Fooling the System: Reassigning value through exogenous dopamine activation

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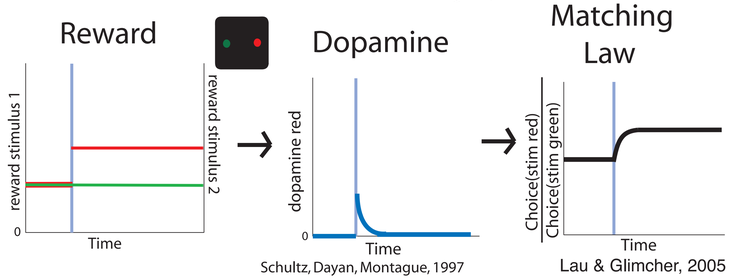
Introduction

Natural Rewards

$$Q_{a,t} = Q_{a,t-1} + \alpha(r_t - Q_{a,t-1})$$

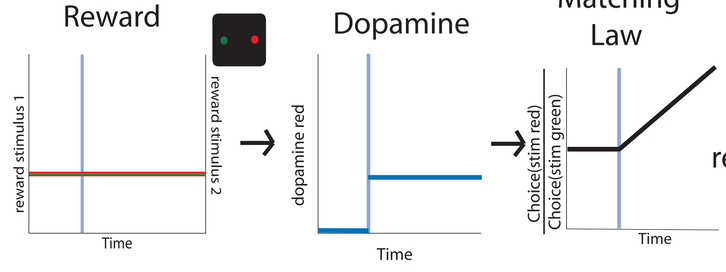
Rescorla & Wagner, 1972



Drugs of Abuse?

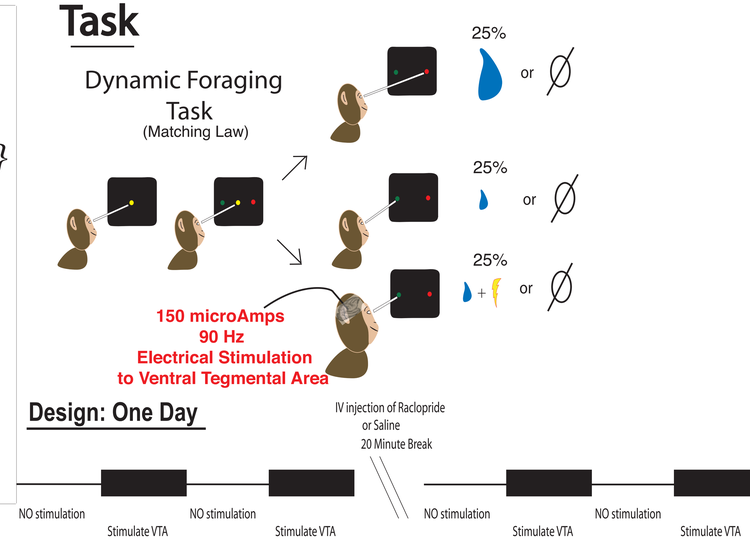
$$Q_{a,t} = Q_{a,t-1} + \alpha(r_t - Q_{a,t-1}) + D_t \quad \textbf{or} \quad Q_{a,t} = Q_{a,t-1} + max\{\alpha(r_t - Q_{a,t-1}) + D_t, D\}$$

Redish, 2004

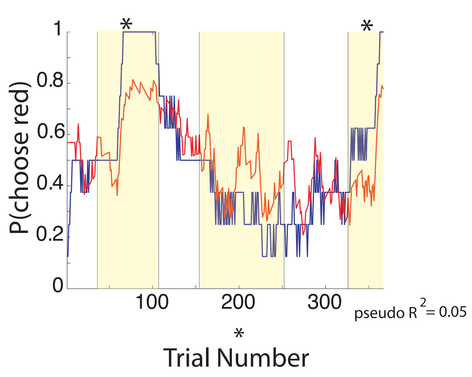


Can we model the effects of dopamine stimulation with a standard reinforcement learning model adjusted for a dopamine surge?

Task



Results

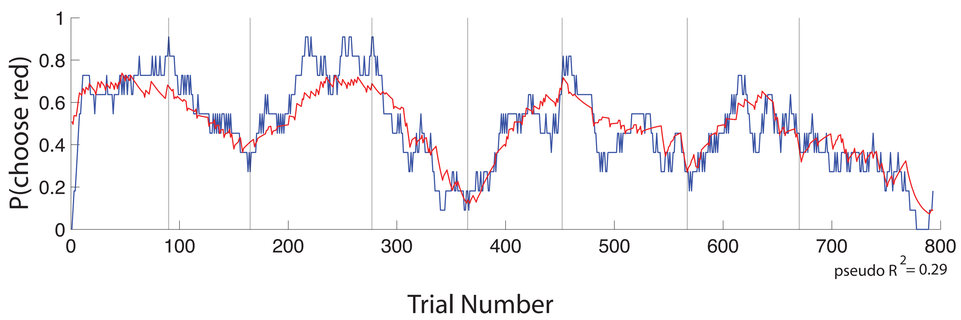


$$Q_{a,t} = Q_{a,t-1} + \alpha(r_t - Q_{a,t-1})$$

- direction of stimulation
- VTA stimulation
- behavior
- model fit

Modeling the behavior of stimulation without adding a term for stimulation fails to fit the behavior well

Standard RL Model fit to behavior without VTA stimulation



Modelling Stimulation

Model

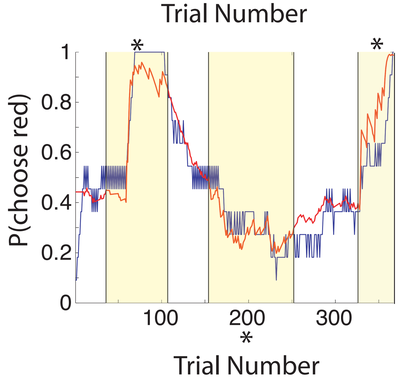
$$Q_{red,t} = Q_{red,t-1} + \alpha\left(r_{red,t} - Q_{red,t}\right) + D_{red,t}$$

$$Q_{green,t} = Q_{green,t-1} + \alpha\left(r_{green,t} - Q_{green,t}\right)$$

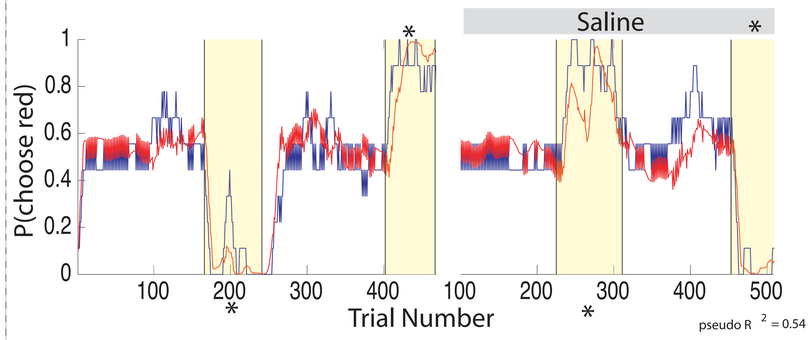
$$DV = Q_r - Q_g + bias_{spatial}$$

$$choice\ \ probability = \frac{1}{1 + e^{beta * DV}}$$

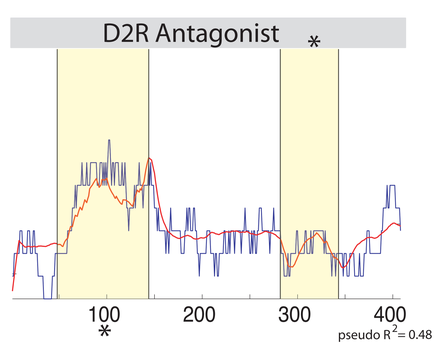
Minimizing predicted probability of choosing the red target against the actual choice (1 or 0)



Model Fit before and after saline



Effects of Dopaminergic Blockade



- direction of stimulation
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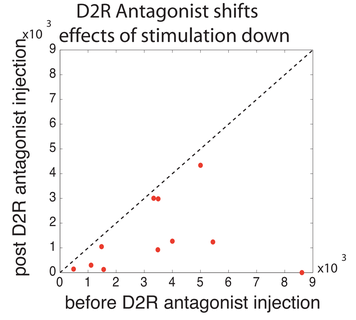

D2 Receptor partial blockade reduces D(t)

Conclusion

- A term for dopamine stimulation is a necessary adjustment to the reinforcement learning model.
- blocking D2 dopamine receptors attenuates effects of stimulation