Abstract View

IMPACT OF CORRELATED INPUT SPIKE TRAINS ON THE FIRING RATE AND VARIABILITY OF A POSTSYNAPTIC NEURON--A MODELING STUDY.

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In cortical neurons, the arrival of a spike from one input may or may not be correlated with the arrival of other spikes from different inputs. We asked how the firing rate and variability of a postsynaptic neuron vary as functions of the correlations between its input spike trains. We developed a stochastic model in which the membrane potential performs a random-walk toward threshold, and derived an analytic solution for the mean output firing rate as a function of the firing rates and pairwise correlations of the inputs. This model made three quantitative predictions. (1) Correlations between excitatory-excitatory or inhibitory-inhibitory input pairs increase the fluctuations in synaptic drive, whereas correlations between excitatory-inhibitory pairs decrease them. (2) These fluctuations may increase firing probability substantially, particularly when the output firing rate is low. (3) The strength and details of these interactions depend critically on the balance between excitation and inhibition. The results were confirmed and extended through computer simulations of an integrate-and-fire neuron with multiple conductances and hundreds of inputs. The input-output rate curves and the changes produced by various correlation patterns observed in simulations were in excellent agreement with the theoretical predictions. The results suggest that weak temporal correlations produced by signals shared among inputs may have two major effects upon a typical cortical neuron: first, to raise its firing probability appreciably, particularly around firing threshold, and second, to increase the variability of the output spike train at all rates.

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