Exponential Scaling of Nested Neuronal Representations

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In many neuronal coding schemes, the stimulus resolution grow linearly in the number of encoding neurons [1]. We show that nested codes containing self-similar, periodic modules can achieve a resolution that is exponential in the number of neurons, even though the spiking of individual neurons is noisy. This scaling is independent of the dimension D of the stimulus space and leads to a resolution that is orders of magnitude better than a standard neuronal population code and generalizes an older result [2].

Neurons in the superficial layers of medial entorhinal cortex (mEC) exhibit grid-like firing maps of planar space at different spatial scales, just as required for modular coding. Our theoretical analysis indicates that these grid cell properties endow the brain with a highly accurate representation of space; the same principles could be used for representing other continuous, high-dimensional stimuli.