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EXPECTATION LEARNING IN THE BRAIN USING DIFFUSE ASCENDING PROJECTIONS

S. R. Quartz*, P. Dayan, P. R. Montague, T. J. Sejnowski, The Salk Institute, La Jolla, CA, 92037.

Diffuse projections originating in subcortical nuclei are known to influence activity-dependent cortical plasticity and learning both during and after development. These signals may report to the cortex important events in the world as well as which activity patterns in the cortex result from actions taken by an organism e.g. proprioceptive signals associated with a movement. Although a number of physiological actions have been attributed to the neurotransmitters used by these pathways (acetylcholine, norepinephrine, serotonin, etc.), their precise functional effects on learning within a large network of neurons are unknown. We explore here a theory in which the derivative of the activity of the ascending pathway drives learning at cortical synapses. This learning is gated locally by a rapid diffusible signal produced by glutamate transmission in a local volume of tissue. We call this effect *volume learning*. This scheme forces the cortical networks to *learn to predict the future changes in activity in the ascending pathway*. Moreover, a powerful influence driving cortical learning obtains when one part of the cortex captures control over the mid brain structures that release the neuromodulators. This occurs by allowing for modifiable NMDA synapses on the path from cortex to the midbrain nuclei. Using a large scale computational model we demonstrate the theory and test it in a variety of tasks including visual recognition. This scheme may result in impoverished cortical representations in the absence of some way by which cortical patterns can be combined, recoded, and redistributed to the cortex. We show how the hippocampus can play a natural role in restructuring representations to make this prediction possible.

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