, gendered, sexed thing (Tremain, 2019, *Ibid*). She rightly calls into question essentialist understandings of impairment but her critique targets an understanding of the body of disabled persons as an impaired thing. In a related vein, the crip theory, that inscribes disability within the queer movement, focuses on how neoliberal capitalism has been the force against which disabled and LGBT people have defined their identities. In this way, crip theory is mostly concerned with the institutions that enforce able-bodiedness and heterosexuality, like educational, religious and financial institutions, among others (see McRuer, 2006). We in no way wish to detract from these politically important arguments. However, when it comes to understanding the embodiment of disabled persons we align ourselves with theorists influenced by the social model that have considered crucial in their accounts the lived experience of disabled people (see Thomas, 2007; Shildrick, 2009; Silvers, 2010; Reeve, 2012).

modeling disability is deceptive because these are the most salient experiences in most, or at least in many disabled people's lives" (Silvers, 2010, p. 20). Everybody has such experiences from time to time. The worry Silvers is articulating is that such experiences may so permeate the lived experience of some disabled persons as to make their lived embodiment different in kind.

The problems we have just described stem from a medicalized understanding of embodiment in terms of physical impairment. Both the medical and the social model conceive of the disabled person's physical impairment from a third-person, objectifying standpoint. What such an objectifying conception of the body misses is how the impaired body is also the medium of the disabled person's experience of the world. In the next section we outline the Ecological-Enactive model of disability, which offers a different perspective on the embodiment of disabled persons, one that is better placed to do justice to how the body of a disabled person situates them in the world.

THE EMBODIMENT OF DISABILITY

The bodily impairments that occur in disability are standardly understood as biomedical clinically observable pathological conditions that cause limitation in capacity or problems in performance (see Boorse, 2010)⁹. Of course there can be impairments or loss of ability that are non-medical but these do not lead to disability. A pianist for instance can lose their finger dexterity through lack of practice leading to an impairment in their ability to play the piano. It is typically assumed, however, that any bodily impairment associated with disability must be a clinically observable medical condition. An example of this type of reasoning is the attempt to specify the meaning of the terms 'disability', 'impairment' and 'handicap' for health professionals by the World Health Organisation. They define the impairments relevant to classifying disabilities as "the loss or abnormality of psychological, physiological, or anatomical structure or function." (*International Classification of Functioning, Disability and Health*, 1980, p. 27).

By understanding the embodiment of disabled persons in terms of impairment, both the medical and social models of disability pathologize the embodiment of disabled persons. The implicit contrast is with the non-disabled, "normally" embodied person whose psychological, physiological and anatomical structures and functions are intact and serving a proper function. The notion of bodily impairment assumes a distinction between normal and pathological embodiment. But how is this distinction to be understood? Is it really coextensive with the distinction between the disabled and non-disabled?

⁹Boorse notes that "the standard use of 'impairment' for biomedical aspects of disability is curious, for there is little reason to think it is a biomedical term at all, let alone a crucial one... I do not know how 'impairment' got its current role as general biomedical term in the disability literature. No doubt one motivation was that many disabilities – paralysis, blindness, missing limbs – are associated with static defects, not disease processes." (Boorse, 2010: p.61). Boorse objects that the biomedical understanding of impairment as a clinically observable pathological condition is too broad – a "gross-dysfunction test may well give most people a disability." (Boorse, 2010, p. 66)

We've seen above how the normal body is typically understood statistically in terms of what is average relative to a reference group (Buchanan et al., 2000). There is assumed to be a standard of normal functioning for humans such as for example sightedness. Disabled people are taken to be impaired insofar as they are embodied in ways which depart from this standard. The blind for instance will count as disabled because they lack the capacity to see, while people that wear spectacles will not count as disabled.

We will follow Canguilhem (1991/2015) in reversing the relation between the normal and the average. Instead of defining the normal in terms of the average, Canguilhem proposed to understand the average in relation to what is normal (Canguilhem, 1991/2015, p. 156). A human trait such as average lifespan in a given population is not normal because it is frequent, but is frequent because it is normal (*Op cit*, p. 160). This is to say that it is normal relative to a form of life – the regular and relatively stable patterns of behavior found within a population. The average duration of a person's life for instance varies in ways that depend on many different factors including the society to which the person belongs, their class, and occupation. These factors vary across and within populations depending for instance on:

"the techniques of collective hygiene which tend to prolong human life, or the habits of negligence which result in shortening it, depending on the value attached to life in a given society, are in the end a value judgment expressed in the abstract number which is the average human lifespan. The average life span is not the biologically normal, but in a sense, the socially normative, life span. Once more, the norm is not deduced from, but rather expressed in the average" (Canguilhem, 1991/2015, p. 161).

The statistical understanding of normality has it exactly backwards. The average is to be understood in relation to what is normal given social practices, such as practices of hygiene and medical practices, and not the other way around. Moreover, what is normal depends on the norms and values that people follow. Practices of hygiene such as washing one's hands are normative in the sense of specifying what a person should do if she is to act in agreement with the values of her community¹⁰.

The distinctions between normality and pathology and health and illness are thus not to be understood in terms of a statistical deviation relative to some reference class. The embodiment of the disabled person should not be understood in terms of a generic bodily impairment. We should instead understand the

¹⁰Conceiving normality as we propose here is consistent with the idea that rigid or very conservative societies sometimes pathologize behaviors that deviate from what is considered normal (see Foucault, 1991). Non-conformists are sometimes blocked by other members of a practice from exercising their capacity to establish new norms. Think about how homosexuality was classified as a mental disorder until 1973. Some 'deviations' will, however, gradually be integrated and assimilated by a society and come to be considered normal. How fast this happens will depend on the political, economic and religious forces at play. The development of the queer movement is a good example of how societies progressively acknowledge and integrate behaviors that were once considered deviant and pathological. For an analysis of the sociological relations between homosexuality and disability, and how both have been pathologized, see McRuer (2006).

distinction between normality and pathology in relation to an individual organism and its capacity to adapt to its environment, which in the case of humans is a sociomaterial environment. It is a defining characteristic of life that the organism can establish norms and values that arise from the organism's need to maintain its dynamic stability with the environment. The organism has an interest in and cares about its own continued existence. The concern for its existence is an intrinsic value for the organism borne out of the need for the organism to continuously take action to maintain its integrity. As Canguilhem noticed: "life is not indifferent to the conditions in which it is possible" (Canguilhem, 1991/2015, p. 126)¹¹. If a living body is to remain viable over time, the organism must regulate how it engages with the environment based on changes in its internal or external conditions. The organism can sense that it is hungry, thirsty, sick or fatigued, for instance, or it can sense joy, pride, frustration or satisfaction in its actions. In short, the organism has an evaluative perspective relative to which it evaluates how it is faring in relation to its environment. At minimum, an organism should regulate how it acts so as to bring about an improvement in its circumstances, while at the same time avoiding threats to its own continued viability.

We will refer to the organism's capacity to distinguish between situations as for example improving or deteriorating as "bodily normativity." We describe the organism's evaluative capacity as "normative" because it is a guide to how the organism should act if it is to meet the demands of its environment and remain in harmony with it. Bodily normativity is what enables the organism and the environment to continuously form a temporarily stable equilibrium with each other¹².

¹¹Canguilhem is anticipating here key ideas in ecological-enactive cognitive science [c.f. Merleau-Ponty (1942/1963) on the difference between the physical and living orders]. In our work we've shown how norms and values are intrinsic to the organic living body that has a sense of how well or badly things are going in its engagement with its environment. This is the evaluative dimension that is intrinsic to their engagement with the environment. The individual may sense a disequilibrium that tells them all is not quite right. The norms in play in the individual's engagement with the environment are situated: they concern what the individual should do to improve its situation to correct for a sensed disequilibrium (Rietveld, 2008a; Rietveld and Kiverstein, 2014; Bruineberg and Rietveld, 2014). The norm here relates to the adequacy of the individual's grip on a situation. The individual's grip is adequate, or inadequate, better or worse. There is an important connection between our idea of situated normativity and what enactivists call adaptivity (Di Paolo, 2005; Thompson, 2007; Di Paolo et al., 2017). Adaptivity refers to the capacity of organisms to differentially evaluate encounters with the environment based on their consequences for the organism's self-individuation (Varela, 1991). The organism *should* effect action on environmental flows of matter and energy when they contribute positively to the organism's sustaining of its viability. When an event threatens to destabilize an organism's capacity for self-individuation it *should* take compensatory action. Conditions of viability are here providing the values relative to which interaction with the environment can be regulated. Viability is a source of value because the organism has an interest in its own continued existence. See Kiverstein and Rietveld (2018) for further discussion of how the enactive idea of adaptivity relates to the ecological notion of situated normativity.

¹²Our notion of bodily normativity was primarily inspired by Canguilhem and Merleau-Ponty, but can be related to what is sometimes called "sense-making" in the enactive literature. The organism relates to its surroundings based on a concern for its own continued existence as an individual. The regulation of its activities based on this concern is what enactivists call "sense-making." The environment of an organism is not a value-neutral space in which it acts but is imbued with what Varela (1997) described as a "surplus of significance." It is "a place of valence, of attraction and repulsion, approach or escape" (Thompson, 2007, p. 158).

Crucially, humans don't only care about their own continued existence. They care about a wide variety of activities because over the course of their lives they develop skills for acting well in many different contexts and situations. We should not think of bodily normativity as a capacity belonging to individual persons distinct from social and cultural normativity – the rules the person "follows" (Wittgenstein, 1953) as she engages in social life. People grow into and become skilled participants in a multiplicity of different practices in their everyday life. By taking part in communal customs and practices the person develops what we can describe as a "situation-specific discernment," a feel for how they should act in a particular situation (Rietveld, 2010). Bodily normativity in humans takes the form of an ability for distinguishing, typically in the flow of activity, between better and worse, appropriate and inappropriate, what is significant and worth paying attention to and what is not. Humans by taking part in many different activities develop a multiplicity of different (and sometimes conflicting) cares and concerns that feed into their sensitivity to how they are faring in life. People are normally able to act adequately in a given situation because they embody a concern for what counts as adequate action within a practice. Given that the practices humans take part in are holistically related – they form what Wittgenstein (1967, p. 108) described as "the whole hurly burly of human activity" – these multiple cares and concerns must be integrated in a person to form a "single complex sensitivity" (Rietveld, 2010)¹³.

Based on bodily normativity, multiple affordances the environment offers will stand out for an individual as calling for action. We borrow the notion of "affordance" from ecological psychology to refer to the possibilities for action the environment makes available to an animal belonging to a form of life (Gibson, 1979; Rietveld and Kiverstein, 2014).¹⁴ The multiple affordances that invite the individual to act we describe as forming a field of relevant affordances (Rietveld et al., 2018). The individual's discernment for what it ought to do in a particular situation can thus be understood in terms of its skill-based, selective responsiveness to a field of relevant affordances. Based on their sense of what a practice requires of them and the care they cultivate by taking part in practice certain affordances will stand out as inviting action. Insofar as they embody a single complex

Sense-making, is "viable conduct" because the environment's significance (its "sense") is enacted by organisms in their active engagement with the environment. The classic example is the chemotaxis of the bacteria in which the tumbling or swimming forward of the bacteria depends on what it senses, but what it senses depends on how it moves. This sensorimotor loop is an example of sense-making in the enactive tradition.

¹³The expression "single complex sensitivity" is due to McDowell's (1998) work on Aristotle. He uses the expression to describe the second nature the skilled individual (or *phronimos*) cultivates that allows them to appreciate what the right thing to do is in a particular situation.

¹⁴More precisely, we define the affordances of the human environment as relations between aspects of the sociomaterial environment in flux, and abilities available in a form of life (see Rietveld and Kiverstein, 2014). We borrow the notion of "forms of life" from Wittgenstein (1953) who used the term to refer to regular, and relatively stable patterns of activity that can be observed in the social world. We argue that the affordances of the human environment grow out of the regular activities of people as they engage in practices. It follows that the environment people act in isn't only a material environment – it is sociomaterial because the materials people make use of in their activities have been organized and structured through a history of practices.

sensitivity, they will be ready for engaging with a holistically structured field of multiple relevant affordances.

Canguilhem described the person in good health as feeling “more than normal – that is, adapted to the environment and its demands – but normative, capable of following new norms of life” (Canguilhem, 1991/2015, p. 200). He gives as an example an organism that is forced to resettle at a higher altitude after being accustomed to living at the sea level, perhaps because of the flooding of its natural habitat. The variation in its environment implies a change in oxygen concentration in the air, different food, ambient temperature, *etc.* In order to flourish in these new conditions, a healthy organism would institute new norms to compensate for the changes in its habitat. It will need to select from among the new possibilities, what is good and exclude what is bad for it. If the organism is incapable of producing new norms to adapt to the new environment, that organism would go from a normal state in the previous environment to a pathological state in the new one. The healthy organism, the one that, in this case, can move from a lower to a higher place. It is ‘more than normal’ in the sense of being able to adapt to a variety of ensuing events. What the organism does can be described as “more than normal” because it is able to find new ways of doing things that are better suited to this environment than their previous habitual ways of doing things.

We suggest Canguilhem’s idea of *health as the experience of being more than normal* is an important clue for how to understand the embodiment of disabled people in ecological-enactive terms. Such an account will improve on the medical and social models understanding of embodiment in terms of bodily impairment because it will allow us to make a distinction between normal and pathological embodiment.

NORMAL AND PATHOLOGICAL EMBODIMENT: TOWARD AN ECOLOGICAL-ENACTIVE MODEL OF DISABILITY

To be normal is for a living body to be able to maintain a state of dynamic stability with its environment. This is something the organism needs to continually reestablish by regulating its engagement with the environment based on bodily normativity. The stability the organism achieves is always hard won under conditions of continuous change, which is why we describe it as a “dynamic” stability. The organism must therefore always be ready to act not only in familiar circumstances it has encountered regularly in the past, but also to adapt its activities to novel situations that differ from anything the organism has hitherto encountered. Indeed human agents in adapting their activities to the particularities of a given situation cannot just repeat what they have done in the past. They must adapt what they have done in the past to the particularities of the situation that now confronts them. Think about bicycling through a busy city. You follow the same route but under unique traffic conditions that will never be repeated in exactly this form again. To maintain a state of equilibrium the agent must adapt what they have done previously

to these unique and often unrepeatable conditions. To respond adequately to affordances as they take shape in this particular situation will often require the organism to risk, and be tolerant of potential failure. You may for instance almost collide with another cyclist talking on their mobile phone, or with a pedestrian that casually walks into the cycle path. Yet most of the time you succeed in avoiding injury by spontaneously taking measures that allow you to skillfully correct for such incidents as they arise.

It is this capacity of the living body to continuously restore dynamic stability by adapting in better or worse ways to uniquely occurring conditions that we take to be a defining characteristic of a healthy living body as contrasted with one that is sick. Canguilhem in the passage we quoted from above associates health with the capacity to follow “new norms of life” (*Op cit.*) – a capacity he associates with what we have called *bodily normativity*. Being healthy means being able to establish a state of dynamic stability with the environment, and not only in the present situation, but also in a near open-ended range of other situations going into the future. The bodily normativity that governs the organism’s engagement with its environment will need to be made anew on each occasion because dynamic stability is continuously achieved anew, often under uniquely occurring and unrepeatable conditions. The norms that regulated an organism’s conduct in the past are a guide to what the organism does in the present, and going into the future. They cannot however fully determine what the organism does in other possible situations the individual might find themselves in. To achieve dynamic stability in these other possible situations will call for transcending the norms that have governed the organism’s activities in the past, and the following of new norms that allow the organism to establish dynamic stability under the new and often unique and particular circumstances it now encounters. To adapt to changing conditions, the organism must be ‘more than normal,’ that is, capable of adapting not only to the demands of its current situation based on what it has done in the past. It must be “normative” in the sense of being able to institute new norms that allow it to reach dynamic stability in a changing environment in which it is confronted with novel situations.

This ability to adapt to change is transformed in illness into a capacity to limit or avoid change. The organism’s relationship with the environment is qualitatively different from that which it can accomplish when in a healthy condition. Canguilhem suggests that a person is sick when they can no longer exercise the capacity to follow new norms of life (Canguilhem, 1991/2015, p. 186). Instead, the person organizes their life around a single norm – the avoidance of situations they might generate what Goldstein referred to as “catastrophic reactions.” Goldstein distinguished “ordered” from what he called “disordered” or “catastrophic” reactions. Ordered behaviors are experienced “with a feeling of smooth functioning, unconstraint, well-being, adjustment to the world, and satisfaction” (Goldstein, 1934/1995, pp. 48–49). In catastrophic reactions the person feels “unfree, buffeted and vacillating” because it is unable to respond adequately to situations it could have ordinarily dealt with when healthy (*Op cit.*, p. 49; Goldstein, 1940, ch. 4). The living body is unable to establish a dynamically stable relation

with the environment in situations in which this would normally prove possible. As a consequence the person experiences the environment as dangerous, a threat to their existence. Consider Goldstein's description of the reaction of one of his patients with a lesion in the cerebral cortex when he tries to perform an easy arithmetic task and fails.

"By simply looking at him we discover a great deal more than his arithmetical failure. He looks dazed, changes color, becomes agitated and anxious, starts to fumble. A moment before, he was amiable; now he is sullen and evasive or exhibits temper. He presents a picture of a very much distressed, frightened person, a person in a state of anxiety. (...). We may call the state of the patient in the situation of success *ordered behavior*; his state in the situation of failure, *disordered* or *catastrophic behavior*." (Goldstein, 1940, pp. 85–86).

Anxiety may arise in very innocent circumstances for a person in a pathological state. If the person anticipates being unable to adequately respond to a situation (e.g., solve a simple arithmetic problem), the situation becomes very threatening for him, and anxiety will block his capacity to perform at all (Of course it can also be the patient has panic attacks every now and then and in the meantime can function quite normally). The avoidance of such challenges becomes the sick person's way of being-in-the-world. They live a life in which they keep everything in the environment as stable as possible, and avoid at all costs unfamiliar things and events. Goldstein reports how patients of his would avoid taking walks because simply going for a stroll could lead to unexpected encounters, and catastrophic reactions. Even unfamiliar routes around the hospital were avoided (Goldstein, 1940, p. 100). Living according to the norm of avoiding change amounts to a shrinkage of the possibilities for action the individual is open to acting on. A pathological living body achieves a state of dynamic stability only by arranging their affairs so as to keep the environment as constant as possible at the cost of explorative engagement with the world that would normally also lead to new skills. The person acts more generally with the aim of keeping themselves in situations they can adequately manage given their illness. Illness is characterized by a stagnation of life in which the person restricts their engagement with the environment with the aim of avoiding catastrophic reactions.

Our Ecological-Enactive model uses Canguilhem's analysis of health and illness to distinguish "normal" from "pathological" modes of living embodiment. A person is normally embodied if they can adapt their activities adequately not only in response to the particularities of their current situation, but also in responding to a near open-ended range of alternative possible situations. They are able to transcend their current situation as is shown by their readiness to respond adequately to many other eventualities and possibilities. They can, in Canguilhem's terms, "institute new norms in new situations" (Canguilhem, 1991/2015, p. 197) By contrast, when a person is unable to institute and follow new norms and instead acts exclusively on the basis of the norm of avoiding adapting to change then we will describe them as being pathologically embodied. A person is pathologically embodied when they morbidly avoid situations that could lead to catastrophic reactions by withdrawing from life, confining

themselves to regimented and ordered situations which they can manage¹⁵.

We'll argue in the next section that disability (at least in people with CP) doesn't necessarily entail pathological embodiment because impairment doesn't necessarily lead to a shrinkage in the environment, and the withdrawal from life characteristic of pathological embodiment. We make this argument by contrasting reports from subjects with CP. One of the individuals reports experiences of pathological embodiment. The other individuals whom we interviewed using the phenomenological method described in the introduction, we will suggest, are best interpreted as describing experiences that correspond to normal embodiment.

PATHOLOGICAL AND NORMAL EMBODIMENT IN PERSONS WITH CEREBRAL PALSY

We begin this section by considering the case of Michael as an example of pathological embodiment in Cerebral Palsy¹⁶. Michael's CP has led to left-sided hemiplegia, which highly limits what he can do with his left hand. He also needs a walking stick to walk. This is how he describes his relation with his environment:

"The world, that is, my surrounding environment, appears as something hostile, which I am a part of, but certainly not 'in.' The world is an object I continually manipulate, rather than being a friendly place and somewhere I feel at ease or even at home. Within this hostile world, other people appear as obstacles to be avoided, not just because I fear bumping into them and hurting myself, and them. Even a hand offering help with shopping bags can appear hostile as it is an unexpected disruption to my 'walking plan'. I live in a world which assails the body and self, and I can only hope that the adjustments will allow me to survive" (Cole et al., 2017, p. 2).

The hostile world that Michael describes mirrors Canguilhem and Goldstein's description of illness. Recall how the sick person tries at all costs to keep the environment as stable and predictable as possible in order to cope with life. Michael's embodiment

¹⁵A reviewer notes that whether or not a person experiences their environment through their pathological embodiment will most likely vary a great deal across individuals. It will depend on factors such as personality, level of social support, level of energy in a particular situation, self-confidence and self-esteem and so on. We fully agree with the reviewer that pathological embodiment is likely to be a consequence of the person's past history and their intersubjective relation with other people. We are grateful to our reviewer for discussion of this point.

¹⁶We note that in making this claim we do not mean to medicalize Michael's condition. A central problem with the medical model of disability is that it conceives of pathology in terms of a defective body to be treated and cured through rehabilitation or normalization. We agree with Barnes (2016) that "to be physically disabled is not to have a defective body" (p. 1). At the same time we suggest it is important to do justice to the vulnerability and suffering that can be part of living with a physical disability. By understanding experiences of pathological embodiment in terms of catastrophic reactions we think we can do justice to both of these points. Our concept of pathological embodiment is developed to do justice to the very real difference in lived experience that are characteristic of illness. We avoid medicalizing disability but we also seek to do justice to the differences in lived experience that we will see, through reflection on the case of Michael, can be a part of living with CP.

is pathological when he is unable to adapt what he does to unexpected change. He doesn't feel capable of coming up with different and better ways of doing things. He lives his life in a "surviving mode," and in that mode of being, the environment is polarized in a way in which all that matters is for him to keep himself alive. This existential feeling of being constantly under threat (Ratcliffe, 2008), and on the verge of anxiety and catastrophic behavior is clearly described by Cole et al. (2017) in relation to Michael:

"What cannot be over-emphasized is the existential nature of inhibited intentionality. The difficulties the walker [Michael] faces threatens not only his agency, his ability to commune with other human beings, but also his very existence. Walking down the street is about way more than just walking. Inhibited intentionality shrinks one's social world" (Cole et al., 2017, p. 3).

Michael's lived experience contrasts markedly with the descriptions of a number of persons living with CP we interviewed. The experiences they described make it clear that they are able to skillfully explore for new affordances in order to establish new and better ways of doing things. This is the essence of normal embodiment as we have described it above. Thus consider SG, a 28-year-old woman with spastic cerebral palsy that affects motility in her legs and her right arm. The following is the description SG gave in the context of a phenomenological interview of her experience of shaking hands and how it has evolved through time, how she has learned to deal with the challenges of meeting a new person, or greeting someone at a party:

"I'd definitely rather just shake hands with my left. I don't know if you noticed, but I shake hands with my left, because that's the side I prefer to show of myself. I'm more confident in the meeting when I know people, if I'm allowed to give my left hand rather than my right. But it's taken me so many years to figure out that I can just give the left hand, because I've always given the right one, and it's always been like "ugh!" meeting new people. At a huge birthday party where you don't know anyone and have to go say "Hi, S" while keeping balance on my rollator as well. So in reality it's a question of balance. Then I'll use the left so I can stabilize with the right. It was a huge relief for me to find out I could just give the left hand! There wasn't much to it, because it just feels more comfortable for me, and that's really what matters."

Notice SG's attitude toward her impairment. She realizes that shaking hands with her right hand – a social convention in the western world – implies that she can't easily maintain her balance. Thus, her right hand will not be the best hand to offer to the person she is greeting. Shaking hands with her right hand feels wrong. She feels much better as a whole – she can maintain a better bodily equilibrium, look at the other person's face, and so on – when she offers her left hand. This is something she found out after a long time of shaking hands using her right hand. It happens every now and then that one encounters a person who for some reason (perhaps an injury or because they

have their hands full) shakes hands with their left hand. Thus, SG did not need to come up with a completely new pattern of social engagement. She just needed to be open to a non-standard, unconventional way of doing things, others likewise have recourse to on occasion.

SG describes a similar experience in the context of the experiment we described in the introduction. The task she refers to consists of lifting a tray on which is placed a cup of water. Initially she struggled to perform this action. Here she describes a feeling of discontent she experienced when performing the action with her father:

"...I wanted to try and see what would happen if I only did it with my left. And I could feel it was more insecure, because the glass with water created some balance issues."

Afterward, she performed the same task with the therapist. Here she reports her experience of having found a manner of performing the action that worked better for her:

"Suddenly it dawned on me that I had done it this way every time, and now I could do it differently. I hadn't even thought that you could do it that way! So, in the middle I stopped, because I had time to think "God, you're right," but I had already begun the action! And really it was because it dawned on me that I could do it in a different manner than I thought!"

Despite the movement limitations SG experiences, she's still able to be spontaneous in the performance of the tasks at hand. She is constantly looking for better ways to perform the exercise, and even though she might find a way in which she feels comfortable performing, she feels she can keep looking for better ways to perform an activity. Sometimes she fails to improve, sometimes she succeeds in coordinating her actions to new affordances that allow her to establish a new way of acting. This flexibility and adaptability to upcoming challenges is absent in what we have described as pathological lived embodiment, as seen in the case of Michael above. Every unforeseen event – even a helping hand – can become an insurmountable challenge that can trigger severe anxiety the person acts to avoid. Instead of being open to exploring for affordances that allow for the formation of a temporary stable equilibrium with the environment, the person acts to limit to the best of their ability, situations in which they are unable to respond adequately¹⁷.

For a person with CP, performing tasks with the impaired limb will typically prove to be suboptimal, compared with how they would perform them with their unaffected limb. They can however often face the task with some degree of openness to what

¹⁷One might object that Michael's experience of his embodiment can only be described as pathological if one endorses our rather idiosyncratic, and non-standard understanding of pathological embodiment. In order to justify this description of Michael, we would therefore need to say more in defense of our understanding of normality and pathology. But recall that our account of pathological embodiment follows from the EE account of bodily normativity outlined in section "The Embodiment of Disability." Our argument for this account is that it is developed to account for the lived experience of persons, and the way in which the body isn't simply something a person possesses but is the lived medium of their experience of the world. We suggest such an argument is further supported by the reports from people living with CP we have given above, and in the rest of the article.

might happen, without panicking. They are open to finding ways to perform the task that work better for them. This often calls for creative improvisation if they are to avoid getting into trouble. Yet they are prepared to take risks in spontaneously adapting to the demands of the situation, modes of engaging with the environment characteristic of healthy or normal embodiment. Recall CN – the woman we quoted from earlier describing her experience of horse-riding. This is how she described her experience of the tray exercise of the tray exercise when she does it with her mother:

“I think that we just do it, because we know each other so well. We just do it. We know where the limits are, and what you do in those cases. So I don’t think there’s any challenge in it. Of course, when you change with your left hand and such, and optimally I’d grab the tray with my right hand independently of which way it was going. If you hadn’t said that I should grab it with my left, I would have grabbed it with my right. So, I don’t think there’s anything challenging or uncomfortable in this.”

Based on the experiences we have described in this section, we can identify two features distinguishing normal from pathological forms of embodiment in these persons. Normal embodiment occurs in people with CP with a preserved capacity for adapting their manner of engaging with the affordances of the environment so as to find the affordances that work for them. Second, the normally embodied person should be ready to test established patterns of activity to the best of their ability when circumstances call for them to do so. They should be able to explore for better ways of engaging with the relevant affordance that correct for discontentment with their previously established ways of doing things. These features of normal embodiment and normal experiences have been deeply investigated both in phenomenology in relation to the lived body, and in Ecological-Enactive cognitive science in relation to the living body. In the next section we will make use of these accounts to round off our argument that people with CP can be normally embodied despite their physical impairments.

NORMALITY AS OPTIMALITY AND THE TENDENCY TOWARD AN OPTIMAL GRIP

Following Canguilhem we’ve suggested that a key feature of health from an Ecological-Enactive perspective is to transcend what in the current situation is experienced as normal in readiness for a near open-ended number of other possibilities that may lie on the horizon. We experience a situation in a manner that deviates from what is optimal. The person is then drawn into action by relevant affordances in such a way as to temporarily restore dynamic stability. Merleau-Ponty gives the example of standing too close to a painting you are viewing in a gallery (Merleau-Ponty, 2012, p. 315). You experience a tension in relation to the painting, and you step back so you can better see the details in the context of the painting as a whole. Merleau-Ponty understands life as a process always delicately balanced between relatively stable equilibrium with

the environment, and disequilibrium, or instability (Merleau-Ponty, 2003, p. 149; Rietveld, 2008b; Kiverstein and Rietveld, 2018). Organisms compensate for this inherent disequilibrium through movement. When faced with the tension generated by disequilibrium, the norm will be for the organism to act in order to relieve the tension so as to move in the direction of “the optimal conditions of its activity” (Merleau-Ponty, 2012, *Op cit.*). Relevant affordances stand out for the agent from their surroundings based on divergence from an optimal condition. The organism is continuously being moved to get ready for action possibilities that can contribute to reducing divergence from a state of relative equilibrium. They will normally tend toward an optimal grip on a whole field of relevant affordances (Rietveld et al., 2018).

The normal lived-body is the one that *tends toward* optimality, creating new and better bodily norms to guide its activities. Steinbock (1995) in discussing Husserl’s account of perceptual normativity has described this dynamic well when he writes:

“From one perspective experiences are ordered according to the previous norm; from another, they actually surpass it such that the old order refers to the new as norm; the former as abnormal, the newer as normal.” (Steinbock, 1995, pp.146–147).

To make the same point in our Ecological-Enactive terms, the skilled individual is able to adapt to an environment in flux by sometimes exploring for unconventional possibilities. They will creatively establish novel ways of engaging with the environment by expanding their set of skills (including fine-tuning an existing skill).¹⁸ For disabled people, it is very important to explore for new and improved ways of doing things by trying out what is possible, as well as having a practical knowledge of her own bodily capabilities, skills, and limitations. Consider in this light the following remark of CN reporting on her experience of passing and receiving a cup of water in our experiment:

¹⁸Gallagher (2018) introduces the concept of an affordance space which he tells us is “the full range of possible affordance fields relative to an individual, including the current affordance field plus any possible changes in that field due to changes in physical or cognitive skills or environment” (p.722; c.f. Brincker, 2014). Gallagher’s affordance space concept overlaps our distinction between the field and landscape of affordances. It can be compared to the field insofar as it concerns relevant affordances in relation to the individual agent over time. But it can also be compared to the landscape of affordances in relation to an individual insofar as it concerns the set of *possible* fields for an individual and this goes beyond those multiple affordances that are soliciting action at a given moment. Gallagher suggests the affordance space for a disabled person that uses a wheelchair will differ from that of a non-disabled person. Their affordance space will for instance depend on their wheelchair skills, the layout of the environment, and the social and cultural attitudes of others in ways that the affordance space of the non-disabled person does not (ibid, p.723). We agree with Gallagher there will be differences in how a disabled person engages with the landscape of affordances. A person that is born blind will not be able to drive a car for instance. We suggest that we can account for this difference in what Gallagher calls the affordance space of the disabled persons in terms of the different skills and abilities disabled people develop. The blind person’s lack of access to the affordances of driving is due to their inability to drive, both now and in the future. Crucially we are arguing the other skills they develop will often allow them to access unconventional affordances available in the landscape. They are still able to establish new and better ways of doing things in many cases and so their disability doesn’t necessarily entail a pathological embodiment. Thanks to the reviewer for drawing our attention to Gallagher’s (2018) paper and the relevant example.

“I think more about how to grab it without everything going wrong. I knew that I would never grab around it, because then there’ll be water everywhere and I’ll be wearing wet pants for the rest of the day. (...) So of course you think about how to solve it. And you also do that day to day.”

She did not stick to her pre-established routine ways of engaging with the world, but was open to exploring for new ways of doing things that work better for her given the constraints of her physical impairments. We think it makes sense to describe her as tending toward an optimal grip on the possibilities that matter to her, correcting for disequilibria as they arose in her engagement with the world. The normal is not only the optimal as it is found in the person’s present circumstances, but also the capacity to transcend what counts as optimal in the present situation. The person must also be open to engaging with previously unexplored affordances as they are encountered in the future. A disabled person, we will argue, can be considered normally embodied just so long as she is able to adequately adapt her actions to the particular situation in which she is acting. This may call for her to break with how she has done things in the past and open herself to new affordances that allow her to improve her skills. Then, even if the disabled person is less flexible compared to the non-disabled person, she is still able to tend toward an optimal grip in adapting to the demands of her environment.

Thus, returning to our Ecological-Enactive account of normal embodiment we gave at the end of the previous section, we can redescribe the two dimensions of normal lived embodiment as follows. Crucially, these dimensions are also manifest in the experience of people with CP we interviewed:

- (1) The agent is able to tend toward what is optimal in their lived experience of the world. They are capable of adequately engaging with multiple relevant affordances in the practical contexts in which they are to be found.
- (2) They can transcend what is currently optimal in their active engagement with the world by exploring responsiveness to unorthodox affordances and/or developing/enriching abilities to *establish new and ‘improved’ possibilities for engagement going into the future.*

Normal embodiment doesn’t mean lack of difficulty in performing daily tasks. We continuously encounter obstacles and have to correct for action slips and failures in normal everyday life. It is usual for a person with CP to find daily activities more challenging than a non-disabled person. But, even when faced with very difficult activities, it is inherent to normal embodiment to be able to explore in search of affordances that allow the individual to tend toward an optimal grip. It is important to consider that CP is a congenital disorder, which leads the person with CP to develop from the very beginning an open attitude to risk-taking, often exploring alternative strategies to deal with daily challenges (see Martiny, 2015). A good example of this is KR, another participant in our experiment. KR is a middle-aged man with CP with dystonia in his left arm, which limits to a high degree his arm and hand movements. Faced with the task of passing and receiving a cup of water in our experiment, he struggled considerably. This is how he described the experience

after having performed the task with his impaired hand by just pushing it, instead of grabbing it.

“It’s impossible if I had to take it. It would be very demanding. Anything is possible, but... I think it may be possible that I take the one with water in and lift it, but I would have to carry the left arm, put the hand down the cup and push on the thumb, and I would probably still spill half the water.”

And he adds later in the interview:

“The water part was pretty much an impossible task. (...) You have to be creative. Push it. I’ll have to do it that way, then. There’s a solution to all problems.”

KR exemplifies the experience of facing a demanding task while holding on to the conviction of being capable¹⁹. It is a matter of trying different actions, to find a solution, and also to keep trying to transcend the currently established ways of tending toward an optimal grip. In the first round of tasks, KR didn’t spill water in the passing and receiving of the cup, mainly because he did most of the work with his other hand, while barely grabbing the cup with his impaired hand. In the second round, he tried to do the same task mostly with his impaired hand, knowing that it was a riskier strategy:

“When I had to give the cup back, I did it differently. It was almost conscious, because I wanted to do it differently than I had done it last time. (...) I thought that the last time I didn’t spill, so now I wanted to see what would happen if I did.”

We’ve shown how people with CP can overcome the challenges they are faced with in daily life so as to exemplify the two dimensions of normal embodiment we’ve identified. Thus, although dealing with daily life undoubtedly brings with it many challenges, the person with CP need not be thought of as being pathologically embodied. They do not necessarily experience the anxiety that comes with the failure to adapt to change, but on the contrary are often ready to risk failure in exploring in search of affordances that allow them to tend toward an optimal grip. With the help of the phenomenological tools and the EE account of normal embodiment we’ve proposed, we have shown how it makes sense to think of many people with CP as normally embodied.

HOW TO UNDERSTAND THE “DIS” IN “DISABILITY”?

There is an apparent tension between the notions of disability and normal embodiment we would like to end by discussing. If, as we

¹⁹The conviction of being capable is not, by itself, enough for someone to be normally embodied. The person might be anosognosic, or pathologically grandiose in their estimation of their own capabilities. They may well think they can do things they actually can’t. Our thanks to the reviewer for pressing us on this point. We have provided an analysis of normal embodiment in terms of a person being able to establish a dynamic stability with the multiple affordances that are relevant to them. Our account of normal embodiment is not dependent on what a person believes they can do but on whether they are able to tend toward an improved grip on a field of relevant affordances.

have argued, a person with a physical disability like CP can still be considered normally embodied, why do we describe these persons as disabled? We aim in this section to understand disability from a first person perspective. From a phenomenological point of view, we suggest that disability is a form of self-experience. Being disabled can be described in terms of the experience of I-cannot.²⁰ The experience of 'I-cannot' permeates to different degrees the person's practical engagements with affordances in the environment. Thus a person that experiences a speech impediment will for instance have an experience of I-cannot because of the norms of embodied communication, which are intolerant, and even hostile toward people that speak with a stutter. Here we are in agreement with the social model that the limitations disabled people live through are often "a consequence of the profound oppressions of everyday life" (Paterson and Hughes, 1999, p. 603).

We in no way mean to deny or downplay the difficulties and challenges people with CP face and often overcome. Physical disabilities more generally, are directly linked with activity limitations, and suffering that is not experienced by non-disabled people. The 'dis' in disability is to be taken seriously. Nevertheless, disability doesn't necessarily lead to an inability to tend toward an optimal grip on a field of relevant affordances. It is still possible for many people with CP to be open to exploring the affordances for the environment they care about, and to engage with them in different ways, and in ways that are adequate to the situations in which they are found. A key part of what disability means for a normally embodied person is, we suggest, constantly correcting for this experience of I-cannot. When they tend toward an optimal grip by finding their way to affordances that allow them to temporarily form a dynamic stability with the environment, they are overcoming the experience of I-cannot.²¹ Each time they find affordances that allow them to conquer instability, they are at the same conquering their experience of I-cannot. Thus an experience of I-cannot is quite consistent with a disabled person at the same time experiencing a world in terms of its affordances because of the skills they have developed.

The being-in-the-world of non-pathologically disabled people is, however, fundamentally different from that of non-disabled people insofar as the former must constantly conquer and reconquer the experience of I-cannot. A person with CP will always experience some challenges dominated by the feeling of I-cannot. By remaining open to different affordances, they are able to compensate for this feeling without experiencing a catastrophic reaction - the experience of being unable to adequately adapt to a situation. The affordances they make

use of may differ from those exploited by people that are not disabled. We suggest that the I-cannot experienced by the non-pathologically disabled person can be understood as a local I-cannot, with a background of I-can: I-can do it in a different way, I-can ask for help, I-can do it slowly, *etc.* This contrasts with the experience of I-cannot of the pathologically embodied person, which deeply pervades her being-in-the-world. She lives in a dangerous and threatening world, and must structure her environment so as to avoid catastrophic reactions in which she is unable to establish a dynamically stable relation with the environment. It is this pervasive feeling of I-cannot that drives the pathologically disabled person to keep everything around her as stable as possible, in order to preserve the small and fragile region of I-can, and avoid life-threatening anxiety. This pathological preservation of the local I-can inhibits the person to transcend her way of engaging with the world in favor of better ways, thus preventing her from tending toward an optimal grip²².

CONCLUSION

We've argued that disability doesn't necessarily entail pathological embodiment based on the experience of people living with CP. We've done so by providing an Ecological-Enactive account of the person's embodiment that allows us to distinguish between pathological, and normal forms of embodiment, while at the same time doing justice to the lived experience of disability. We've argued that people with CP are often normally embodied because they can find ways to tend toward an optimal grip on a field of relevant affordances. They can transcend the way they have done things in the past in order to explore for new affordances that allow them to adapt adequately to their situation. There are many factors involved in the capacity (or incapacity) of a disabled person to explore for alternative ways of dealing with daily challenges: not only the actual physical capabilities of the person, but also psychological, social and environmental factors that can encourage or discourage them to make the effort and tend toward an optimal grip. One serious concern with the medicalizing and pathologizing of disability is that it can turn a normally embodied disabled person into a pathologically embodied one by obstructing the person's capacity to tend toward an optimal grip. The person can experience their impairment in ways that inhibit them from looking for alternative or unorthodox ways of engaging with the affordances in the environment and from developing new skills and abilities. Thus, consider SG's description of the difficulties she experiences in passing a

²⁰Patterson and Hughes have described the experience of I-cannot using Drew Leder's notion of "dysappearance" (Leder, 1990). The disabled body dysappears in the sense that it becomes the focus of attention. Typically in lived experience the body recedes into the background - it is the point of view from which we engage with the world. The body obtrudes into lived experience when a person is in pain but also in disability due to the hostile environment the disabled person lives in. As Patterson and Hughes write: "When one is confronted by social and physical inaccessibility one is simultaneously confronted by oneself. When one encounters prejudice in behavior or attitude, one's impaired body dysappears." (Paterson and Hughes, 1999: p.603).

²¹See Martiny (2015) for a more detailed analysis of the need for "constant adjustment" experienced by people with CP.

²²One might object that the elderly fit our description of pathological embodiment - they structure their environment so as to keep things as constant as possible in order to avoid situations to which they cannot adapt. Yet this is an adequate response to the increasing limitations they experience due to old age rather than a consequence of pathological embodiment. We suggest the crucial difference is that the elderly are driven to avoid change not in order to avoid catastrophic reactions in which they fail to adapt to the environment. What they do is maintain themselves in situations they are able to manage well just as a part of their skilled engagement with the environment. Shrinking the space of affordances they open themselves to is what it takes for them to skillfully tend toward an optimal grip.

cup of water using a manner of grasping the cup her former physiotherapist describes as proper:

“I got annoyed. My old physiotherapist would say “you can’t hold it like that! You need to do a proper grip.” And then I correct myself, because I’ve always been taught that I can’t do it like that, so of course I have to be able to do the other thing. And it’s a bad and a wrong way to do it. So really I correct myself in these situations.”

If people with CP are not allowed to find alternative ways of dealing with daily challenges, if therapy hinders their capacity to explore and develop their own abilities that work for them given their embodiment, or if the sociomaterial environment is built around only able-bodied people, their practical engagement with the world will become much harder and the risk of becoming pathologically embodied will increase. This is because the way the disabled person conquers the experience of I-cannot is by finding their way to affordances that allow them to act adequately within the constraints of their impairment. The “proper grip” that SG describes her former physiotherapist as enforcing, is a socially accepted way of engaging with specific affordances in practical contexts. This proper grip, however, does not necessarily work well for the person with CP. If they are to succeed in tending toward an optimal grip this will often call for them to break with the established ways of doing things in their life-world. People with CP can adapt and develop new skills, but interpersonal relationships can still be challenging: It can be difficult for them to interact and coordinate with non-disabled people. This is mostly due to the fact that non-disabled people are not skilled in interacting with people with CP, and they bring with them a pre-established normativity that often conflicts with the abilities and skills developed by a disabled person to perform activities in everyday life.

Experiences of I-can and I-cannot are complex phenomena in which the person’s embodiment and skills are faced with the demands of an environment structured by sociomaterial practices. Pathological embodiment can arise out of sociomaterial practices that make it too hard or impossible for the disabled person to explore, and establish her own skilled ways of engaging with the relevant affordances, including the social affordances that materialize in interaction with other people. In a similar manner, a friendly, supportive and flexible sociomaterial environment can prevent a disabled person from becoming pathologically embodied. We’ve argued the lived embodiment of a person with CP doesn’t necessarily entail pathological embodiment. On the contrary, people with CP can still explore

their environments for affordances that make it possible for them to live a rich and fulfilling life.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JT gathered and analyzed the experiential reports of people with cerebral palsy. JT and JK co-authored the manuscript. ER provided feedback and helped to refine the argument of the manuscript.

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Between Ecological Psychology and Enactivism: Is There Resonance?

Kevin J. Ryan Jr.^{1*} and Shaun Gallagher^{2,3}

¹ Department of Philosophy, University of Nebraska at Omaha, Omaha, NE, United States, ² Department of Philosophy, University of Memphis, Memphis, TN, United States, ³ Faculty of Law, Humanities and the Arts, University of Wollongong, Wollongong, NSW, Australia

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*Correspondence:

Kevin J. Ryan Jr.
kevinryan@unomaha.edu

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Ecological psychologists and enactivists agree that the best explanation for a large share of cognition is non-representational in kind. In both ecological psychology and enactivist philosophy, then, the task is to offer an *explanans* that does not rely on representations. Different theorists within these camps have contrasting notions of what the best kind of non-representational explanation will look like, yet they agree on one central point: instead of focusing solely on factors interior to an agent, an important aspect of cognition is found in the link or coupling between an agent and the external world. This link is fluid, dynamic, and active in a variety of ways, and we do not need to add any internal extra something in the perception-action-cognition process. At the same time, even devout defenders of ecological psychology and enactivism recognize that plenty happens inside an agent during cognition. In particular, no one denies that the brain plays an important role. What, then, is the role of the brain if it's not in the game of representing the environment? One possible option is to describe the brain as a resonant organ instead of a representational organ. In this paper we consider the history of resonance in more detail. Particular focus will be placed on two different sets of approaches that have developed the concept of resonance: a representational reading of resonance and a non-representational, dynamic account of resonance. We then apply these accounts to a case study on music performance, specifically in the context of standard tonal jazz. From this application, we propose that a non-representational resonance account consistent with both enactivism and ecological psychology is a viable way of explaining jazz performance. We conclude with future considerations on research regarding the brain as a resonant organ.

Keywords: resonance, enactivism, ecological psychology, jazz performance, improvisation

INTRODUCTION

Orthodox ecological psychologists and enactivists agree that the best explanation for a large share of cognition is non-representational in kind. Such antirepresentational sentiments are noted explicitly by Claire Michaels and Zolt Palatinus in their 9th commandment of ecological psychology: “thou shalt not make unto thee any mental image or likeness of *anything*” (2011, p. 25, emphasis added). In the enactivist church, Hutto and Myin (2017) are among the high-priests who declare it a mortal offense to espouse representations (also see Varela et al., 1991; Gallagher, 2017). On such views, mental representations are abstractions that do no real explanatory work. In both ecological psychology and enactivist philosophy, then, the task is to offer an *explanans* that does not rely on representations.

Different theorists within these camps have contrasting notions of what the best kind of non-representational explanation will look like. They nevertheless all agree on one central point: instead of focusing solely on factors interior to an agent, a good part of cognition is to be found in the link or coupling *between* an agent and the external world. This link is fluid, dynamic, and active in a variety of ways. Thus, the well-situated agent will pick up invariant information from the environment or engage with its world – either by choice (in the case of self-driven actions) or attraction (when something from the environment solicits and/or grabs the agent's attention) – which will in turn drive iterant loops of perception, action, and cognition. One likewise does not need to add an internal extra something in the perception-action-cognition process.

At the same time, even devout defenders of ecological psychology and enactivism recognize that plenty happens inside an agent during cognition. Furthermore, although a full, embodied story will require taking into account many bodily and affective aspects of cognition (Colombetti, 2014), including even activity in the gut guiding behavior both in concert and independently from brain activity (Davidson et al., 2018; Liang et al., 2018), no one denies that the brain plays an important role. What, then, is the role of the brain if it's not in the game of representing the environment?

One possible option is to describe the brain as a resonant organ instead of a representational organ. In what follows, we begin (in Section “RESONANCE: METAPHOR, MECHANISM, OR SOMETHING ELSE?”) by considering some of the history of resonance, especially in contact with the work of James J. Gibson, in more detail. Particular focus will be placed on two different sets of approaches that have developed the concept of resonance: (1) a representational reading of resonance and (2) a non-representational, dynamic account of resonance. Section “RESONANCE IN MUSIC PERFORMANCE” then applies these accounts to a case study on music performance, specifically in standard tonal jazz improvisation. We then conclude the paper with future considerations on research regarding the brain as a resonant organ.

RESONANCE: METAPHOR, MECHANISM, OR SOMETHING ELSE?

While the concept of resonance has played a role in the ecological psychology literature for over 50 years, it remains theoretically underdeveloped (cf. Raja, 2018, 2019). The idea that the brain resonates with the world instead of representing it first appeared in James J. Gibson's work on perception and the senses. In Gibson's words (1966):

Instead of supposing that the brain constructs or computes the objective information from a kaleidoscopic inflow of sensations, we may suppose the orienting of the organs of perception is governed by the brain so that the whole system of input and output resonates to the external information. (p. 5).

To understand the notion of resonance, following Shepard (1984), we can consider the case of how a piano resonates

with external sounds as a prototype example of a resonant system. Assume you have a guitar and are standing near a piano. You pluck an open C-string and the piano strings will shortly start vibrating in resonance with the soundwaves in the air. But the piano's C-strings will not be the only ones that vibrate in response to the original guitar note. Other strings with various harmonic relationships to C will, at the same time, become excited and start to vibrate as well, defined by specific constraints: “Resonators respond differently to the same stimuli, depending on their tuning” (Shepard, 1984, 433). There will also be amplification and resonance of the strings happening as a result of being inside an instrument. Indeed, there can be a variety of “modes of resonance” that occur in response to complex stimuli, such as an entire chord being strummed instead of an individual note (a point further discussed in Section “Representational Resonance”). We will return to this example in various parts of this paper.

While the relationship between resonance and instruments is clear, one may wonder if there is any coherent way to make sense of the idea that brains and neurons resonate in similar ways to musical instruments. Neurons, after all, are not strings or hollow tubes; they don't literally vibrate. They do however come to be involved in patterns of oscillation, firing in dynamical connection with other neurons or groups of neurons. Varela (1996), for example, had proposed a role for transient spatiotemporal patterns of synchronous neural activity in explaining cognitive events.

For example, one resonant assembly could transiently bind together the different populations of neurons involved in analyzing the shape, color, and motion of a visual object, and this temporary assembly would constitute a neural substrate for the transient perception of a visual object. (Cosmelli et al., 2007, 737)

In their review article “Resonance, oscillation and the intrinsic frequency preferences of neurons,” Hutcheon and Yarom, 2000 explore the link between different brain rhythms and different perceptual and/or behavioral states. In their words, “A series of firmly established empirical associations with the behavioral states of organisms provides compelling evidence that brain rhythms reflect basic modes of dynamical organization in the brain” (2000, 216). Further developments in the field have helped establish that these resonance processes, especially insofar as they are phylogenetically preserved, may serve some functionally relevant role (Buzsaki and Draguhn, 2004). Similarly, the development of Adaptive Resonance Theory (ART) (Carpenter and Grossberg, 2010; Grossberg, 2013) has attempted to bring together these neuroscientific findings into a general cognitive theory¹.

It is not clear that the concept of resonance in the brain is entirely captured by the notion of neural oscillations and rhythms, however. Sometimes the notion of resonance has been invoked in social cognition as two agents resonating with each other. One mechanism for this social sense of resonance is the mirror neuron system, which activates both when an agent

¹Raja (2019) briefly considers and rejects ART as an acceptable gloss of Gibson's notion of resonance because of its representational baggage.

performs an action, such as grasping a ball, and when that agent sees a conspecific performing the same action (Rizzolatti et al., 1996). Resonance within the brain in this case involves a neural system being activated by (or being sent into an oscillating pattern by) a bodily or environmental event. Other times resonance is even more metaphorical and is simply equivalent to general neural processing in response to the environment.

Considering these several distinct notions of resonance, the musical instrument example does not capture everything essential in the concept. Gibson, for example, further clarifies a possible passive misreading of resonance by noting that “The ‘resonating’ or ‘tuning’ of a system suggests the analogy of a radio receiver. This model is inadequate because there would have to be a little man to twiddle the knobs. A perceiver is a *self-tuning* system” (1966, p. 271, emphasis in original). The ability to self-tune is essential for making clear that, unlike passive systems or artifacts, cognitive resonance is not just something that the external world forces onto the organism. Indeed, sometimes resonance can occur without standard environmental inputs, such as during dreams or hallucinations. Such cases provide support to Gibson’s idea that there is an essential aspect of self-tuning involved in the system. Accordingly, embracing the idea of the brain as a resonant organ does not presuppose that the brain is a passive organ, since certain aspects of enactive resonance are not always themselves a passive process of information pick-up. Inhibitory processes can intervene, and the brain can activate in anticipation of some possible experience or activity.

For our immediate purposes, besides establishing a role for neurons resonating with each other, self-tuning may be best understood along with the idea that the brain is never isolated from the body or environment, and it always operates within this larger system to some degree. Accordingly, past experiences can set up the parameters of the resonance processes that will shape ongoing experience of the environment, which may, in turn, re-tune resonance processes. In cases of perception and action, the connection between organism and world will be a direct dynamical coupling. In cases of imagination or hallucination, the connection may not be one of direct coupling, but the patterns at play will still, to some degree, bear the mark (be similar to, or reactivate) some of the previous connections between agent and environment that correlated with perception and action in the first place (see, e.g., Lotze et al., 1999; Lee et al., 2012).

The move to highlight a self-tuning aspect to resonance alone does not solve a related issue about the nature of agency in resonance. Put succinctly, if the central claim of resonance is that all the brain is doing is resonating with ecological information, then it is not clear why any additional processing should occur inside the organism. Yet some of the choices made by an agent extend beyond information available in the environment. There is thus, it seems, a need for internal processing that cannot be explained solely by appeal to resonance. If we were working on the idea that resonance is a metaphor, then this result might be rather benign. However, all of the main theorists we will be discussing – Vicente Raja, Thomas Fuchs, and Roger Shepard – agree that resonance is a material process rather than a mere metaphor. As a result, in exploring their respective approaches,

we need to ask what is the best way to understand this relevant additional internal processing?

To achieve this goal, the remainder of this section is broken into two subsections. The first considers a representational reading of resonance. The second considers a non-representational alternative, which we shall refer to interchangeably as a dynamic reading of resonance. Since these sections will serve as the introduction to various takes on resonance, most of the critical work that has been leveled against them will be reserved for later sections of the paper.

Representational Resonance

A main and early proponent of the representational account of resonance is Shepard (1981, 1982, 1984). Some of his ideas on the topic were briefly introduced in the above case of the piano resonating with the guitar. A few more need to be added to give a complete sense of his account. In particular we need to consider the notion of a complex nesting of resonance within a cognitive hierarchy and the notion of complementarity instead of isomorphism between resonating systems (Shepard, 1984).

Since we have moved from mere metaphor to a material process, we likewise need to consider how resonance may be physically realized in a particular system such as the brain. Shepard (1984, 433) flags three upshots of resonant systems that will have implications for the use of this concept in cognitive science. First, resonant systems will have constraints that are shaped both by what is being tuned and how it is tuned. Second, there are multiple ways to excite a resonant system. Third, and in relation to the second point, there are different modes of excitation in a resonant system.

We can see these three elements in play by returning to the case of the piano as a resonant system (Shepard, 1984, 433-4; also see Raja, 2019 for different musical instrument examples). In regard to the first point, the harmonics that a piano resonates at will be impacted by how the strings have been tuned. The resulting sounds will simultaneously have a particular timbre that is shaped by various physical features of the piano, in contrast to the physical characteristics of a guitar, sax, flute, drums, etc. A similar relationship holds in the case of neurons, where some elements of their resonance patterns will be shaped by how they have been “tuned” over a lifetime of engaging with the environment, while others – such as theta, beta, or gamma brainwaves – are inherent to their nature and place in brain architecture.

In regard to the second point, the activation of strings can occur from various different signals and sources, including but not limited to soundwaves that are strong and identical to a given tuning. For instance, in addition to matching tones, resonance could be realized by sounds that are harmonically related, sources from incomplete tones, or sounds with variable energy and force. Finally, for the third point, activation of a piano is not achieved only by the strings resonating with external sounds. It may also be activated by playing other notes or chords on the piano itself, as well as plucking or striking the string directly by hand.

There are several limitations with a piano as our guiding example, in addition to those canvassed above, namely the piano is not able to be self-tuning nor begin playing on its own accord.

Not even a sophisticated pianola would entirely solve these problems. As such, we now turn to address this point through the role of a complex agential hierarchy in place for an organism but not for an inanimate object.

Shepard (1984) notes that it is important to conceptualize the various resonant modes as organized hierarchically within the system. When combined with endogenous and exogenous sources of excitation, this hierarchical system is able to pick out or represent the complex web of perceptual invariants in the environment. Sometimes it does so by moving up or down levels, perhaps focusing on high-level, general kinds (e.g., one hierarchical organization represents the sound of a doorbell) or low-level, more specific features (e.g., a lower-level part of that hierarchy represents a specific pitch regardless of timbre, or perhaps another hierarchical organization represents my parent's doorbell instead of doorbells in general). Other times a higher level may resonate directly without requiring the excitation of lower levels of the system, such as if we are simply thinking about or imagining a doorbell ringing. As a result, Shepard suggests that these internally and externally driven sources of resonance are consistent with the idea that perception is "externally guided hallucination," a claim that has since become part of predictive processing accounts of perception and action (Clark, 2013, 2016).

This view of perception as "externally guided hallucination" presupposes a view of the brain as more than just mirroring the external world. Shepard here suggests that some aspects of the brain are not directly resonating with the outside world, especially in cases of non-ideal perceptual environments. Instead of direct perception, the brain is "sympathetically excited" by purely internal activities (1984, 436). Understanding perception as a subset of hallucination, heavily subsidized by internal processes of imagination, is a view rejected by the dynamical approaches to resonance that we consider in the next section.

Shepard's account furthermore puts pressure on the role of resonance as a kind of isomorphic mirroring between agent and environment. He suggests that it is better to think of the resonance between brain and world as a case of *complementarity* patterns. For instance, consider one of Shepard's favorite examples of a key and a corresponding lock. There is a direct correspondence between a key and the lock and it is a necessary condition for the proper functioning of the locking system. However, we would be hard pressed to say that the key is isomorphic to the lock. Instead of matching, this relation between key and lock is complementary; the key complements the lock in the right sort of way to unlock or lock the door. We will return to Shepard's account again through the work of Charles Nussbaum in considering musical performance below and the idea of complimentary will play a central role in that context as well.

One may be tempted to claim here that moving away from isomorphism may itself be a move away from a representational account. Complementarity, however, may still characterize representational function insofar as it meets what Ramsey (2007) has called "the job description challenge," where the mark of representational processes is that they serve an explicit representational function. Consider the case of perception in ambiguous or non-ideal perceptual situations. In these cases, it is important that the brain can complement the available information with its own productions rather than simply pick

up information and react. Insofar as some self-tuning patterns of resonance can be stimulated and maintained by various parts of the brain, they can stand in for missing aspects of external stimuli, supplementing when the stimulus is too impoverished. This stand-in may occur in a manner that addresses the job description challenge.

Shepard (1975) himself explicitly notes the representational components of his theory in several papers (1975, 1984). The sorts of representations he has in mind here are often centered on mental imagery. Thus, in his words, "I conjecture that Gibson disavowed the term *mental image* because he could not imagine what sort of thing a mental image could be... However, in neglecting the representation of objects and events that are not physically present, Gibson seems to have given up too much" (1984, 420, emphasis in original). Shepard further cites evidence for similar durations for mental image rotation across perception and imagination to suggest that an agent must be working with a representation of an external object during imagination, when the object isn't actually present.

This notion of mental imagery in Shepard can further be thought of as representational insofar as it lines up with recent notions of structural representations. Following Piccinini (2018), this kind of representation includes (2018, 3):

- (1) A homomorphism (partial isomorphism) between a system of internal states and their target,
- (2) A causal connection from the target to the internal states,
- (3) The possibility for the internal states to be decoupled from their target, and
- (4) A role in action control.

All four of these features are indicative of Shepard's account. In addition, following Ramsey (2007), Chap (6), it seems that structural representations at least *prima facie* qualify as satisfying the job description challenge.²

Dynamic Resonance

We will now introduce two alternative approaches to resonance from enactivist and ecological psychology backgrounds. When looking at points of similarity between these two non-representationalist camps, we shall refer to them collectively as constituting a dynamic notion of resonance.³

Thomas Fuchs, like Shepard and Gibson, highlights the fact that the notion of resonance comes from considerations about acoustics and oscillations. He further draws out the acoustic language to a different metaphor of the brain as taking part in jazz improvisation. In Fuchs' words, "the brain is not the conductor of the body; rather, it is like a musician in a group of jazz musicians jointly improvising on the basis of certain chords" (2018, p. 134). This is similar to Gibson (1979/2014)

²While we are accepting that this move may be enough to distinguish Shepard's account as representational, there have been arguments against the idea that structural representations are best understood as types of representations in the first place (cf. Segundo-Ortin and Hutto, 2019).

³On one hand, one could say that Shepard also took a dynamical approach to cognition. On the other hand, insofar as representations are often offered as a stand-in for more dynamical kinds of explanations, we believe that the use of dynamical explanations here captures something importantly different from representationalists yet similar between enactivists and ecological psychologists.

motto “behavior is regular without being regulated” (1979/2014, p. 215)⁴. This improvising jazz picture can be contrasted to traditional cognitivist assumptions that neatly partition sensory input/brain processes/action output and treat the brain as a conductor. For cognitivists, the brain may be part of the body (as a conductor is part of the orchestra) yet it is essentially distinct from more strictly embodied activities and, instead, plays its main role in guiding our actions in response to our sensations (reflected in an understanding of the conductor somehow playing the orchestra as their “instrument”).

In contrast to cognitivism, a dynamical account takes as an important insight that, while the brain plays some essential and likely unique role in cognition, (1) it is not in the business of controlling the entire process of cognition, (2) it is necessarily and inextricably responsive to various aspects of the overall cognitive system in deep and consistent ways, and (3) it cannot be understood in isolation from other processes happening across the body and environment. Even the soloist in a jazz band is similarly bound by these sorts of constraints, assuming that the band is structured more around improvisation and less around playing composed music.

Fuchs suggests that the acoustical focus likewise brings the essentially temporal nature of cognition to the fore. As a result, in his words, “Resonance contains a dynamical as well as a rhythmical element and thus establishes a *temporally* overarching relation between the systems involved... ‘resonandum’ and ‘resonans’ thus cannot be separated” (2018, p. 166). Such inseparability is furthermore taken as a sign that the explanation of resonance, and of the brain in general, cannot be representational in nature; a representational account, if nothing else, must at least allow for some form of decouplability between the initial representational vehicle and its representational content (Gallagher, 2017, Chap. 5). In contrast, the *relata* in resonance in some way need to remain coupled for resonance to work: brain-body, organism-environment, you-me, etc.

Resonance can be found in two intersections, according to Fuchs. First, the brain and body resonate with each other in a dynamical, intertwined, circular process that involves homeostasis. Damasio (2010, 21) calls this a ‘resonant loop’. This brain-body resonance is tied into the fact that the brain is “*the integral of the overarching process of life* which encompasses the whole organism” (Fuchs, 2018, 119, emphasis in original). From the level of densely interconnected brain activity across the brainstem and cortex, to the role of affect as essential to cognitive activity, and out further still to the densely intertwined efferent and afferent feedback between the brain and non-neural body, changes in one locus will reverberate and resonate with all other areas in the system.

Second, there is a resonance between an organism and the environment. This particular resonance occurs through a “dynamic set of isomorphic patterns” that develop between the brain, body, and world. An example of isomorphic resonant patterns would be when a specific (or similar) brain pattern occurs in response to the presence of a specific (or similar) environmental context. Moreover, neural evidence has shown that brain patterns change in response to learning new habits and

skills, such as the increase in musical ability resulting in different neural activations compared to novices first learning how to play (Oechslin et al., 2013). Such results suggest that the dynamics of these isomorphic patterns are skill dependent on experience instead of arriving hardwired ahead of time. Fuchs’ emphasis on the isomorphic quality of resonance is tied to his endorsement of an Aristotelian formulation of intentionality, where the mind takes on the form (*eidos* or *morphe*) of the perceived object (Fuchs, 2018, 166ff).

If resonance occurs across brain, body and environment, however, then distinguishing two sorts of resonance is not enough to provide the complete story. While multiple types and scales of resonance will be essential to understanding what it means for the brain to be a resonant organ, these can be further parsed out to give a more detailed sense of exactly how all of them are ordered. According to Vicente Raja (2018, 33), there are three possible target scales for resonance: (1) the agent-CNS (Central Nervous System) interaction, i.e., “the CNS activity in relation with the overall activity of the agent in her environment,” (2) body- or inner-CNS interaction, and (3) CNS-environment interaction. While Fuchs considers resonance across these scales, he does so without marking them in these terms. Keeping them together is ultimately important for the overall account of dynamic resonance. Yet distinguishing them is equally important since it makes the contours of how different kinds of resonance relate to each other clearer than they would be otherwise.

The inner-CNS scale, which would narrowly track the first resonance presented by Fuchs, involves an important form of resonance between the CNS and other parts of the body, no doubt. The problem with placing a focus solely on this level to understand perception and/or action is that the inner-CNS scale fails to track variables at the ecological level, which are needed for the complete brain-body-world explanation of perception and action.

The CNS-environment scale, in contrast, fails to account for important ways that an agent is able to modulate and alter their interactions with the environment. More specifically, on this scale, the focus would move directly between activity of the CNS and the environment, without taking consideration of the peripheral nervous system or bodily affects. And even though the agent may not have complete control over their relationship to the environment, there is more endogenous processing going on outside of the CNS itself.

At the agent-CNS scale, which Raja takes to be the correct target for explanation, the focus is how activity of the CNS resonates with the organized activity of an agent within her environment. This scale necessarily requires drawing on the full suite of intra-organism resonances (e.g., intraneural resonance among different neurons and brain regions coupled with homeostatic resonance between the brain, heart, stomach, and lungs), including those under agential control and those outside of it, and the resonances between the embodied agent and her environment. This scale is also equivalent to a full integration of the two resonances described by Fuchs.

Raja further develops the notion of dynamic resonance by first appealing to Michael Anderson’s account of “neural reuse” for an account of resonance in the brain and, second, Dynamical Systems Theory for an account of ecological, i.e.,

⁴Thanks to a reviewer for highlighting this more direct connection to Gibson.

organism-environment, resonance. According to Raja, these are compatible theories, with structural and theoretical parallels. Neural reuse allows for a rich flexibility and sensitivity in patterns of functional connectivity to the demands of different cognitive tasks, consistent with the notion that neural resonance may change as an adjustment to different goals and tasks. As Raja notes, the idea of neural reuse is precisely expressed by Gibson in an unpublished manuscript: “a given set of neurons is equipotential for various different functions in perception and behavior. The same neuron may be excited for different uses at different times. [Accordingly] neurons, nerves, and parts of the brain have a vicarious function. A nerve cell is not the same unit in a different combination of nerve cells” (cited in Reed, 1988, p. 224).

According to proponents of neural reuse, different conjuncts of brain areas will be dynamically (re)configured as functional units depending on the task, setting up a specialized resonance in response to particular cognitive demands. The additional dynamic coupling between the brain understood as a resonant organ founded on neural reuse, on one hand, and the environment, on the other, is defined in relation to a common ecological variable that constrains the actions of the agent. Accordingly, we are able to say that the intra-organism system (i.e., the agent) as one system *resonates* dynamically with the environment in order to engage with the world. For Raja, these two systems integrate, via resonance, to form one overarching dynamical system. While there are cases of linear coupling between different (sub)systems in cognition, the vast majority of cases involve non-linear coupling [a concept also embraced by Fuchs (2018, 223)], which would imply some constraints on any isomorphic resonance). Non-linear cases are marked by an interdependency between the two (or more) systems under consideration (Van Gelder, 1995). Such non-linear coupling may be read in line with a shift from understanding the cognitive system as an agent connected with the environment to, instead, focusing our cognitive explanation on the organism-environment as itself a single relational cognitive system. Indeed, such shifts are important for moving past the internalism/externalism dichotomy that plagues traditional accounts of cognition.

Raja postulates that the resonance between these two dynamical systems is one wherein the ecological scale constrains the intraorganism scales but not vice-versa. In his words, “to explain resonance is to account for the coupling of the dynamic systems at the ecological and intra-organismic scales in terms of the ecological variable that constrains a given agent-environment interaction” (2018, 41, emphasis in original). The importance of this directionality comes from a core commitment of ecological psychology to the idea that the environment will play a particularly strong guiding force in organism-environment interactions. Moreover, Raja suggests that considerations of both biological and explanatory plausibility push toward an unequal relationship in favor of ecological constraints on the organism over and above any organism constraints on the environment.

At the same time, Raja has noted that information at the ecological scale is ultimately developed in the interplay of organism and environment (Raja, 2020; also see Raja and Anderson, 2019). Raja appeals to the work of William Warren on behavioral dynamics, among others, to help clarify this interactive

process. According to Warren, the challenge of behavior is accounting for the required mix of stability and flexibility utilized by an agent when engaged with the world. Furthermore, in his words, “[f]rom the agent’s point of view, the task is to *exploit physical and informational constraints to stabilize the intended behavior*” (Warren, 2006, 359, emphasis in original). Such an exploitation is clearly an active process on the part of the agent, which entails that the ecological variable should be understood as including the interplay between organism and environment as part of the process, rather than operating as a mere external constraint.

A major point of similarity, then, between Fuchs and Raja, and more generally between enactivists and ecological psychologists, is the appeal to dynamical non-linear coupling between brain, body, and world. In the case of action and perception, we should consider the role of enabling constraints (Anderson, 2015), where neural activity is constrained by higher-order, organism-environment dynamics. This does not mean that brain dynamics are passive. Rather, not only does brain activity function within the proper constraints of organism-environment dynamics but organism-environment dynamics are also (at least partially) enabled by brain activity. Thus, “the brain supports on-going behavior, to anticipate forthcoming behavior. ... [which] allows a healthy codetermination of action by the actor’s history and context together with the momentary contingencies that choose the behavior that is enacted” (Van Orden et al., 2012).⁵ For both enactivism and ecological approaches, once we start looking at resonance processes in the brain, we are immediately led to consider the larger system of brain-body-environment.

RESONANCE IN MUSIC PERFORMANCE

Thus far we have considered the debate around resonance on a rather abstract level. In this section, we turn to a particular case of what happens in the brains, bodies and environments of musicians during music performance. Although resonance (including both acoustic and neuronal resonance) is an important part of all different kinds of music performance, we shall primarily focus on standard tonal jazz performance. Doing so will help adjudicate between the various positions displayed above and, we believe, will ultimately side in favor of a dynamical account of resonance. As a theoretical model in its current state, we acknowledge that our account is open to empirical verification or falsification. We furthermore hope that it may serve to help guide future empirical work in various aspects of music performance and pedagogy, and developments in these areas will loop back to further help develop our theoretical account accordingly.

To begin, we will say a few words about standard tonal jazz performance. When it comes to playing a jazz standard or song, the format follows three main steps. First, the band begins by playing the “head,” which is a statement (or implication) of the main melodic line that demarcates the song. Second, the band moves into the solo section. While different subgenres of jazz embody different expectations and constraints on solo practices,

⁵We thank one of the journal reviewers for this reference.

the main constraint for the standard format is harmonic in nature: the chord changes introduced in the head are kept consistent throughout the performance, and “correct” notes are dictated by following this chord progression. Melodic and rhythmic choices, in contrast, are largely left to the decision of the performer. Third, after everyone has taken one or two choruses to play their respective solos, the band plays the outro, which is often a restatement of the head, and the song ends.

During an improvised performance, resonance happens on several different levels.

- First, the individual performer resonates with the music. This is a resonance between the sounds one creates and the sounds in the environment (e.g., the sounds made by other musicians). Much of this resonance will happen at the moment of sound creation. It may be driven by (1) consciously anticipated,⁶ and sometimes planned, notes and/or (2) feedback from awareness of the sounds that are actually created during performance. On one hand, as the music unfolds, the performance environment is constituted as a niche of musical affordances. The sounds that a musician produces could thus successfully or unsuccessfully resonate with the affordances in the environment. On the other hand, anticipatory processes and any short-term planning involved while playing suggest intra-organism resonant loops constantly underlying the performance. The combination between these respective elements constitutes what Christensen et al. (2016) call a “mesh” between anticipatory control, practiced/skilled bodily movements, and the affordances presented by the music (see Christensen and Sutton, 2019; Gallagher, in press).
- Second, there needs to be an intersubjective and affective resonance between an individual’s performance and the performance of other musicians. This may be mediated by the music itself, by conscious, non-conscious, and non-verbal perceptual cues, or sometimes by verbal feedback during performance (see Høffding, 2019; Høffding and Satne, 2019).
- Third, in some cases there may also be resonance between the musical group and the audience. Depending on the performance context and individual musicians, this final resonance may be as interactive and important as the earlier kinds, act as a unidirectional constraint (e.g., the band is shaping the audience response but the musicians have little response to audience feedback), or rather unimportant to the unfolding of the performance.

Such resonances may or may not be understood as metaphorical in nature (non-metaphorical resonance may include neural resonance; see Large (2010) for a general overview of neural resonance in music). Either way, we decided on a heavily improvised performance practice as our case study since

it presents a distinct explanatory problem for resonance in the form of a specific type of uncertainty. In musical performances that have preexistent, thick song structures, a large part of the cognitive work can be explained by appeal to a more stable performance environment (through, e.g., the use of a score or by the performance of a well-practiced song). This stable environment may involve either strong standing mental images of a music performance, a la Shepard, or it may provide a clear environmental variable that constrains intra-organismic resonance underlying action, a la Raja. Parts of these explanations may be carried directly over into jazz performance with little modification. Yet there is nevertheless an important difference between improvised and composed music to the extent that the actions of the musician are open to more immediate changes and on the fly decisions about the music. We will call this situation one of increased environmental uncertainty during jazz performance.

Uncertainty here doesn’t mean that jazz performance takes place in a poorly structured performance environment. Instead, it is meant to highlight the fact that, in addition to the importance of an agentive self-tuning of resonance, the performance space and the music itself do not impose any overly strong constraint on choices made during performance, even as they impose some constraints. Since these constraints are extremely flexible, there may be a worry that the invariant structures in the environment – a core aspect of ecological explanations – are not strong enough to stand on their own without additional internal processing of a kind eschewed by Michaels and Palatinus (2011). A soloist is not just a coupled oscillator resonating with patterns of their environment, after all. They also must create improvised choices in the moment of performance. To explain the creative possibilities of jazz performance, it seems that we must go beyond matching or strict isomorphic resonance to something more in either a representational or dynamic account of resonance.

In what follows, we will not be attempting to offer a complete account of how resonance operates during jazz performance. We will also not be offering an argument to show that a representational account of resonance cannot function to explain jazz performance. We instead will consider how the two different accounts canvased in the previous section – representational and dynamic – each make sense of jazz performance. Furthermore, we will also consider the limitations of a purely isomorphic account of resonance before we consider how more details about dynamically formed constraints between agent and environment can answer the main concern about how dynamic accounts can deal with the environmental uncertainty at hand.

Isomorphic Resonance

While we suggested above that isomorphism is not the way to go, we grant that one of the simplest routes to respond to the challenge is to insist that isomorphism is all we need to explain musical performance. Because parsimony is an important part of scientific theorizing, we will begin with what seems to be the most parsimonious account of the jazz musician isomorphically resonating with external components of the environment in order to drive a performance forward. Indeed, after invoking considerations of parsimony in particular, one may wonder why we need more than isomorphic matching, at least in the

⁶The anticipation applies not only to the process of producing notes when the musician is playing, but to hearing what is produced - which means that the musician is not passively hearing, but actively listening, which is part of what resonant self-tuning implies. In this context, for the difference between hearing and listening, understood as intelligent and selective, see Roland Barthes (1985, 247) and for an enactive understanding of this, see Carvalho (2019).

case of resonance between an agent and the environment, or specifically with the music.

A purely isomorphic analysis runs into problems with its focus on matching resonant patterns in cases where one-to-one mapping is either impossible or not preferable. This may be an artifact of focusing on perception in non-improvisational settings, where one might claim a clear connection between the invariant structures of the environment and the actions of an organism. The worry may also be the result of the artificial limitations of incorrectly focusing on the CNS-environment scale (an isomorphism between brain and environment) instead of on the agent-CNS scale (brain-body-environment).

One possible response to this concern is that the neural patterns are only partially isomorphic patterns relevant for action, rather than abstract or ideal isomorphic patterns. After all, the patterns involved in resonance involve a rich affordance landscape, laden as it is with a variety of meanings for the organism. Thus, one may suggest that isomorphic resonance is not about locking down static environmental features but, instead, grasping patterns in the world through perception, or enacting patterns in the world through action, that ultimately allow agents to act on the rich, complex, and dynamic environment.

Unfortunately, while not entirely inconsistent, some parts of Fuchs' analysis of isomorphic resonance in perception go against this reading. For instance, after appealing to Herbert Dreyfus and Charles Taylor on an Aristotelian view of the mind, Fuchs (2018) claims:

the brain could be conceived as a matrix, which like the mind is able to 'receive all forms,' that is to say, to take them over in its own structure as neural patterns or potentials. In the actual perception 'mind and object become one,' corresponding to an encompassing resonant system state in which the *same pattern or form is activated in the brain as it is displayed by the object.*" (p. 167, emphasis added).

In Aristotelian terms, the form of an object can be distinguished from its matter, and it is the form (*morphe*) that is replicated in neural patterns during perception. However, accepting this Aristotelian idea runs into a problem concerning exactly what it means to be isomorphic. What is the exact isomorphism between the taste of a good wine and its correlated neural state? Is the structural similarity of the isomorphism to be taken at a first level of isomorphism (e.g., the brain resonates with the invariant features for the taste of this particular wine) or a higher-order (e.g., the brain resonates with the invariant features of the experience of tasting this wine)? If taken in the first level sense, what does it mean to resonate with the "taste" of the wine? Indeed, which specific properties are actually being resonated with in cases of perception, aesthetic or otherwise? Since Fuchs account is supplemented by a theory of action and gestalt completion, he may be able to provide direct answers to such questions (e.g., the brain is resonating with the invariant features of the wine as it hits the taste buds⁷). Someone who only focuses on isomorphic resonance, in contrast, would be

unable to provide this more detailed account needed to explain jazz performance.

This series of questions alone is not a reason to turn toward a representational account of resonance. However, it does suggest a need for having a more detailed account of resonance beyond isomorphism. In a similar manner, since the representational resonance account has a detailed way of answering these points, we will begin with it before turning to a dynamical account.

A Need for Representations?

Facing an uncertain environment is often a main motivation for positing representational accounts in the first place. In the case of music perception, drawing on considerations from both ecological psychology and Roger Shepard, we suggest that Nussbaum (2007) account is one of the best developed of what could be construed as representational resonance applied to the case of music⁸. Before delving into the particulars of this account, however, there is one immediate issue about his clearly stated focus on an account of Western art music and its listeners (2007, 38-40) that needs to be addressed.

The worry here is that this account cannot be applied to jazz ensemble performance without some serious modifications. We grant that there is additional work, especially empirical in nature, that needs to be conducted before we can say that Nussbaum's picture as given holds up well in the case of explaining jazz performance and the perception that goes on in jazz musicians during performance. Nevertheless, most of the basic tenets underlying his theory can be applied without much reworking, such as a particular role being placed on "acceptable" moves during the development of solos that respect certain tonal, chord, and key related constraints. While this focus on harmony does not fully exhaust an account for all important aspects of jazz performance, those extensions will be equally difficult for all accounts of resonance to satisfy, and thus we shall not consider them in more detail at the current moment.

Following Gibson's definition of affordances, Nussbaum suggests that the physical music itself can act as an external representation for audience members and performers. It does so by being a series of invariant relationships, i.e., musical affordances, that are intertwined with motor and action responses to the music. If this kind of external representation were the only one in this account, it would be easily amenable to dynamical accounts of resonance. Even the most radical non-representationalist doesn't claim that there are, strictly speaking, no representations in any parts of human cognition. Language, after all, is an essential part of different cognitive capacities and an example of a representational system *par excellence*.

External representations, however, are not the only sorts of representations for Nussbaum. He instead argues that musical surfaces are "a carrier or vehicle from which information can be extracted by performing appropriate transformational operations that are supported by *representations in the human mind-brain*" (2007, 23, emphasis added). These internal representations are

⁸Nussbaum is clear that his account is representational but he does not explicitly consider it as a resonance-based account in the terms we have been exploring in this essay. However, considering the role of resonance for Shepard, we believe that this extrapolation is at least warranted as an analytical tool for our current purposes.

⁷Thanks to one of the reviewers for raising this point.

musical rules implemented in the motor system, similar in kind to Chomsky's (1965) rules in generative grammar and as developed by Lerdahl and Jackendoff (1983) in the context of musical meaning. More could be said about how this implementation process operates, but the details are unnecessary to motivate the main idea that internal representations are taken by Nussbaum as a necessary part of explaining brain function.

On this account, the role of representations seems to be even more important in improvised music because there is no score to act as an external representation storage for the music. Moreover, while the standard performance structure may set basic parameters within which a musician must perform, there remains a vast amount of possible decisions that a musician could make. Thelonious Monk, for instance, was well known for utilizing unconventional chord voicings during performance. His selection of such chords may have been available in the music, but it had to be interpreted and/or they had to be added to the piece in some way. Such decisions are indicative of a certain ambiguity for both how a jazz musician perceives the music and for how they decide what to produce next. They also mirror well the discussion of Shepard's account from section Representational Resonance.

Speaking directly in regard to ambiguity in perception, Nussbaum echoes Shepard and notes that "degraded and ambiguous inputs immediately reveal the extent to which information extraction depends on pattern completion, which in turn requires internal representations and constructive procedures that operate over these representations" (2007, 34). Instead of isomorphism, the suggestion here would be that the better push is instead for complementarity between brain and world. Such complementarity, in turn, may require the brain to represent aspects of the world rather than to isomorphically resonate with them. Resonant isomorphism may beget either representationalism or non-representationalism; in contrast, non-isomorphism would appear to require some sort of complementary representationalism. The key question therefore becomes do enactivist and ecological accounts of resonance have the resources needed to explain the process of resonance underlying jazz performance without appealing to these kinds of complementary representations?

Based on these considerations, a representational resonance account of jazz performance may be sketched as follows: assume that a trumpet player is soloing during *My Funny Valentine* in a trio consisting of her, a drummer, and a piano player. From years of practice, the trumpet player has built up a rich store of internal representations regarding her playing possibilities, including an understanding of both rhythmic and tonal possibilities for performance according to idioms in the musical language of jazz. In this particular performance, she puts those representations to use in order to address the combination of both the song structure at hand as well as the performances of the rest of the group. The uncertainty and openness of the performance space – the particular chord phrasing of the piano or the subtle tempo shifts of the drums – are supplemented by internal representations, on this account, since the invariant features of the environment alone are not enough to secure a successful performance.

Considering this brief account and the turn to complementarity, the challenge for dynamical resonance

can be restated as whether it can offer a story of complementarity without representations. Before turning to dynamic resonance, a preliminary point to consider here *contra* Nussbaum would be that his representational approach fails to acknowledge a possibility for metastability within the brain that provides the requisite flexibility, while not itself being a representational phenomenon. The brain can move into multiple different stable patterns of activation that are dependent on the specific dynamics of the action in play. Boxers, for example, will deploy different movements and fighting patterns depending on how close they are to their opponent (Rietveld et al., 2018). In a similar way, jazz musicians may choose to be more or less adventurous with their soloing based on factors such as trust, experience, and audience expectations. Such notions are not captured by the kinds of internal representations that Nussbaum utilizes in his account. While adventurousness is a broad concept, at the very least it seems to be captured by the musician's self-selection regarding how much metastable behavior they engage in when listening and performing. This metastability in behavior is further likely to be supported by neural metastabilities such as those proposed by Friston (1997).

Dynamical Resonance Returned

We currently have the following picture of dynamical resonance: dynamical resonance provides an explanation of how an organism picks up relevant environmental information, responds to it as needed, and acts without any sort of representing by the organism in any meaningful sense of the term. Enactivists maintain that agents enact a world – that is, they enact meaning – and this happens in a way that depends on a dynamical-relational coupling of organism/agent-environment. This enactivist view is fully consistent with an ecological interpretation of affordances as relational – i.e., that affordances are not agent-independent characteristics of the environment, but define an agent-environment relation. Resonance thus occurs in affordance-based responses to various aspects of the environment in order to support actions.

On this picture, the environment, in contrast to the agent, does not resonate with an organism. As described so far, the environment is there existing as a constraint or partial constraint. Understood this starkly, we are here faced with an issue: following Raja, if resonance only occurs when the musician is tightly constrained by an environmental variable, we run into a distinct problem with the uncertainty of the environment coupled with the flexible nature of improvised jazz performance.

This problem concerns the fact that even informationally rich and invariant features of a jazz performance still leave a wide latitude of possible choices for musicians. In other words, a musician may resonate with parts of the sonic world during a solo, yet their choices are not overly constrained by that resonance process. They may even refuse processes of resonance as much as become entrained by them.⁹ Part of Raja's answer to this issue may be cashed out in regards to both neural reuse, which allows for a flexible engagement between an agent

⁹This is akin to the idea of habit breaking as found in improvised dance (see Kronsted and Gallagher, in press).

and their environment, and a role for behavioral dynamics (Warren, 2006). We suggest that this move is an essential part of responding to the worry. However, it leaves open whether we should consider the cognitive explanation in this case to be of different interrelated dynamical systems – the brain (where neural reuse happens), the musician and the environment – or one overarching dynamic system consisting of a single musician-environment system. For the sake of space, we shall primarily focus on the second reading here.

The latter interpretation of a single system runs into a *prima facie* concern based on the idea that an environmental variable must constrain the intraorganism scales. In short, the single cognitive system interpretation may go against Raja (2018) position that there's a distinct environmental variable constraining the organism. To clarify what we take the heart of this worry to be, we are not concerned with the idea that the environmental constraint may be overly restrictive of an agent's behavior, nor are we concerned that the focus on an ecological variable keeps us stuck on the ecological level without giving a proper explanation of the brain as resonant organ. Instead, the issue is how to make principled sense of an environmental variable if, as enactivists argue, cognition is fundamentally an enacted improvisation among the co-performing aspects of the brain, body, and world.

One response from ecological psychologists is to note that the environment is not separate from the organism but, instead, includes it (see Segundo-Ortin et al. (2019) for more information). Another plausible option is that a co-performance among these aspects doesn't entail equal weight being distributed among all of them at all times. Enactivists need not rule out the idea that one factor may take the lead in certain circumstances. Resonance may moreover require that, in certain cases, it would make sense to talk about a variable ostensibly external to the organism or agent constraining the actions (or operating as boundary conditions on the dynamics) of the organism or agent. Instead of necessarily treating all aspects of the cognitive system as co-equals in the cognitive process, a proponent of ecological psychology may argue that there is reason for at least decomposing parts of the overall agent-environment system in ways where the balance of power, so to speak, itself can vary from circumstance to circumstance. Indeed, the appeal to enabling constraints mentioned above may be a way of grounding this sort of response.

Another important thing to note is that playing in a jazz performance is not identical to tasks such as walking down the street or moving furniture around the room.¹⁰ In enacting a performance, a musician is not only resonating with several different aspects of their environment, but, in addition, by playing the music they are creating important parts of their musical environment, capitalizing on musical affordances made

by themselves and the other musicians. In this sense, the musical (as well as the intersubjective/social) environment is resonating with the performance. The self-tuning of the performer, or group, important in Gibson's account of resonance, is at the same time a tuning of the environment. The other musicians in the group, for example, also resonate with the performance and with the music all of them are making together. Thus, we suggest that a jazz performance is one where there is mutual, looping resonances between the musicians, each other, and various aspects of their environment, important parts of which they are creating on the fly.

This mutual resonance points to what is missing from a mistakenly strong reading of environmental information acting as a unilateral constraint on human action. What is missing from it is an account of how humans and other organisms can be active forces that shape their environments. Since we can actively construct or reorganize an environment to enhance resonance processes, or to make the environment resonate with us, a full account of resonance must explain this part of the process as well, the importance of which is highlighted by theories of niche construction in particular (Laland et al., 2016). Such alterations of the environment can take place at quick timescales as well as over the course of an individual's lifetime (or multiple lifetimes, if we are considering a species and not just individuals). While the theory of neural reuse from Raja's account does reference some considerations about niche construction as it stands, it does not yet explain how organisms actively modulate their niches and the rest of the environment in real time.¹¹ While making this shift does not necessarily require a radical rethinking of core tenants of ecological psychology, foregrounding a changing and sometimes ambiguous environment is important if we are to develop a full account of resonance moving forward, especially for musical performance.

As an example of this real time environmental modulation in jazz improvisation, consider how accompanying musicians act as affordances for a soloist. The choice a bassist makes between playing a walking bass line or a consistent pedal point will impact the affordances available to a soloing sax player and call for complimentary rather than isomorphic responses. At the same time, the soloist acts as an affordance for the other musicians, especially in the case of bebop and similar subgenres. The individual and collective choices of the musician(s) in such cases will have an immediate impact on the purportedly constraining environmental variable. This impact both gives at least a modicum of control to the performers to shape the song and provides a much more dynamic environmental variable (or set of variables) with which the musicians resonate during performance.

More could also be said here about the nature of action in jazz performance. Some cases or aspects of resonance may be isomorphic, as Fuchs suggests. Other cases or aspects of resonance will be non-isomorphic. In this regard, Fuchs is heavily influenced by gestalt theories and the idea of pattern formation

¹⁰If, as we propose here, jazz performance involves quick, close to immediate, short-term resonance of the environment, rearranging furniture could support a form of slow, long-term (perhaps more metaphorical, although nonetheless material) resonance of the environment. Not only is it a rearrangement of affordances, but one could say of a furnished room that it "really resonates" (i.e., metaphorically resonates) with its inhabitant. In popular parlance, one might say that one "gets good vibes" from being in a particular environment.

¹¹One can argue that the reuse principle extends beyond neural plasticity to include "metaplasticity" (Malafouris, 2013), that is, the redeployment of artifacts, environmental resources, economic and cultural practices that, intentionally or unintentionally shape our cognitive and social practices (also see Gallagher, 2017).

when it comes to explaining action plans and actions. In short, during action, open loops between the environment and potential neural couplings are completed by resonance processes that link the environmental stimuli with planned action. In the case of a jazz solo, the improviser will combine planned moves and openness to the environment in order to properly resonate and act accordingly to make their solo.

Furthermore, following Fuchs' use of the notion of "kinetic melodies" (which derives from Luria (1973) and has also been developed by Maxine Sheets-Johnstone (2011)), we can say that a jazz improviser will deploy various learned motor gestalts and schemas to craft their particular improvisations. While there may be times when a musician decides to be more or less innovative and daring in their performance, any case of improvising will still fall back on at least some basic motoric components (e.g., a trumpet player must blow a certain way to create a sound and a pianist needs to shape their hands in certain ways to create chords). In a similar manner, following suggestions from Love (2017) ecological description of jazz improvisation, even highly skilled and creative jazz musicians, repeat runs and phrases with fair amounts of regularity during performance.

CONCLUSION

Although we have contrasted representationalist and non-representationalist accounts of resonance, our intention was not to enter into the representation war (Clark, 2015), or to offer a full account of why one should be favored over the other. That would be a different project that has been subject to ongoing debate (see Downey, 2018; Williams, 2018). Rather, our aim has been to understand and explore the concept of resonance and its possible role in understanding the dynamical processes of brain-body-environment, and to highlight some problems and possible solutions in such an account. In this respect we've considered issues pertaining to isomorphism versus complementarity, flexibility and agency, the weighting of system factors, and the possible role of environmental rearrangement or niche construction. These are issues that a dynamical resonance account needs to continue addressing as it develops.

One final addition to round out the solution is to appeal to the concept of *attunement* as either an addition or possible replacement to resonance. For instance, in considering the notion of resonance and its potential use in distributed cognition, Heft (2001) argues that:

terms such as... resonance are useful moves forward in helping us shed the dualistic trappings of inside/outside thinking. But at the same time, they may handicap thinking in a different way, by connoting a passive role for the individual relation... Because knowing processes are marked by an individual selectively engaging the environment, a term with a more intentional connotation may better direct the thinking here. In this respect, *attunement* would seem to be more suitable (366, emphasis in original).

Since all of the previous theorists discussed are aware of this issue – especially if we include Gibson (1966) clarification that

the brain is able to *self-tune*, and not merely reacting like a tuning fork excited by some soundwaves in the environment – it may be better to see attunement and resonance as co-extensive processes, rather than suggesting that we need to replace all uses of resonance with attunement or that the notion of self-tuning makes attunement somehow theoretically redundant.

There is likewise an important consideration regarding the different senses of passivity that could be at play. For instance, neither Fuchs nor Raja would argue that the brain, body, or world are static and unchanging. Indeed, even within the brain, and from single neurons all the way up to the whole brain, both acknowledge and embrace the fact that the constellation of neural activity evolves and develops over time, and this happens as it attunes to changing environments. The environment is likewise seen as integrally bound up with organisms instead of separate from them.

As such, we suggest that a full dynamical account of jazz performance will bring ecological resonance and enactive attunement to bear at the same time, where differing circumstances call for differing degrees of passivity and activity. At the same time, we hasten to add that it would be a mistake to think of the brain (or the organism, or the agent) as shifting between resonance and attunement. It is instead the case that the system is often in the process of doing both. The jazz soloist we discussed above is both resonating and attuning at the same time, after all, and we see no reason why that process would be different in other areas of cognition.

The full and dynamical account of our jazz improvisation case would therefore combine at least practices that involve resonance, attunement, and niche construction. This dynamical explanation offers a distinct story to tell regarding everything from why a musician played a specific note instead of another note, to how the entire ensemble can maintain their performance together over time.

Although novelty and uniqueness may be important for our everyday engagements, the general role of perception is not to come up with unique interpretations of the environment, but to properly orient us toward it. The same may be true for part of improvisation, at least to the extent that perception of what is already going on is needed while improvising. But such close perceptual orientation to the world does not seem to be true for all of improvisation. Likewise, while perception in jazz performance requires similar sorts of resonance as perception in other contexts – in order to perform, an improvising musician must be attuned and responsive to what has been played and is currently being played, just like someone walking down the street must be attuned and responsive to what is happening on the ground and around them – the jazz case goes beyond them as well. Jazz improvisers often place a premium on novelty and unique engagement with the environment, regardless of whether they stay close or move far away from source material during performance.

A continued engagement with this issue will require furthering considerations about resonance and attunement processes for agents acting in the world. We hope we have shown that we can approach such issues with a stronger sense of how ecological and enactive accounts of resonance resonate, and to what degree

they hold in a fully developed account of music perception and production in particular, and perception and action in general.

AUTHOR CONTRIBUTIONS

KR and SG co-wrote and co-edited the entire document.

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