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Cooperative synaptic plasticity in pyramidal cell dendrites

The dendritic tree of mammalian neurons receives thousands of synaptic connections. Recent studies indicate that functionally related excitatory synapses can be distributed in a spatially nonrandom, clustered fashion in the dendritic arbor of cortical pyramidal cells; however, the relevance and generation mechanisms of this synaptic organization is unclear. One possible explanation is that local nonlinear interactions between coactive synapses within distinct dendritic compartments may enable neurons to discriminate, and specifically potentiate through plasticity, certain spatiotemporal patterns of inputs produced by correlated presynaptic activity. We have used two-photon imaging and uncaging combined with electrophysiology in pyramidal neurons in acute hippocampal slices to shed light on how the spatiotemporal pattern of excitatory synaptic activity determines their cooperation and long-term plasticity. We found that the integration mode and plasticity of coactive inputs depend on several factors, including their relative location within the branch, their fine-grained spatial distribution, their ability to generate dendritic spikes, as well as the local excitability of the parent dendrite. The combination of these components lead to location and pattern-dependent synaptic plasticity rules, which may support activity-dependent recruitment of specific neurons to new representations during learning processes.