

A complete description of Pavlovian learning entails various levels of scale including neurons, synapses, circuits, and behavior. Mathematical models of Pavlovian learning have emphasized changes in behavior, and there has been little attention paid to producing biologically realistic models. The temporal difference learning (TDL) model has received much interest, because although it was never intended as a biologically realistic model it produces learning signals that parallel the activity of dopamine neurons during Pavlovian learning, and this neuronal activity is theorized to also function as a learning signal.

We embedded a TDL algorithm within a model of mammalian brain circuitry. Our model produces biologically realistic changes in dopamine neuron firing rate, extracellular dopamine, postsynaptic receptor activation, postsynaptic neuron firing rate, and behavior. Thus, our model confirms the cohesiveness of the current theory of Pavlovian learning, and it uniquely predicts how disturbances at smaller levels of scale will manifest in behavior.