# Modeling Olfactory Discrimination in Drosophila


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Fruit flies are capable of distinguishing many odors with a remarkable degree of specificity. Recently, a series of experiments [1, 2, 3] has documented odor-evoked response patterns in both the first order neurons, the olfactory receptor neurons (ORNs), and the second order neurons, the projection neurons (PNs) of the antennal lobe. A single odorant can elicit activity in multiple ORNs and their corresponding PNs, and a significant degree of overlap of PN activity exists for different odors. Moreover it has been shown that the firing patterns in the third order neurons in the mushroom body is sparse [4, 5]. How is the overlapping, combinatorial representation in the antennal lobe transformed into a sparse representation in higher olfactory centers?

Here we show that a transformation to a sparse code can be accomplished in the olfactory system by direct feedforward connections between the PNs and the third order neurons (3Ns). Determining the correct PN to 3N synaptic weights is equivalent to finding a linear discriminator that classifies two labeled sets of vectors, one representing the odors to which the 3N responds, and the other the odors to which it does not respond. Because 3Ns respond sparsely, one of these sets has only a few examplars. The capacity of such a sparse discriminator increases exponentially as a function of the number of dimensions [6], which, in this instance, is the number of olfactory receptors.

Model 3Ns can be constructed to respond to only one out of an experimental data set of 110 odors with high reliability. All model 3Ns have the same threshold, and hence do not require individual fine-tuning of intrinsic properties for specificity. Furthermore, specificity is maintained at different concentrations and with different degrees of connectivity between PNs and 3Ns. This model thus represents a plausible mechanism by which combinatorial codes can be read out for the purpose of sparse odor discrimination.


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**References**


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