Bifurcation of polyrhythmic patterns in 3-cell bursting motifs

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We examine multistability of several coexisting bursting patterns in a central pattern generator network composed of three Hodgkin-Huxley type cells coupled reciprocally by inhibitory synapses.
It is established that the control of switching between bursting polyrhythms and their bifurcations are determined by the temporal characteristics, such as the duty cycle, of networked interneurons and the coupling strength asymmetry.
A computationally effective approach to the reduction of dynamics of the nine-dimensional network to two-dimensional Poincare return mappings for phase lags between the interneurons is presented. We describe the effective way educe detailed models of central pattern generators to equation-less return mappings for the phase lags between the constituting bursting interneurons. Such mappings are studied geometrically as the model parameters, including coupling properties of inhibitory and excitatory synapses, or external inputs are varied. Bifurcations of the fixed points and invariant curves of the mappings corresponding to various types of rhythmic activity are examined. These changes uncover possible biophysical mechanisms for control and modulation of motor-pattern generation. Our analysis does not require explicit phase equations that model the system, and so provides a powerful new approach to studying detailed models, applicable to a variety of biological phenomena beyond motor control.
We demonstrate our technique on a motif of three reciprocally coupled, inhibitory and excitatory, cells that is able to produce multiple patterns of bursting rhythms. Motifs of three coupled cells are a common network configuration including models of biological central pattern generators.
The family of 2D mappings reveals the organizing centers of emergent polyrhythmic patterns and their bifurcations, as the asymmetry of the synaptic coupling is varied.

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