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Coding of static and rapid odor stimuli in olfactory receptor neurons

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Olfactory receptor neurons (ORNs) transduce odorous information via a G protein-coupled transduction cascade into ultimately action potentials to be conveyed to second order mitral and tufted neurons in the olfactory bulb. We will address ORN basal firing activity and how ORNs encode for odorants when presented continuously or repeatedly at different stimulation frequencies. The latter is seen as a more naturalistic stimulation pattern as ORN stimulation is driven by odorants carried in to the nose by the rhythmically inhaled air.

In the absence of stimulation individual mouse ORNs display a low basal action potential firing rate varying from 0 to 2 Hz. Interestingly the basal firing rate depends on the odorant receptor (OR) a given ORN chose to express and is driven by the thermal activity of the OR in the absence of stimulation. During constant odor exposure ORNs can display different response patterns, either firing continuously or responding with bursts of action potentials that are generated around every second and driven by underlying oscillations within the transduction cascade. ORNs expressing a given type of OR respond with one of the two patterns for reasons currently not understood. Rhythmic stimulation at either 2 or 5 Hz, representing breathing at rest and frequencies during exploratory sniffing, evoked markedly different response patterns. While at 2 Hz an ORN could respond reliably to every odorant exposure with a short burst of action potentials and therefore reliably code for the presence of odorants, it failed to do so at 5 Hz. At intermediate odorant concentrations presented at 5 Hz the fidelity to respond to every stimulation decreased and responses had longer response delays after the onset of stimulation (phase shift). At higher concentrations ORNs failed to respond altogether to repeated odorant exposures, reducing greatly the information sent to the bulb. Thus paradoxically higher stimulation frequencies seem to degrade the information relayed to second order neurons raising the question why mice chose to sniff during olfactory exploration.