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Poster presentation

Interplay between spontaneous and sensory activities in barrel cortex: a computational study

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Introduction

The observation that cortical neuronal responses to repeated application of the same stimulus have a high degree of "trial to trial" variability has led to the notion that neuronal responses are affected by the intrinsic spontaneous state of the system and are not solely a direct reflection of the sensory input. Complementing this, a number of sources of recent evidence have suggested that ongoing ("spontaneous") spatiotemporal patterns of activity do not merely reflect stochastic network fluctuations and internal noise sources, but can be affected by the recent history of sensory experience. This evidence includes multi-electrode array recordings, voltage sensitive dye imaging [1,2], as well as electron-microscopic evidence of a change in inhibitory synapse density and concomitant physiological changes after a substantial period of whisker stimulation [3]. These observations lead to some interesting questions. Is the spontaneous functional connectivity network itself modified by sensory-evoked activity? And if so, what mechanisms could account for it, and what information processing tasks might such a phenomenon help to perform? We are specifically testing a hypothesis that varieties of spike timing dependent plasticity (STDP) that have been previously documented can account for this effect.

To address these questions, we have developed a biologically inspired model of (initially) a single barrel, consisting of approximately 2000 neurons (Izhikevich point neuron model, [4]). We model layers 2/3 and 4 each representing a 200 μm × 200 μm × 200 μm cube of tissue. The connectivity is random with connection probabilities for each neuron class (layer 2/3: excitatory pyramidal, and inhibitory basket and non-basket; layer 4: excitatory spiny stellate) constrained by data from the physiological literature. STDP occurs at the excitatory synapses. Sensory evoked activity is generated by direct input to layer 4 neurons from a Linear-Nonlinear-Poisson (LNP) model of thalamic nucleus VPm with experimentally recorded thalamic transfer functions [5]. Our model accounts for spontaneous activity in the barrel cortex and allows us to generate specific testable predictions concerning the effect of temporally patterned whisker stimulation on spontaneous spatiotemporal dynamics in barrel cortex. This model may help us to generate and refine hypotheses concerning the role of ongoing network activity in memory consolidation and perceptual learning.

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