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Poster presentation

Signal discrimination performed by population of spiking neurons enhanced by a background gamma oscillations

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Selective attention increases the gamma-band power of local field potentials in the cortex and the coherence between local field potentials and the spikes when an attended object falls in the receptive field [1]. Mechanisms by which a population of connected neurons produces such gamma-band oscillations have been established, both by experiments and modeling studies [2]. From a cognitive viewpoint, attention enhances performance of discrimination tasks, where relevant stimuli compete with distracters [1,3]. However, how gamma-band activity can benefit subjects performing attention-related tasks has not been understood sufficiently (but see [4] for a recent advancement).

In this presentation, we analyze a population of noisy unconnected neurons (binary neurons and leaky integrate-and-fire neurons) subject to external gamma-band activity, which we interpret to be generated by a different part of the brain. We show that the performance of discriminating two static signals is enhanced by moderate amplitudes of gamma modulation [5]. The discrimination scheme that we consider is based on the spike count calculated from the response of the neural population. For very weak gamma modulation, the spike-count variability is very large for both stimuli because the spike-count statistics follow the Poisson distribution. For intermediate modulation amplitudes, the neurons quite likely fire around the peaks of the gamma oscillation. In this situation, the spike-count variability is small because most neurons are forced to fire just once. In contrast, the neurons seldom fire in other phases of the gamma cycle, suppressing unreliable spiking events that would deteriorate the signal discrimination. As a result, a neuron fires once every gamma cycle with high probability [5,6]. This phenomenon occurs only for the stronger of the two stimuli in this intermediate regime. For a very strong gamma modulation, spike-count variability is decreased for both stimuli. However, the mean spike count is almost indistinguishable for the two stimuli, which makes the signal discrimination difficult. We also numerically show that a range of the stimulus strength for which the enhanced signal discrimination occurs is not small and that the strongest enhancement occurs for stimuli near the threshold level for firing.

Our results provide an important link between the dynamics of neural populations and the discrimination tasks in which attention is known to enhance performance.

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