Response variability of type-1 neurons to periodic and random pulsatile input

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Globus pallidus (GPe) and subthalamic nucleus (STN) neurons of the basal ganglia communicate with inhibitory and excitatory efferents respectively, but individual cells are not necessarily reciprocally connected [1]. Examining previous models [2] reveals that neurons with both type-1 and type-2 phase response curves (PRCs) could be involved in the GPe-STN circuitry. *In vivo* and *in vitro* GPe recordings show spike time variability that may be due to stochastic external synaptic input, periodic input, or intrinsic membrane noise. In an effort to systematically understand the variability caused by various intrinsic and extrinsic factors (including periodic and stochastic [3]), we report here some modeling work on response properties of type-1 neurons (with period T_0) to periodic (T_f) and random (with Gaussian noise η) external pulsatile input by using piece-wise linear approximations to the corresponding typical PRCs. 1:1 phaselocking is achieved for $r(= T_f/T_0) < 1$, but large enough that $r > 1 - A$, where A is the maximum phase advancement of the PRC. The stability of this state depends also on the skewness of the PRC (parametrized by M). PRCs with right skewness allow synchrony for stronger stimuli, but left skewed PRCs limit the stability region to $A < 2(1 - M)$. Thus left skewed PRCs can show a bigger parametric region displaying a variable spike output. The neuron's desynchronizing mechanism and the firing rate variabilities are studied around but outside of 1:1 locked state. For r close to unity, the coefficient of variation (CV) of the interspike intervals is a sensitive function of the skewness factor M. But for weaker stimuli or for $r \ll 1$, CV is high but confined to a narrow range. The results are extended to two and large number of uncoupled neurons with type-1 PRCs that are receiving common periodic and/or random inputs.

References

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