# Rodents Solve an Extradimensional Set-Shifting Task by Forgetful, Adaptive Reinforcement Learning

Evan M Dastin-van Rijn, Abigail Alpers, Elizabeth Sachse, Aaron Wald,
Adriano Reimer, Eric Song, Alik S Widge

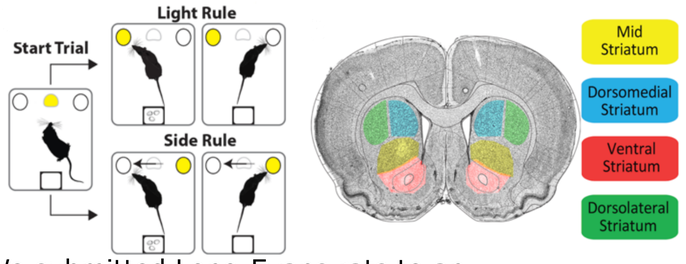
TNE LAB
Translational NeuroEngineering

dasti006@umn.edu
alper089@umn.edu

## Introduction

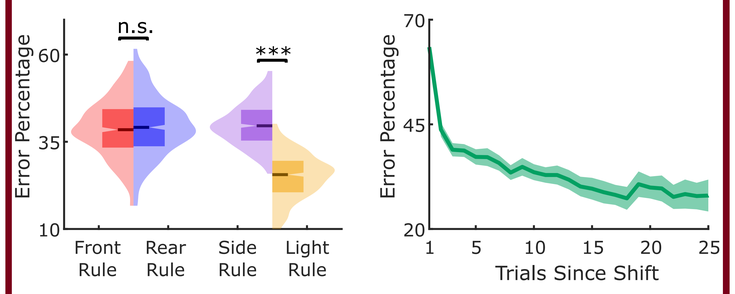
- The balance between flexible and rigid thinking is disrupted in mental illnesses such as OCD and anxiety.
- The extradimensional set-shifting task has been used to probe this balance in rats, with work from our lab demonstrating decreased reaction times with stimulation.
- However, the specific behavioral strategies used to complete this task and the manner in which striatal stimulation modulates these strategies is not well understood.

## Methods

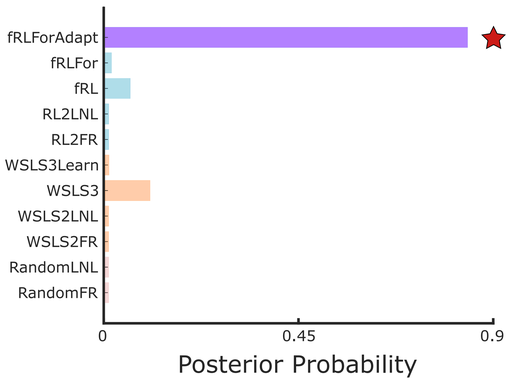



We submitted Long-Evans rats to an extradimensional set-shifting task which they completed daily, alternating between stimulation and sham conditions.
Behavior was fit using 11 different computational models encompassing random, win-stay lose-shift, and reinforcement learning strategies.

## Rats Adapt to Rule Changes




## Forgetful, Adaptive Reinforcement Learning Accurately Describes Rat Behavior




Chosen features:

$$Q_f(t+1) = Q_f(t) + \alpha PE|PE|^{\gamma}$$

Unchosen features:

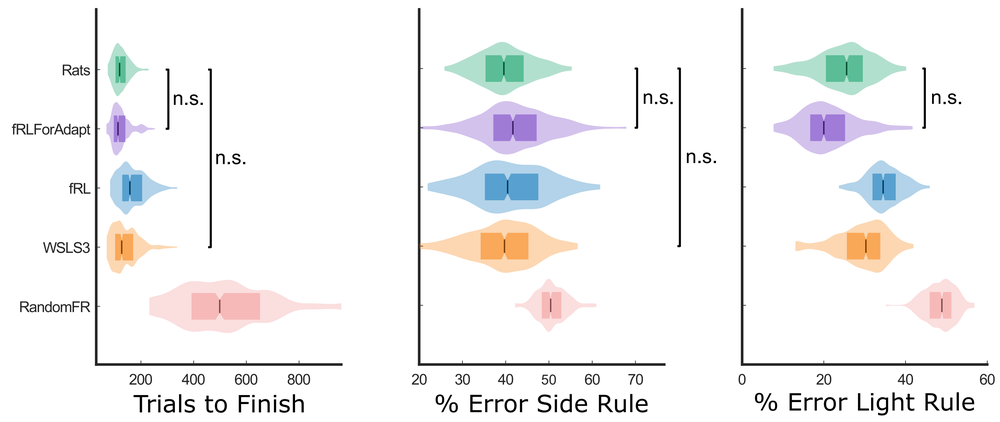
$$Q_f(t+1) = (1-F)Q_f(t)$$

Value function:

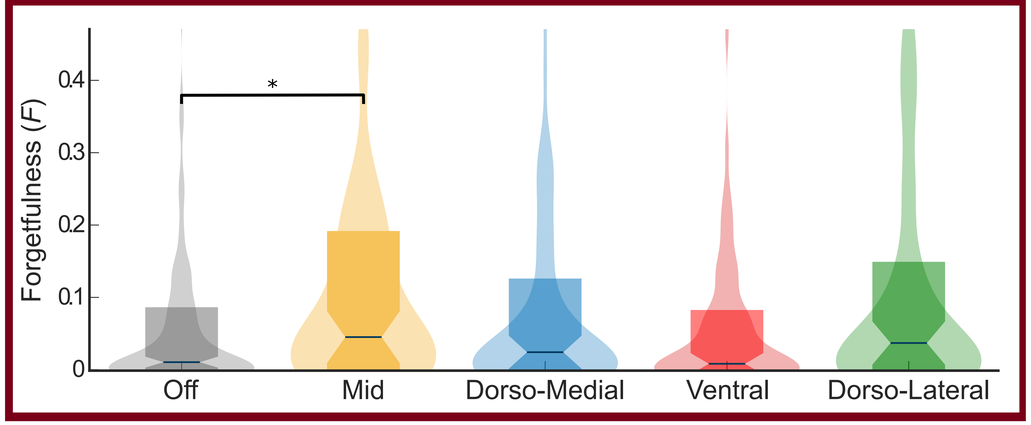
$$V_C(t) = \sum_f Q_f(t) \times \mathbf{1}_C(f)$$

Action selection:

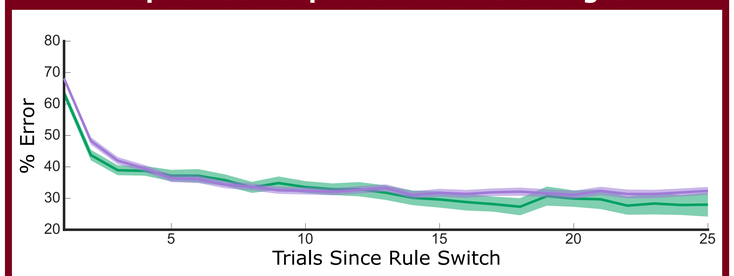
$$P_C(t) = \frac{\exp(V_c(t)\beta)}{\sum_C V_c(t)\beta}$$




## Mid-Striatal Stimulation Enhances Cognitive Flexibility




## Flexible, Adaptive Reinforcement Learning Replicates Adaptation to Rule Changes




## Conclusion

- The Forgetful, Adaptive Reinforcement Learning model best fits and replicates rat behavior.
- This indicates rats are flexibly varying their estimation of rewarding actions depending on the changing states confirming that the extradimensional set shifting task is able to effectively engage cognitive flexibility.
- Mid-striatal stimulation improved cognitive flexibility by reducing the valuation of unchosen actions (forgetfulness).
- This finding supports the hypothesis that deep brain stimulation for psychiatric indications may provide therapeutic benefit by improving cognitive flexibility.

## Acknowledgements

This poster is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No. CON-75851 and the National Institute of Neurological Disorders and Stroke of the National Institutes of Health under award number 1R01NS120851-01A1.

## References

1. Widge AS, Heilbronner SR, Hayden BY. Prefrontal cortex and cognitive control: new insights from human electrophysiology. F1000 Res. 2019 Sep 27;8: 1696.
2. Hamilton DA, Brigman JL. Behavioral flexibility in rats and mice: contributions of distinct frontocortical regions. Genes, Brain and Behavior. 2015;14(1 ):4-21.
3. Widge AS, Zorowitz S, Basu I, Paulk AC, Cash SS, Eskandar EN, Deckersbach T, Miller EK, Dougherty DD. Deep brain stimulation of the internal capsule enhances human cognitive control and prefrontal cortex function. Nature Communications. 2019;10:1536.