Robustness of learning that is based on covariance-driven synaptic plasticity

By Loewenstein

Abstract:

It is widely believed that learning is due, at least in part, to long-lasting modifications of the strengths of synapses in the brain. Theoretical studies have shown that a family of synaptic plasticity rules, in which synaptic changes are driven by covariance, is particularly useful for many forms of learning, including associative memory, gradient estimation, and operant conditioning. Covariance-based plasticity is inherently sensitive. Even a slight mistuning of the parameters of a covariance-based plasticity rule is likely to result in substantial changes in synaptic efficacies. Therefore, the biological relevance of covariance-based plasticity models is questionable. Here, we study the effects of mistuning parameters of the plasticity rule in a decision making model in which synaptic plasticity is driven by the covariance of reward and neural activity. An exact covariance plasticity rule yields Herrnstein's matching law. We show that although the effect of slight mistuning of the plasticity rule on the synaptic efficacies is large, the behavioral effect is small. Thus, matching behavior is robust to mistuning of the parameters of the covariance-based plasticity rule. Furthermore, the mistuned covariance rule results in undermatching, which is consistent with experimentally observed behavior. These results substantiate the hypothesis that approximate covariance-based synaptic plasticity underlies operant conditioning. However, we show that the mistuning of the mean subtraction makes behavior sensitive to the mistuning of the properties of the decision making network. Thus, there is a tradeoff between the robustness of matching behavior to changes in the plasticity rule and its robustness to changes in the properties of the decision making network.

Journal:
PLoS Computational Biology

Volume:
4

Pagination:
e1000007

Notes:
{PMID:} 18369414

Full Text:
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