Intracellular recordings *in vivo* from locust antennal lobe (AL) projection neurons (PNs) revealed that individual PNs phase-lock with population oscillations at times that depend on the stimulus. It was shown that there is a fine structure to the timing of PN action potentials within the population response that is stable over trials and is different for different PNs (Laurent *Trends Neurosci* 19: 489-496, 1996). It suggests that after processing through the AL odor identity is contained both in the identities of the active PNs and in the relative timing of spikes in those PNs. Kenyon cells (KCs) of the mushroom body (MB) - postsynaptic target of PN afferents - decode stimulus-specific spatio-temporal patterns of PN activity. These cells fire only when several PN spikes arrive within a short time window (Perez-Orive et al. *Science* 297: 359-365, 2002). Operating as precise coincidence detectors, KCs can transform spatio-temporal patterns of AL activity into new firing sequences.

In vivo recordings from the MB demonstrate very high specificity of the Kenyon cells (KCs) responses during odor processing (Perez-Orive et al. *Science* 297: 359-365, 2002). Typically only a few KCs from the recorded population of neurons responded reliably when a specific odor was presented. Experimental data suggest that few independent mechanisms may determine the high specificity of the KCs. This includes (but is not limited to) the nonlinear intrinsic properties of the individual KCs and the inhibitory circuits in the MB based on lateral horn interneurons. However, even with the intrinsic (active conductances) and synaptic (input from lateral horn) mechanisms present, the specificity of KCs responses would still require some initial tuning of the synaptic weights between the AL and the MB. With strong synaptic afferents, only a few aligned PN spikes would be required to induce spiking in a KC. In this case the KC could not detect stimulus specific synchrony in the input from the AL, so many KCs would fire for each odor presentation. We have explored the possibility that spike-timing dependent plasticity (STDP) could be responsible for the initial (possibly during development) tuning of the afferents between the AL and the MB. With STDP-based models the degree and sign (potentiation or depression) of synaptic changes depend on relative timing of presynaptic and postsynaptic spikes. Transient synchronization between PNs' spike trains induced correlated input in the postsynaptic KCs and could trigger action potentials in these cells. Thus, the timing between pre- and postsynaptic spikes required for potentiation could be achieved. On the other hand if only a few inputs from AL are required to induce a KC spike, this spike would occur early in the cycle and all the following inputs from PNs will induce depression.

We have tested this with a network model including one-dimensional chain of simplified KCs each receiving *N* inputs with realistic spike trains. Slow temporal patterns and transient synchronization between spike trains in different afferents were modeled (Bazhenov et al. *Neuron* 30: 569-581, 2001). There were small variations in input spike trains from one trial to another to match experimental data. STDP was introduced at all synapses. When the initial (before training) synaptic weights were increased from 100% to 140%, more KCs produced spikes during stimulus presentations. At 140% all the cells displayed spikes and many fired regularly with 1-2 spikes per each trial. Different stimuli produced similar responses in many KCs, so specificity of KCs activation was lost. After the STDP learning rule was applied for 150 trials, the synaptic weights developed a stimulus-specific pattern. The network activity was dramatically reduced. The trained network responded with the same pattern of spiking KCs (usually including only 1-3 “odor-specific” KCs) independently of the initial synaptic weights in 110%-140% range. When initial weights were set at 100%, less KCs could respond after training suggesting that longer training might be needed.

We also tested whether a network trained with several different stimuli can preserve response specificity for each of them. In the first experiment, four different odors (50 trials for each odor) were presented one after another during training phase. In the second

experiment only one odor from this set was applied. The total number of trials was kept constant in both experiments. The network trained by a set of odors responded to any single odor from this set with firing patterns that were almost identical to those in the network trained by this odor alone. It indicates that STDP preserves the network's ability to respond with different patterns for different odors from a training set. When a set of 8 very similar odors was presented, the naive network responded with similar patterns. After training, network responses could be separated into several classes each with distinct firing structure. Finally, we tested whether training can increase reliability of Kenyon cells responses against random input variations. At each trial the timing of a certain fraction of the input spikes was randomly altered. In a naive network as the size of this fraction was increased, the reliability of KC spiking (percentage of responding KCs) was quickly reduced to less than 50%. After the training, the same level of jitter in the input spike trains could not reduce the reliability below 80%.

Our results suggest that STDP-based learning rule operating on synaptic afferents between AL and MB can control and tune synaptic weights to provide high specificity of KCs' responses to the odors that have been learned before, possibly at early stages of development. This tuning combined with nonlinear intrinsic properties of the KCs and inhibitory circuits of the MB can allow MB interneurons to operate as a coincidence detectors selecting correlations in the input spike trains. The long-term synaptic plasticity in the MB may underlie the ability of KCs to efficiently decode the precise temporal patterns of the AL neurons, in particular when the odor contains noise or when the odor intensity is varied.