Abstract View

RELIABILITY, PRECISION AND THE NEURONAL CODE

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Reliability is the reproducibility of a neuron's spike train in response to repeated presentations of the same stimulus. A high reliability characterizes neurons that can support a spike-time code, unlike neurons with discharges forming a renewal process (such as a Poisson process). These two classes of cells cannot be distinguished using a reliability measure based on the firing-rate histogram. In model neurons, state variables representing the neuronal dynamics converge from a set of initial values to an attractor, leading to a reproducible sequence of spike times. Intrinsic noise introduces jitter in the spike times. We define a new measure of reliability, R, based on these attractors and how the jitter increases with the standard deviation d of the noise. When the neuron stays on one attractor, R=1 and the jitter in the nth spike time is proportional to d. When the neuron visits q attractors on different trials, R=1/q and the jitter increases faster than d. For a renewal process, R=0. We determined the reliability and stability of the attractors for an integrate-and-fire neuron driven by constant current I, white noise current with standard deviation d, and external driving force f(t). When f is random or strongly quasiperiodic, most spikes are reliable but there are always unreliable spikes. When f is periodic, either all spikes are reliable, or all are unreliable. This leads to a reliability resonance as a function of driving frequency, the reliability being maximal when the neuron produces one spike per drive cycle. Theoretical results were compared to experimental data from rat neocortical slices.
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