

Abstract View

SYNAPTIC PLASTICITY PROMOTES HIGHLY SYNCHRONOUS ENSEMBLES OF PROJECTION NEURONS IN A MODEL OLFACTORY SYSTEM

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In the locust olfactory system multiple intrinsic and circuit neuronal properties act together, conveying coincidence detection attributes to the decoders of olfactory information - Kenyon cells (KCs) of the mushroom body (MB). Acting as coincidence detectors, KCs respond to selective odor specific patterns of synchronization across antennal lobe (AL) projection neurons (PNs). Using a computer model we explored whether synaptic plasticity of the AL afferents to the MB helps KCs to exploit the synchrony in the input spike trains. On a cycle-by-cycle basis we studied what combination of synchronous and asynchronous PN input patterns induced KC spiking, with particular attention for those selected and reinforced through spike-timing dependent plasticity (STDP) at the KC dendrites. In the naive (before training) system, odor presentations elicited relatively dense response patterns in the MB, with olfactory representations characterized by the participation of several KCs (often >25%). However, response reliability was low, as most neurons fired less than one spike per trial. After learning, sparse responses involved typically 1 KC that fired reliably across trials. Joint analysis of the final synaptic strengths indicated that STDP selectively promoted ensembles with a large fraction of synchronous PNs and inhibited all others. While enhancing sparseness and selectivity of olfactory representations in KCs, STDP consistently reduced the jitter of the stimulus-locked KC spikes (32% lower after STDP, $p < 0.02$). Minimum jitter was observed in KCs driven by sets of PNs with the highest degree of population synchrony. Our modeling results show that STDP, by increasing the relevance of synchronous PNs to KC firing, could promote high KC spike timing reliability to levels similar to those observed experimentally.

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