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NEUROSCIENCE 2012

Presentation Abstract

Program#/Poster#: 790.20/UU13

Presentation Title: Achieving large coefficient of variation in subthalamic neurons exhibiting type-1 phase response curve behavior

Location: Hall F-J

Presentation time: Wednesday, Oct 17, 2012, 11:00 AM -12:00 PM

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Abstract: Spike time recordings of subthalamic neurons (STN) of the basal ganglia can exhibit high (up to 1) coefficient of variation of inter spike intervals (CV) in vivo, but slice experiments reveal that they are spontaneously oscillatory with very low CV. The origin of such high variability in oscillatory neurons could be either intrinsic noise, or noisy synaptic input interacting with ion channel dynamics. We address here the role of noisy synaptic input and its interaction with low-threshold calcium (T) currents in controlling inter-spike interval variability. The STN neurons predominantly speed up the oscillation frequency (i.e. show phase advancement) in response to an excitatory test stimulus placed during their ongoing oscillation (type-1 behavior). Such phase responses can be quantified by phase response curves (PRCs). We study model neurons described by Wang and Buzsaki equations that result in type-1 behavior to quantitatively investigate whether and how the proximity of the model to the spike onset plays a role in determining the high CV. Near the bifurcation, but in the regime of oscillation, excitatory Poisson input applied to the oscillating type-1 PRC model causes very small CV when the firing rate is small. Increasing the Poisson input frequency increases the firing rate and raises the CV, but the rise is very small (less than 0.2 even for frequencies above 50 Hz). On the other hand, inhibitory Poisson input reduces the firing rate with increasing input frequency, and in effect raising the CV from 0 to levels up to 1. A neuron spontaneously oscillating at 26 Hz reduces its frequency below 5 Hz with CV above 0.5 when subjected to a Poisson inhibitory synaptic input of 1 kHz or more with a weak synaptic strength of 0.01 mS/cm/cm (using a double exponential synaptic function with rise time of 0.1 ms and decay rate of 10 ms). Placing the model neuron farther into oscillatory regime and thus away from the bifurcation point that represents spike onset widens the window of high CV to bigger firing rates, but it also requires synaptic input with much higher Poisson rate. Activating T-current introduces spike bursts increasing the firing rate and also the CV. We study the role of T-current in further enhancing the CV at higher frequencies.

Disclosures: **R. Dodla:** None. **C.J. Wilson:** None.

Keyword(s): SUBTHALAMIC NUCLEUS

NOISE

PHASE RESPONSE CURVE

Support: NIH Grant NS047085

[Authors]. [Abstract Title]. Program No. XXX.XX. 2012 Neuroscience Meeting Planner. New Orleans, LA: Society for Neuroscience, 2012. Online.