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Importance of Temporal Information for Olfactory Codes
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Physiological studies of the antennal lobe (AL) and olfactory bulb (OB) have revealed that sensory input to these neuropils is transformed over a short time period during and after odor stimulation. The temporal nature of this transformation is likely to arise from processing by local neural networks. Yet, the role of this transformation in olfactory coding remains controversial. If the temporal aspect of odor representation is important, then we hypothesize that both stimulus duration and stimulus concentration will affect odor recognition. We test this prediction using mathematical modeling coupled to behavioral experiments with honeybees. The behavioral studies reveal that increasing the concentration of the stimulus improved detection and discrimination at shorter stimulus durations. Response latencies reveal that animals make decisions about odors within approximately 500 ms. The mathematical model includes both excitatory and inhibitory cells corresponding to projection neurons (PN) and the interneurons, respectively. The model exhibits complex firing patterns similar to those seen experimentally. For example, the firing patterns consist of epochs in which a subset of PNs fire synchronously; at each subsequent epoch, PNs drop in and drop out of the ensemble. The model also exhibits a form of spatial decorrelation in which the temporal representations of similar odors evolve to distinct patterns. Dynamical systems methods are used to systematically study how properties of the attractors, as well as the transient dynamics, depend on parameters including network architecture.

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Publications

1. A. Borisyuk and B.H. Smith, Representation of odor mixtures and learning in the insect antennal lobe, in preparation.

2. A. Borisyuk and B. H. Smith, Odor interactions and learning in a model of the insect antennal lobe. Neurocomputing 58-60, 1041-1047, 2004.

3. D. Terman, A. Borisyuk, X.Wang, S. Ahn and B. H. Smith, Dynamic clustering and decorrelation of inputs in a model of the insect antennal lobe, in preparation.

4. S. Ahn, X. Wang and D. Terman, Multistability in excitatory-inhibitory neuronal networks, in preparation.

5. X. Wang, S. Ahn and D. Terman, Analysis of dynamic clustering in a model for neuronal firing patterns in the insect's antennal lobe, in preparation.

6. B. H. Smith, G. A. Wright and M. Carlton, More time means better detection and discrimination of odorants in the honeybee, in preparation.