Title: Synaptic plasticity controlled by surprise

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Abstract:
During Hebbian plasticity, pre- and postsynaptic activity work together to cause a change of the weights. However, neuromodulators signaling reward, novelty, or suprise influence synaptic plasticity as well. We therefore have to consider in models of synaptic plasticity a total of three factors (pre, post, modulator) that control learning [1]. Such three-factor rules have also been called neo-Hebbian [2]. While the role of neuromodulators related to reward is well studied in theories of reinforcement learning, a theory of surprise-driven learning is missing. Here we discuss theories of surprise that can serve as starting point for a framework of surprise-based learning.

Two components are needed in a framework of surprise-based learning [3]: (i) a confidence-adjusted surprise measure to capture environmental statistics as well as subjective beliefs, (ii) a surprise-minimization learning rule, or SMiLe-rule, which dynamically adjusts the balance between new and old information without making prior assumptions about the temporal statistics in the environment. We apply our framework to a dynamic decision making task and a maze exploration task to demonstrate that it is suitable for learning in complex environments, even if the environment undergoes gradual or sudden changes. A synaptic implementation of learning in a network of spiking neurons with hidden neurons provides additional insights [4].

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