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POSTER PRESENTATION

Synapses showing a preferred frequency in a reciprocally inhibitory neuronal network

Myongkeun Oh[1*], Hua-an Tseng[2], Farzan Nadim[1,2]

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Experimental and theoretical analysis suggest that a synapse capable of exhibiting both short-term facilitation and depression acts as a band-pass filter – where efficacy is maximal at an input frequency referred to as the preferred (resonance) frequency [3]. Different synapses from the same presynaptic cell can display different preferred frequencies [1,2]. It has been suggested that such frequency filtering by a synapse can provide an effective tool for selective communication between neurons [1]. However, little is known about the functional role of resonant synapses in network activity.

Recent data from our lab indicates that inhibitory synapses in the crab pyloric central pattern generator (freq ~ 1 Hz) show resonance with a preferred presynaptic frequency of ~ 0.5 Hz (Fig. 1A). Additionally, it is known that the bursting pacemaker neurons and some bursting follower neurons in this network have maximum impedance frequencies in response to periodic current injection (membrane resonance), all within the range of the network frequency [4]. To explore the potential role of synaptic preferred frequency, we use a model consisting of two neurons

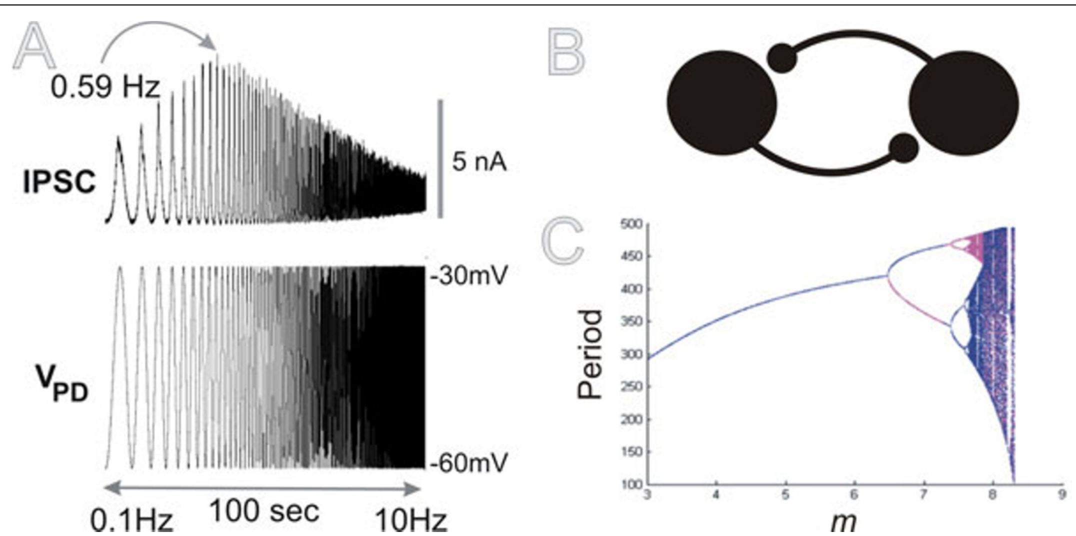

Figure 1 A model of two reciprocally inhibitory neurons coupled with synapses showing a preferred frequency. A. Pyloric synapses show a preferred frequency as shown in voltage clamp recordings. **B.** Schematic of the model. **C.** Bifurcation diagram showing the period of the two cells as a function of *m* representing the maximal synaptic conductance. Colors denote periods of each cell.

* Correspondence: mo42@njit.edu
[1]Department of Mathematical Sciences, New Jersey Institute Technology, Newark, NJ, 07102, USA

coupled with reciprocally inhibitory synapses that display preferred frequencies (Fig. 1B). This model represents the coupling between the pyloric pacemaker neurons AB/PD and the follower neuron LP. The effect of preferred frequencies in our model is explored analytically as well as with simulations. In a network of two neurons coupled with resonance synapses, the frequency of each presynaptic neuron affects the strength of synapse and therefore the frequency of the postsynaptic neuron. Due to the recurrence of the network, these effects are reciprocal. We show that, regardless of cell type, the dynamics of each cell can be described by a logistic map which is composed with two functions: one characterizing the dependence of the synaptic conductance on the previous cycle period of presynaptic neuron, and the other determining the cycle period of postsynaptic neuron depending on this synaptic conductance. We show that the synapses with preferred frequencies can lead to complex network outputs, even in a simple two-cell network. In fact, the activity state of the two-cell network, as a function of the maximal synaptic strength (m) is characterized by a bifurcation diagram that involves a classical period-doubling cascade leading to chaotic dynamics (Fig. 1C). The analytical prediction leading to the logistic-map bifurcation diagram can be reproduced in simulations, as we show using Morris-Lecar model neurons coupled with resonance synapses.

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Author details
[1]Department of Mathematical Sciences, New Jersey Institute Technology, Newark, NJ, 07102, USA . [2]Department of Biological Sciences, Rutgers University, Newark, NJ, 07102, USA.

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