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A Neuronal Network Model of *Drosophila* Antennal Lobe

Olfaction is an important sensory modality for behavior since odors inform animals of the presence of food, potential mates, and predators. The fruit fly, *Drosophila melanogaster*, is a favorable model organism for the investigation of the biophysical mechanisms that contribute to olfaction because its olfactory system is anatomically similar to but simpler than that of vertebrates. In the *Drosophila* olfactory system, sensory transduction takes place in olfactory receptor neurons housed in the antennae and maxillary palps on the front of the head. The first stage of olfactory processing resides in the antennal lobe, where the structural unit is the glomerulus. There are at least three classes of neurons in the antennal lobe - excitatory projection neurons, excitatory local neurons, and inhibitory local neurons. The arborizations of the local neurons are confined to the antennal lobe, and output from the antennal lobe is carried by projection neurons to higher regions of the brain.

Different views exist of how circuits of the *Drosophila* antennal lobe translate input from the olfactory receptor neurons into projection neuron output. Some imaging studies show that the activation of a post-synaptic projection neuron reflects the activation of the associated pre-synaptic olfactory receptor neurons; however, electrophysiological studies suggest that projection neurons are more broadly tuned than olfactory receptor neurons, and that projection neuron output is shaped by both olfactory receptor neuron input and by lateral connections within the antennal lobe [Bhandawat et al., 2007]. A study of optical recordings of glomerular calcium responses suggests the existence of both a glomerulus specific network, which includes excitatory and inhibitory local connections, and a global inhibitory network that acts on all glomeruli [Silbering and Galizia, 2007]. Recent studies suggest that excitatory local neurons recruit inhibition and spread excitation between projection neurons in different glomeruli; while inhibitory local neurons facilitate gain control [Wilson, 2011].

We construct a conductance based neuronal network model of the *Drosophila* antennal lobe with the aim of proposing possible interactions within the antennal lobe that account for the variety of projection neuron activity observed in experimental data. First, we develop realistic minimal cell models for the excitatory local neurons, inhibitory local neurons, and projections neurons based on experimental data for *Drosophila* channel kinetics. These single cell models exhibit Type II dynamics at the transition to repetitive firing. The inhibitory local neuron model exhibits regular repetitive firing in the presence of stimulus, and the projection neuron model exhibits repetitive firing but of higher frequency than the inhibitory local neuron in the presence of stimulus. The excitatory local neuron exhibits bursting in the presence of some stimuli. We then investigate possible inter- and intra-glomerular connectivity patterns in the *Drosophila* antennal lobe, where olfactory receptor neuron input to the antennal lobe is modeled with Poisson spike trains, and synaptic connections within the antennal lobe are mediated by chemical synapses and gap junctions as described in the *Drosophila* antennal lobe literature. Computational studies using olfactory receptor neuron inputs that mimic experimental recordings demonstrate the possible roles of excitatory local neurons in spreading excitation among glomeruli and in recruiting inhibition.

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