Embedded Ensemble Encoding
- a new theory of brain cortex function

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Abstract

We are developing a novel embedded-ensemble encoding (EEE) theory for mammalian neocortex to unify scales of cell, network and region in the brain, and to infer general principles of how information is processed in the brain. EEE theory is based on the observation that cortical pyramidal neurons produce synaptically-induced dendritic plateau potentials that place an individual neuron into an activated state. This brings that neuron near to threshold, and also reduces membrane time constant. Because of these changes the activated cell **PN**$_{act}$ can readily and rapidly follow synaptic inputs. We hypothesize that ensembles of these activated cells provide the activated ensemble **E**$_{act}$, embedded in the overall cells of the column. There is then a second embedding of an ensemble based on synchronized spiking among the cells of **E**$_{act}$. This twice-embedded ensemble is denoted as **E**$_{sync}$, with **E**$_{sync} \subset$ **E**$_{act}$. Synchronized spike coding *within area* then provides the substrate for a broad distributed ensemble *across areas* that would allow the binding of multimodal features into coherent object perception based on binding-by-synchrony theory. In neuroscience detailed predictions for measures in the brain must be obtained by instantiating theory in simulation, which allows the experimentalist to correlate with the scales and measures that are experimentally accessible. We therefore closely develop theory by connecting detailed mechanistic multiscale models to voltage-sensitive dye imaging, ion-sensitive dye imaging and whole-cell patch recordings of neurons. We propose that EEE theory will reconcile rate-coding theory with binding-by-synchrony theory. EEE also has implications for Bayesian predictive coding theory – we propose the outer ensemble as a predictor for codings in the nested ensemble.