BMC Neuroscience

BioMed Central

Oral presentation

Parameter dependent changes in strength of phase locking in a stochastic simulated central pattern generator

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from Seventeenth Annual Computational Neuroscience Meeting: CNS*2008
Portland, OR, USA. 19–24 July 2008

Published: 11 July 2008

BMC Neuroscience 2008, **9**(Suppl 1):O4 doi:10.1186/1471-2202-9-S1-O4

This abstract is available from: http://www.biomedcentral.com/1471-2202/9/S1/O4

Walking behavior is produced by an oscillatory network of neurons termed the spinal central pattern generator for locomotion (sCPG). The basic building block of this sCPG is a half-center oscillator composed of two mutually inhibitory sets of interneurons each controlling one of the two dominant phases of the locomotor cycle: flexion and extension. The identity and function of neurons making up the sCPG are currently poorly characterized [1].

Simulated networks based upon such a half-center organization have been studied extensively [2,3]. However, many biologically relevant properties of such networks remain uncharacterized. Here we examine noise induced differences in the behavior of half-centers composed of the non-intrinsically oscillatory leaky integrator, and the oscillatory Morris-Lecar neuron. We track four properties of the output of the network over multiple parameter regimes: 1, Strength of phase locking between burst offset and onset times; 2, Relative timing of burst offset and burst onset; 3, Correlations between burst durations; and 4, Cycle period. We find that for all parameters tested the leaky integrator half-center oscillator exhibits strong phase locking between burst offsets and burst onsets. Within the Morris-Lecar half-center, strength of phase locking is malleable and depends upon the balance of excitation and inhibition within each simulated neuron. Changes in phase locking are associated with changes in the latency or temporal distance between burst offsets and onsets.

Previous analyses have shown that biological fictive locomotion exhibits asymmetries in the strength of phase locking between flexor and extensor burst onsets and offsets [4]. The transition from extension to flexion exhibits phase locking which is always strong, while the opposing transition from flexion to extension exhibits phase locking that is weak for a subset of cycles. Such a result implies that there are important structural differences between neurons making up the flexor and extensor portions of the half-center. One possibility suggested by the models is that the flexor and extensor portions of the half-center possess different levels of self-inhibition. These differences in self-inhibition could interact with varying levels of excitation in the presence of noise to explain observed differences in strength of phase locking.

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