A model for sparse and reliable encoding of olfactory cues in the honeybee

Rinaldo Betkiewicz, Michael Schmuker[1,2], Farzad Farkhooi[1,2], Martin Paul Nawrot[1,2]

[1]Theoretical Neuroscience, Institute of Biology, Freie Universität Berlin, Germany

[2]Bernstein Center for Computational Neuroscience, Berlin, Germany

In their natural environment, animals sense and evaluate olfactory cues of time-varying composition and concentration. The olfactory pathways are specifically tailored to the physical reality of chemosensation and, interestingly, similar solutions have co-evolved in invertebrate and vertebrate nervous systems. Our goal is to explain how the insect olfactory system is optimized to reliably estimate the behaviorally relevant spatial and temporal aspects of a rich stimulus environment.

Here, we propose an approach to a realistic model of the honeybee olfactory system that demonstrates sparse and reliable stimulus encoding learning of olfactory stimuli. Specifically, we consider two fundamental processing features: structured lateral inhibition in the antennal lobe (AL) network (Schmuker et al., 2012) and cellular adaptation in successive processing layers (Nawrot 2012; see also poster by Nawrot & Farkhooi). Structured lateral inhibition in the AL improves the separability of odor stimuli, while the neuron-intrinsic mechanism of spike-frequency adaptation (SFA) shapes the stimulus response temporal dynamics. This effect of cellular adaptation becomes progressively pronounced at successive stages of the olfactory network, promoting temporal sparseness. Importantly, at the last stage, in the mushroom body, Kenyon cells (KCs) responses are highly reliable since SFA suppresses response variability (Farkhooi, Müller & Nawrot, 2011) and thus support the formation of stable associative memories (Strube-Bloss, Nawrot, & Menzel, 2011). In terms of a spatial odor code, only a few KCs are activated by a given odor (population sparseness; e.g. Honegger, Campbell & Turner, 2011). This sparse code facilitates the specific association of a stimulus with reward in a model study by Haenicke and colleagues (oral contribution to Symposim III: 13).

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