Dopamine and models for reinforcement learning

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Animal learning is associated with changes in the efficacy of connections between neurons. The rules that govern these changes can be tested in neural networks. Biological plausible rules are provided by reinforcement learning theories. In reinforcement learning, the only information that is needed to train a neural network is a reward when the correct response is chosen, which is reminiscent of animal learning. The efficacies of the connections are modified on the basis of whether the amount of reward on a particular trial is better or worse than expected. The popularity of reinforcement learning models has greatly increased in recent years, because signals related to reinforcement that were predicted by these models have indeed been found in the brain. Specifically, it has been shown that dopaminergic neurons encode the difference between obtained and expected reward. A disadvantage of current reinforcement learning models is that they can be used only for relatively simple tasks. Here we show that reinforcement learning models can be greatly improved by a new role for attention in learning. In our new scheme, an attentional signal feeds back from output units to gate synaptic plasticity at earlier processing levels. The new scheme integrates the role of feedback connections, attention effects, synaptic plasticity, and reinforcement signals into a coherent framework. A specific prediction of the model is that reward expectancy, and the encoding by it through dopaminergic neurons, is important on correct but not on incorrect trials.

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