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How stochastic adaptation currents shape interspike interval statistics of neurons - theory and experiment

Trial-to-trial variability and irregular spiking is an ubiquitous phenomenon throughout the nervous system. In many cases, the origin of this neural noise is not known and difficult to access experimentally. Here, we explore the possibility to distinguish between two kinds of intrinsic noise solely from the interspike interval (ISI) statistics of a neuron. To this end, we consider an integrate-and-fire model with spike-frequency adaptation in which fluctuations (channel noise) are either associated with fast ionic currents or with slow adaptation currents. We show by means of analytical techniques that the shape of the ISI histograms and the ISI correlations are markedly different in both cases: for a deterministic adaptation current, ISIs are distributed according to an inverse Gaussian density and the ISI correlations are negative. In contrast, for stochastic adaptation currents, the ISI density is more peaked than an inverse Gaussian density and the serial correlations are positive. We applied these measures to intracellular recordings of locust auditory receptor cells in vivo. By varying the stimulus intensity, we observed intriguingly similar statistics corresponding to both cases of the model. The results suggest that stochasticity of slow adaptation currents may contribute to neural variability in sensory neurons.

REFERENCES

[1] Schwalger T, Fisch K, Benda J, Lindner B: How noisy adaptation of neurons shapes interspike interval histograms and correlations. PLoS Comput Biol 2010, 6(12): e1001026