Influence of inhibitory circuits in the olfactory bulb on the frequency tuning of mitral cells

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Naturalistic odour stimuli have a rich temporal structure. It has been hypothesised that this structure contains information about the olfactory scene, for example the distance to an odour source [1,2]. Furthermore, it has been suggested that animals might exploit this structure and extract this information in order to find odour sources [3]. As some of this information may lie in the frequency content of the stimuli [2], we studied input frequency dependent responses of mitral cells (MCs) in the olfactory bulb (OB), the first processing stage in the mammalian olfactory system. Specifically, we investigated whether MCs show frequency tuning and, if they do, how different components of the glomerular layer circuitry shape and determine the tuning.

We used a model of the OB (modified from [4]) containing periglomerular cells (PGCs) and MCs, thus focusing on the recurrent and feed-forward inhibition in the glomerular layer. Simple sinusoidal currents of varying strengths and frequencies were used as input to the model. We constructed frequency tuning curves, extracted the peak resonance frequencies and looked at how these changed for different parameter combinations. We also considered the strength of the tuning, measured as (max firing rate – mean firing rate)/ mean firing rate.

We found that the resonance frequency decreased as the excitation of PGCs (both from the input and from the MCs) increased, whereas the strength of the PGC inhibition onto MCs did not seem to have a strong effect. Furthermore, the resonance strength increased with the strength of the excitatory connection between MCs and PGCs when the PGCs received sufficient external input from olfactory stimuli.

These results suggest that the MCs can indeed show frequency tuning and that this depends on the strength of the excitatory synaptic input to PGCs, which provide inhibitory input to the MC. However, the observed frequency tuning occurred in a narrow range (19.5*Hz* – 33.0*Hz*). Future work should investigate how the OB could use this frequency tuning to obtain information about the surrounding olfactory scene.

References

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