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Neuromodulation of spike timing-dependent plasticity:
From retroactive modulation to synaptic eligibility traces

Synaptic plasticity rules are under neuromodulatory control. In the rodent hippocampus, the neuromodulator acetylcholine is released during exploratory behaviour, whereas dopamine signals novelty and/or reward. Using whole-cell recording in hippocampal slices, we found that acetylcholine biases hippocampal spike timing-dependent plasticity (STDP) towards depression, whereas dopamine biases STDP towards potentiation and can even convert depression into potentiation when applied after the plasticity protocol, a phenomenon referred to as 'retroactive modulation'. The latter result raises the converse question, what changes at the synapse caused by the pairing protocol enable dopamine to induce potentiation? The answer might lead to the identification of a synaptic eligibility trace for reward-based spatial learning. Possible implications of these findings for behavioural learning and memory will be discussed.