
A Neurocomputational Theory of Olfactory Recognition
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This project combines theoretical and experimental approaches to investigate the neural basis of olfactory perception in the rat. We first proposed a computational model for odor recognition based on spike synchrony (Brody and Hopfield, 2003). This model addressed not only the computational problem of odor detection but also the problems of concentration invariant and background invariant odor recognition. In parallel, we developed psychophysical assays in the rat suitable for quantifying these neural computations behaviorally (Uchida and Mainen, 2003). In this way we obtained behavioral evidence for concentration-invariant recognition consistent with a strategy based on "combinatorial ratio coding", as proposed in the computational models. This work also led to the discovery of unexpectedly rapid olfactory decisions in well-trained animals: rats performed olfactory discriminations in 200-300 ms, corresponding to 1-2 sniff cycles at theta frequency (~8 Hz). These findings suggest that rapid coding strategies are deployed in the olfactory system and point to the possible significance of the theta cycle in olfactory sensorimotor integration. To investigate these issues directly we are using chronic multi-electrode recording to monitor ensemble activity in the olfactory system and the orbitofrontal cortex (a secondary olfactory area) during psychophysical manipulations. In addition to correlating single unit activity with behavioral variables, we are using single unit correlation measures and spectral analysis of local field potentials to probe interactions within microcircuits and macrocircuits (i.e. within and between brain areas). Our analysis of microcircuits in rats is being guided by a model developed to explain flexible cognitive operations in monkey prefrontal cortex (Machens et al., 2005) which has more general applicability to circuit mechanisms underlying olfactory decisions.

PI Website

http://www.cshl.org/public/SCIENCE/mainen.html
http://www.cshl.org/public/SCIENCE/brody.html

Publications

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