Abstract of Presentation

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Long-tailed EPSP distribution accounts for origin and role of noise in cortical networks

Abstract :

In vivo cortical neurons exhibit a low rate, irregular and asynchronous firing even in the absence of external stimuli. The spontaneous cortical activity, or ongoing activity, has been described in relation to sleep or anesthesia, and is presumably influential in sensory perception and conversely modifiable by sensory experience. However, the underlying mechanism, or especially the functional role, of the ongoing activity is poorly understood. Recent electrophysiological recordings revealed that some cortico-cortical excitatory postsynaptic potentials (EPSPs) can be as large as several millivolts, while the majority EPSPs are weak (< 1 mV). Here we show theoretically that In the absence of external input and background noise, low-rate irregular firing emerges spontaneously in cortical networks of spiking leaky integrate-and-fire neurons when the spread of amplitude of EPSPs evoked on a single neuron obeys a long-tailed, typically lognormal, distribution reported in these experiments. In such a network, massive asynchronous spike inputs to weak synapses are crucial for inducing a subthreshold depolarized UP state. Remarkably, neurons in this state are critical and can maximally transmit information about both rate and timing of presynaptic spikes received at extremely strong synapses. This result indicates that the coexistence of irregular firing and a millisecond-precise spike sequence is not a paradox, but rather the essence of neural code. The maximal information transmission is also confirmed by dynamic clamp recordings from cortical neurons. These results suggest that the brain actively generates internal noise to optimize the reliability of information processing.