Over half a century ago Donald Hebb formulated his theory of learning and memory and postulated that a synapse between two neurons should increase its efficacy if both cells were simultaneously active. According to Hebb, this synaptic change needed not occur instantaneously but rather would be preceded by a short-lived memory trace or “reverberation” that mediates perception and memory consolidation via synaptic plasticity.

Hebb’s ideas to explain memory formation and associative learning have been successfully tested in theoretical models that illustrate how neural networks can process and store sensory information. The common feature of these models is “learning through correlations”, a modern reformulation of Hebb’s postulate, known as Hebbian learning rule: pairs of neural units that are excited by the stimulus should increase their correlation after stimulation; pairs of neural units that are inhibited by the stimulus should also increase their correlation; pairs of neural units, where one is excited and the other inhibited should decrease their correlation; pairs of units where at least one does not respond to the stimulus should not change their correlated activity.

We demonstrate that the neural units (olfactory glomeruli in the antennal lobe of honeybee) that respond to a given stimulus (odor) change their correlated spontaneous activity in a stimulus-specific manner. During a few minutes after stimulation these correlations enable the retrieval of the stimulus from the spontaneous activity of the network (antennal lobe) with a principal-component analysis. We expect our methodological approach to help uncover this form of memory trace in other neural systems.

Complementary information available at: www.andrew.cmu.edu/user/rfgalan/home.htm