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Poster presentation

On the sensitivity of spiking responses to noise

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One potential role of ion channels is to set the timing precision of action potentials, which is known to depend on the stimulus as well as on the properties of the responding neuron. Here, we analyze conductance-based model neurons and show that ionic conductances can set the overall sensitivity of spike timing to noise in a mean-driven firing regime, i.e. if the stimulus mean is above threshold. In this case, ionic conductances can widen or narrow the range of stimulus frequencies that are transmitted with high temporal precision and influence the speed of spike decorrelation in responses to step stimuli in the presence of noise. Moreover, we show that such a dependence of the sensitivity to noise on ionic conductances is reflected in neuronal phase-response curves, which characterize the impact of perturbations on the timing of the following spike as a function of firing phase. In particular, we show mathematically that the jitter of action potential timing can be derived from phase-response curves in a quantitative fashion. This type of analysis allows to predict the influence of individual ion channel types on spike precision and leads us to conclude that temporal precision of responses to rhythmic stimulation is, for example, increased by slow potassium channels while it is impaired by persistent sodium channels. As malfunctions of individual ion channel types can lead to serious neurological diseases affecting network synchronization, such as epilepsy, it is important to further explore the role of ionic conductances for signal processing in individual neurons as well as neuronal networks.