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Genesis and synchronization properties of fast neural oscillations[1]

MAXIM BAZHENOV, Salk Institute, NIKOLAI RULKOV, UCSD — Fast neural network oscillations in gamma (30-80 Hz) range are associated with attentiveness and sensory perception and have strong relation to both cognitive processing and temporal binding of sensory stimuli. These oscillations are found in different brain systems including cerebral cortex, hippocampus and olfactory bulb. Cortical gamma oscillations may become synchronized within 1-2 msec over distances up to a few millimeters. In this study we used computational network models to analyze basic synaptic mechanisms and synchronization properties of fast neural oscillations. Using the network models of synaptically coupled pyramidal neurons (up to 500,000 cells) and fast spiking interneurons (up to 125,000 cells) we found that the strength of feedback inhibition determined the network synchronization state: either global network oscillations with near zero phase lag between remote sites or waves of gamma activity propagating through the network. Long-range excitatory connections between pyramidal cells were not required for long-range synchronization. The model predicts that local inhibitory circuits can mediate global network synchronization with phase delays being much smaller than activity propagation time between remote network sites.

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