EXPERIMENTAL PHASE RELATION CAPTURED BY MODEL CENTRAL PATTERN GENERATOR

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ABSTRACT. Central pattern generators (CPGs), that are groups of neurons forming small networks via synaptic connections, can be identified by observing their activity patterns in behaving animals. In our study, we explore a plausible network that represent swim CPG in the marine invertebrate ? Melibe leonina. We employ mathematical models developed using Hodgkin-Huxley formalism with parameter estimation from leech heart interneurons. The model of leech interneurons has been studied extensively and shown, both mathematically and experimentally, to have the ability to transition into a number of distinct patterns including square wave bursting, spiking, and chaos. In addition, multistability with two or more coexisting stable patterns has been reported for this model. We design the CPG models inspired by the specific phase relations seen in the experimental voltage traces. We include four neurons, connected via fast non-delayed inhibitory synapses modeled by fast threshold modulating function (FTM). Due to intrinsic symmetry, the network can be treated as two pairs of half center oscillators (HCOs). In the HCO, neurons reciprocally inhibit each other, leading to activity patterns that alternate. We consider unidirectional inhibition between the pairs of HCOs, and find phase-locked state that is idiosyncratic of the experimental system. We identify control parameters for the pattern in question, which corresponds to a single attractor for the phase-lag return mapping on a 3D torus. Our goal is to explain the mechanism that causes the particular phase-locked state and explore parametric regime for sensitivity and emergence of additional patterns in the system. In the future, we plan to enhance the CPG models by including extra interneurons ans synapses of other types, introducing heterogeneity in network connections and by increasing physiological fine details that are currently neglected. Mechanistic understanding of CPGs is important for engineering equipments that are dynamically controlled by circuits, such as in robotics and prosthetics.