Fig. 1: Sub-dural electrocorticographic electrode arrays were placed on the sub-temporal cortical surface of 6 epileptic patients. They then performed a basic face and house discrimination task. Subjects were presented with simple, luminance and contrast matched, grayscale faces and houses that were displayed in random order for 400ms each, with inter-stimulus interval between. Subjects were asked to report a simple target, while the electrical potential was measured from each electrode, and a broadband spectral change was isolated from this.

Fig 2: Averaged raw potentials (left) and decoupled, $C_1(t)$, traces (middle) in a single subject demonstrate different specificity of peri-fusiform response for faces (light trace) and houses (dark trace). The column on the right is the projection of the 1st principal spectral component to windowed spectra from each cue (see Fig. 4).

Fig 3: The dynamics of subtemporal neuronal populations in a single subject. (A) Two electrodes (“medial” and “lateral”) on a single sub-temporal strip. (B) Projections of the first principal component. Dark background indicates the 400ms house stimulus presentation durations. Light background indicates times of face presentation. (C-D) Individual trajectories for each face and house presentation. (E) Histogram of latencies to peak of the response to houses in the medial electrode, and faces in the lateral electrode. (F) Total population response activity as mean amplitude from 100ms-500ms post stimulus (see Fig. 4). This demonstrates that the onset of cortical activity can be assessed on a single trial basis, with high temporal fidelity. These properties were robust across all 6 subjects.
Fig 4 Methods: (A &E) The scalp-referenced ECoG potentials were re-referenced with respect to the common average reference across all electrodes. (B) From each electrode, samples of power spectral density (PSD; $P(f, \tau_q)$) were calculated from 1 second epochs centered at the middle of each stimulus presentation, $\tau_q$. (C) Individual $P(f, \tau_q)$, were normalized in two steps: each spectral sample was element-wise divided by the average across the ensemble, at each frequency, and then the log was taken. A principal component method was then applied to try to identify motifs of movement-related change in the PSD. In the first step of this decomposition, the covariance matrix $C(f, \mathbf{f})$ between frequencies is calculated. The eigenvalues, $\lambda_k$, and eigenvectors, $\mathbf{F}_k$, of this matrix (left inset of (D)) reveal the robust common features during visual perception. We name these $\mathbf{F}_k$ “Principal Spectral Components” (PSCs), and order them according to importance, as determined by the magnitude of the corresponding $\lambda_k$. (F) Continuous time-frequency approximations (dynamic spectra) were calculated using a wavelet approach. In each channel, the time-varying Fourier component $\hat{V}(t, f)$ was calculated, with fixed uncertainty between the estimate of the instantaneous amplitude and phase vs. the temporal resolution, using a complex Morlet filter at each Hz. (G) The projection of the 1st principal spectral component can then be estimated at each point in time, by back-projecting the continuous spectra, $e_k(f) \ast \hat{P}(f, t)$, smoothing, normalizing, and re-exponenting to obtain the quantity $C_1(t)$. (H) In response to each stimulus, the time to first peak response can be estimated (yellow arrow), as well as the amplitude of the response (area in pink divided by total time) (see Fig. 3E&F).