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Recurrent inhibition can enhance spontaneous neuronal firing

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Inhibitory interneurons in neocortex, while dampening some behaviors, can also facilitate activity, e.g., helping to sharpen transients and synchronize gamma oscillations. We propose that feedback from fast inhibition can also enhance the spontaneous firing of principal cells. Here we study an idealized feedback model. We drive the Hodgkin-Huxley conductance-based model by external Poisson alpha-function excitatory synaptic input. Its output spikes lead (1 for 1) to recurrent inhibitory synaptic inputs (delayed by δ). We find that the recurrent inhibition can enhance the neuron's firing rate if τ_{inh} is fast enough; the dependence of this enhancement on δ is weak. The spontaneous firing without inhibition is due to temporal summation of subthreshold inputs. The recurrent inhibition (that occurs δ ms later) may reduce the spike threshold of the membrane briefly (e.g, by transiently reducing g_K) and thereby facilitates the next subthreshold excitatory event to evoke a new spike. This mechanism is different from classical postinhibitory rebound, and occurs in the current model for a wide range of δ values, and for short decay times of inhibition. This may have interesting ramifications in understanding the role of inhibitory synapses in neocortex.

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Predicting synchronized neural assemblies from experimentally estimated phase-resetting curves

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Assemblies of (transiently) synchronized neurons have been observed in a variety of neural systems. This phenomenon is reminiscent of the formation of clusters in models of coupled phase oscillators. To investigate real neural networks as systems of coupled oscillators, we have recently proposed an efficient method to estimate phase-resetting curves (PRCs) in real neurons with whole-cell patch-clamp procedures. In particular, we have applied our approach to the study of the neural dynamics in the mammalian olfactory bulb (OB). First we found that i) the estimated PRC of the mitral cells have positive and partially negative regions (type II neurons or resonators); ii) these PRCs possess higher order harmonics, a necessary condition for the formation of more than one oscillator clusters. The PRC-based phase models showed that neurons quickly organized into subsets of synchronized assemblies. The type and pattern of synaptic interactions determined the nature of these assemblies. For excitatory connections neurons divided into three equidistant assemblies were obtained. For inhibitory connections two close assemblies were found. These examples suggest that this simple model can reproduce many features of (transient) synchronization and have led us to begin a more thorough investigation of these phenomena in phase models.