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Introduction

Synaptic depression is a type of short-term plasticity that is observed in many rhythmically active networks [1]. We examine the role that synaptic depression plays in determining the phase of a group of neurons of the crab stomatogastric nervous system. We mathematically construct and analyze a model network consisting of an oscillator neuron that inhibits two follower neurons. We show that constant phase maintenance can be achieved solely through the interplay of the two follower neurons due to the depressive nature of their synaptic connectivity.

Model

The network we are studying is comprised of three neurons, AB, LP, and PY. AB is the pacemaker neuron of the pyloric network while LP and PY are the follower neurons. The activity of these neurons is modeled using Morris-Lecar type first order differential equations. LP and PY receive synaptic inputs from one another and from AB; see figure 1. The synapses are depressing and inhibitory meaning that the strength of the synapse weakens while the pre-synaptic neuron is active. The set of equations used to model this network is similar in form to that of [2].

Results and conclusion

To understand the effect of the depressing synapses between LP and PY, we derived a set of equations that allows us to determine the time at which LP and PY enter their active states relative to when AB enters its active state. This then allowed us to determine which parameters most signifficantly contribute to the phase of LP, Φ_{LP}, and the phase of PY, Φ_{PY}. We found that reciprocal inhibition between LP and PY leads to better phase maintenance than when AB is the sole input to these neurons. This occurs because when the reciprocal inhibition is present, Φ_{LP} and Φ_{PY} are determined mostly by the synaptic properties rather than by their membrane kinetics. In addition, we found that when the input from the oscillator neuron

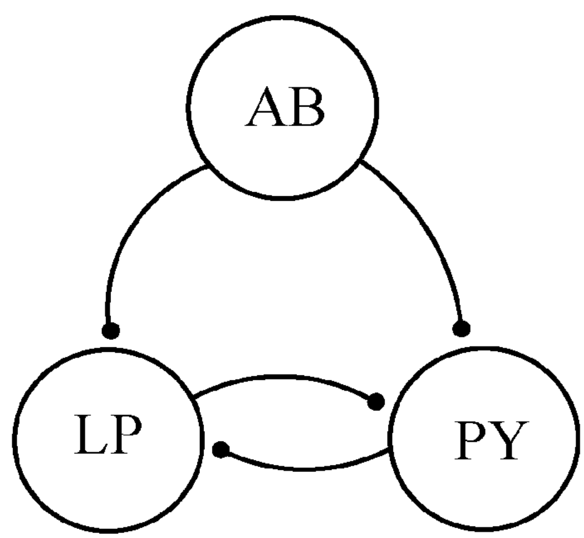

Figure 1
Crab pyloric network.

AB is not depressing, the connectivity between LP and PY is in fact able to produce phase maintenance. The essential property necessary to produce this phase maintenance is for the synapses to increasingly recover from the synaptic depression as the period increases. However, phase maintenance is optimal when the synapse from AB is depressing. Furthermore, these analytic results can be compared to experimental data and can be used to make predications about the biological network in the absence of synaptic depression from the group pacemaker.

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