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A combined computational-experimental study of dynamic responses to olfactory input in a glomerular circuit

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Odorant-evoked input to and output from the mammalian olfactory bulb (OB) is temporally dynamic. Olfactory receptor neuron (ORN) inputs are tightly coupled to the respiratory cycle, and inhalation-evoked input bursts occur with durations, rise times, latencies, and strengths (amplitudes) that vary across glomeruli (for the same odorant) and also in individual glomeruli for different odorants [1]. The temporal spread of sensory input following a single inhalation (~100-300 ms) is comparable to the range of discrimination times for different olfactory tasks [2,3], consistent with these dynamics being important in shaping odor perception. Similarly diverse temporal patterns of activity occur at the level of output from the OB, among mitral cells (MCs), whose firing patterns express strong temporal structure organized around the respiratory cycle and modulated by odorant presentation; significant odor information is carried in these temporal patterns across the MC population.

We investigate these temporal dynamics using a computational model of the ORN-MC circuit that uses a single-compartment, Hodgkin-Huxley-style MC model [4]. The input to the model MC is taken from recordings of odorant-evoked calcium influx into the presynaptic terminals of ORNs of awake, head-fixed rats engaged in an olfactory discrimination task [1,5]. This calcium signal is converted to an excitatory synaptic input for the model MC having a temporal signature that presumably closely reproduces that of the signal received by real MCs. The response dynamics of the MC model are strongly shaped by the input signal (Figure 1). We explore how these dynamics vary for

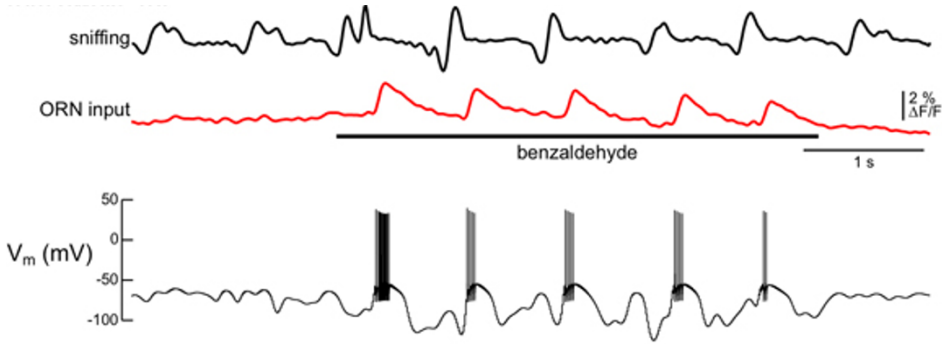

Figure 1 Sniffing and odor-evoked ORN input (top) imaged from an awake rat; ORN input is used to drive a model MC (bottom). Each sniff-evoked burst of ORN input elicits a burst of action potentials in the model MC.

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different odorants, synaptic strengths, and intrinsic MC parameters. We also investigate the response of a variant circuit that incorporates a mediating external tufted cell model between the ORN and MC [6].

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