Choice reflexes in the rodent (and human) sensorimotor striatum

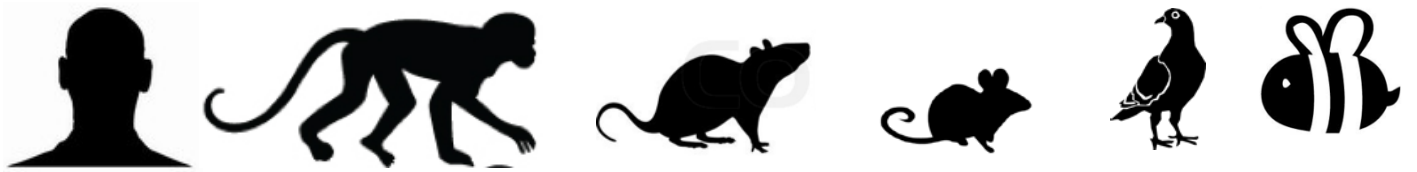
A new mechanism to promote exploration?

Aaron J Gruber

Associate Professor
Dept. of Neuroscience
University of Lethbridge

Rapid response adaptation following poor reinforcements

Lose-switch:



Neural basis:

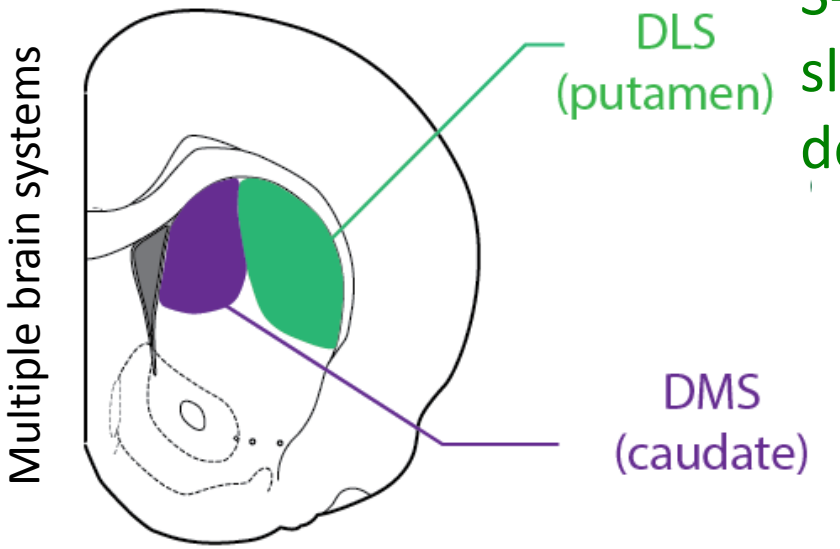
- change in value?
- high stochasticity?
- specific mechanism?

Rapid response adaptation following poor reinforcements

Lose-switch:

Neural basis:

- change in value?
- high stochasticity?
- specific mechanism?



‘Sensorimotor habit’
S-R associations
slow to change
devaluation insensitive

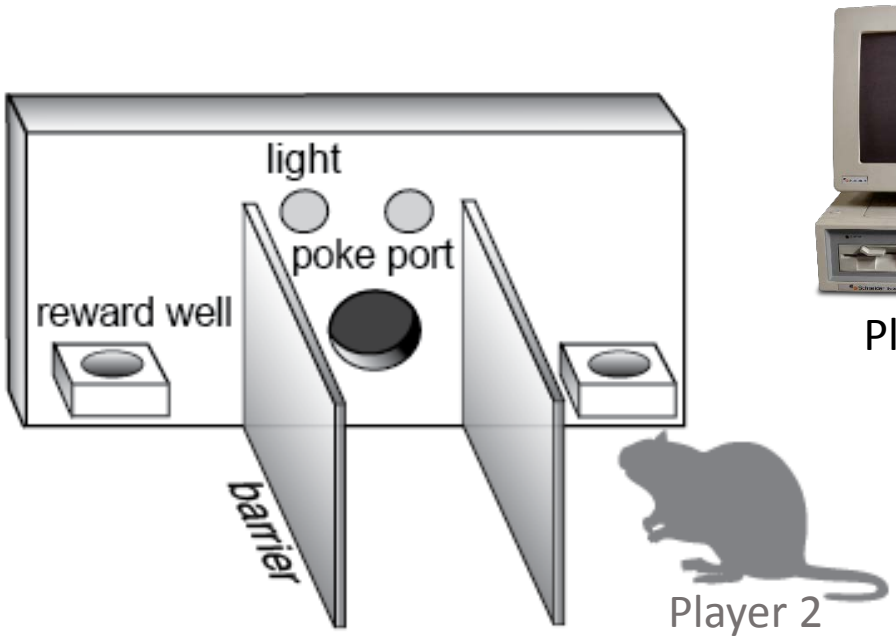
‘deliberative’
A-O associations
rapid change
devaluation sensitive

Competitive Task: 2 x 2 matrix game ('Matching Pennies')

- $C_n^{p1} = C_n^{p2}$: Player 1 wins
- $C_n^{p1} != C_n^{p2}$: Player 2 wins

Competitive Task: 2 x 2 matrix game ('Matching Pennies')

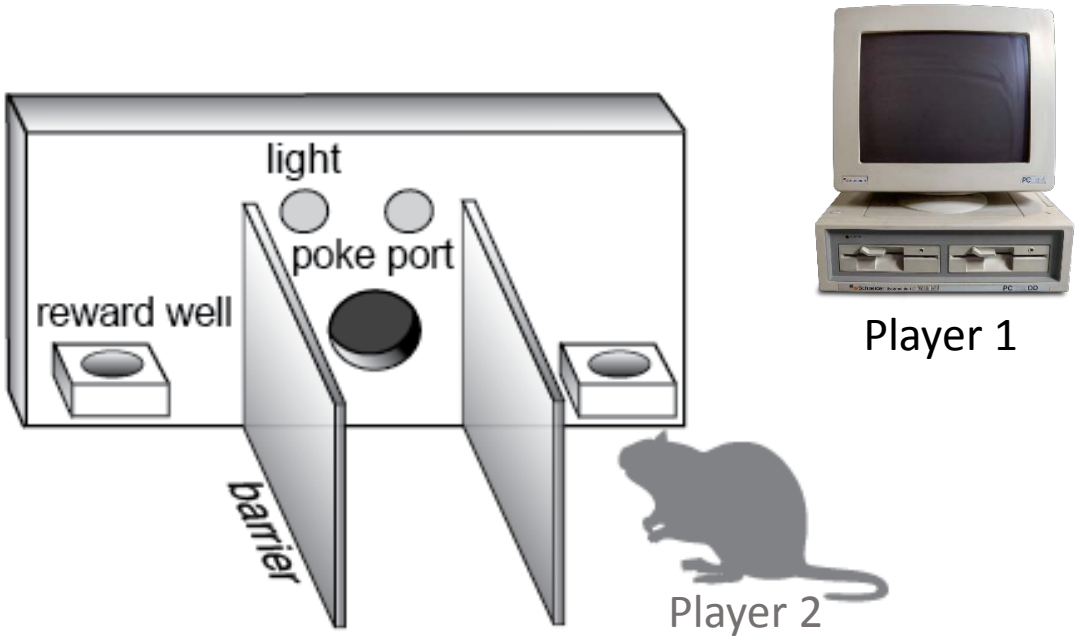
- $C_n^{p1} = C_n^{p2}$: Player 1 wins
- $C_n^{p1} != C_n^{p2}$: Player 2 wins



Player 1

Competitive Task: 2 x 2 matrix game ('Matching Pennies')

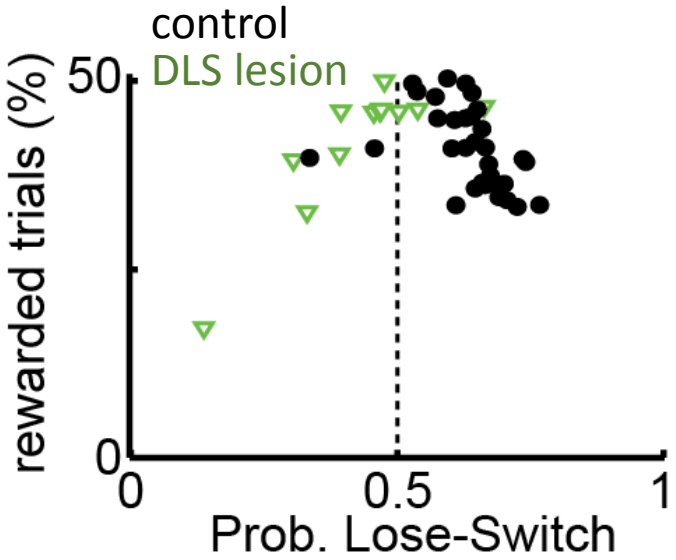
- $C_n^{p1} = C_n^{p2}$: Player 1 wins
- $C_n^{p1} != C_n^{p2}$: Player 2 wins



- Optimal strategy against strong player is a 'mixed strategy' (random responding)
- Expected win probability is 0.5 against an optimal opponent

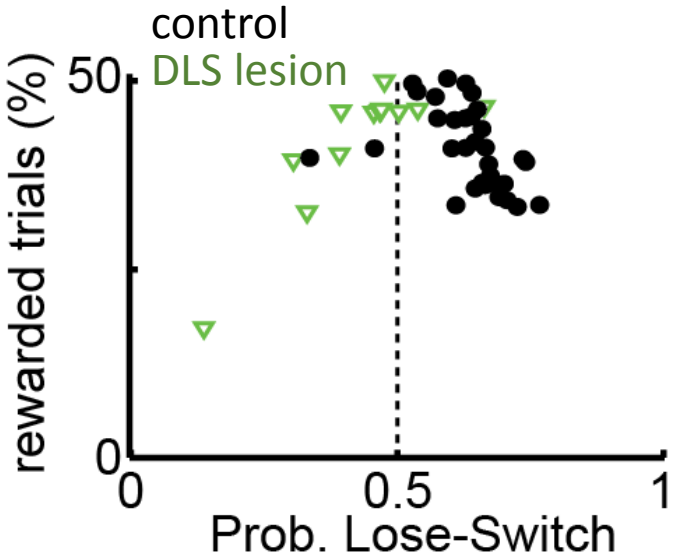
DLS is necessary for lose-switch responding

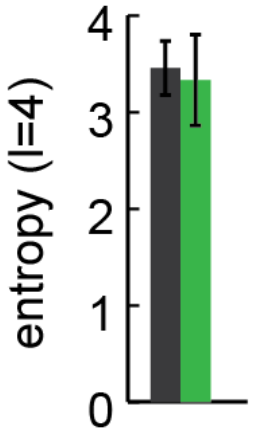
Prediction: ‘habits’ in DLS will produce patterned responses & poor performance



DLS is necessary for lose-switch responding

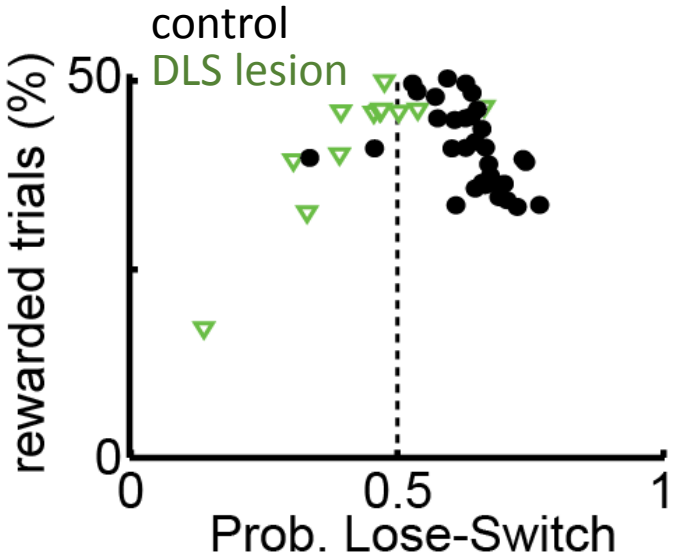
Prediction: ‘habits’ in DLS will produce patterned responses & poor performance

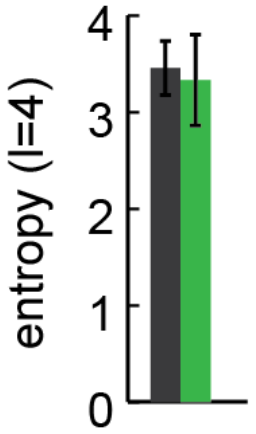




DLS is necessary for lose-switch responding

Prediction: 'habits' in DLS will produce patterned responses & poor performance





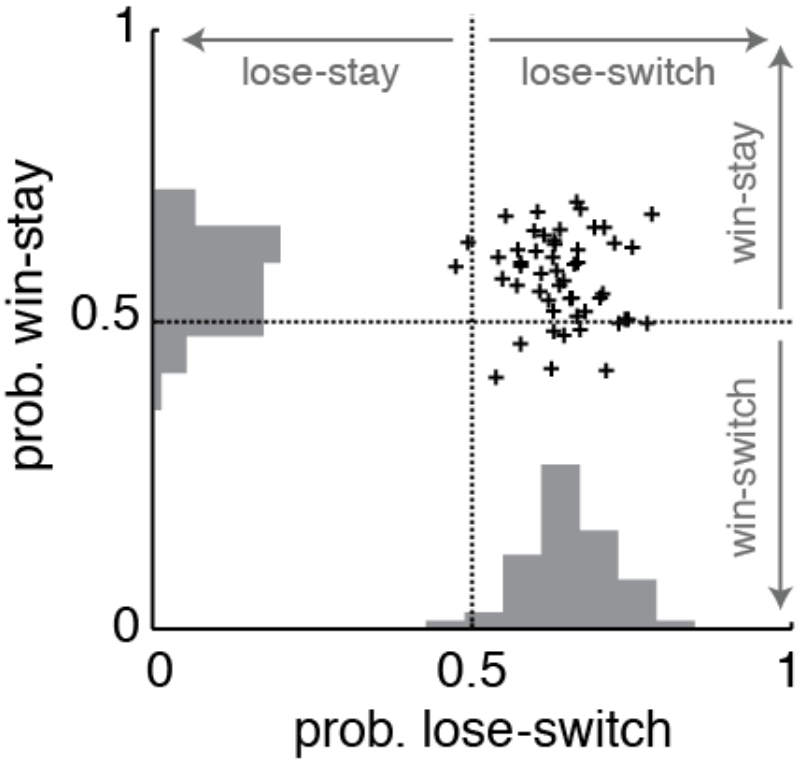
- **Counter to devaluation experiments**

- **Led us to hypothesize that:**
  1) Loss information in DLS is short lived
  2) Involves negative reward prediction error signal by dopamine
  3) General feature of DLS processing; same features in humans

Lose-Switch decays and is independent of Win-Stay

Lose-Switch and Win-Stay are:

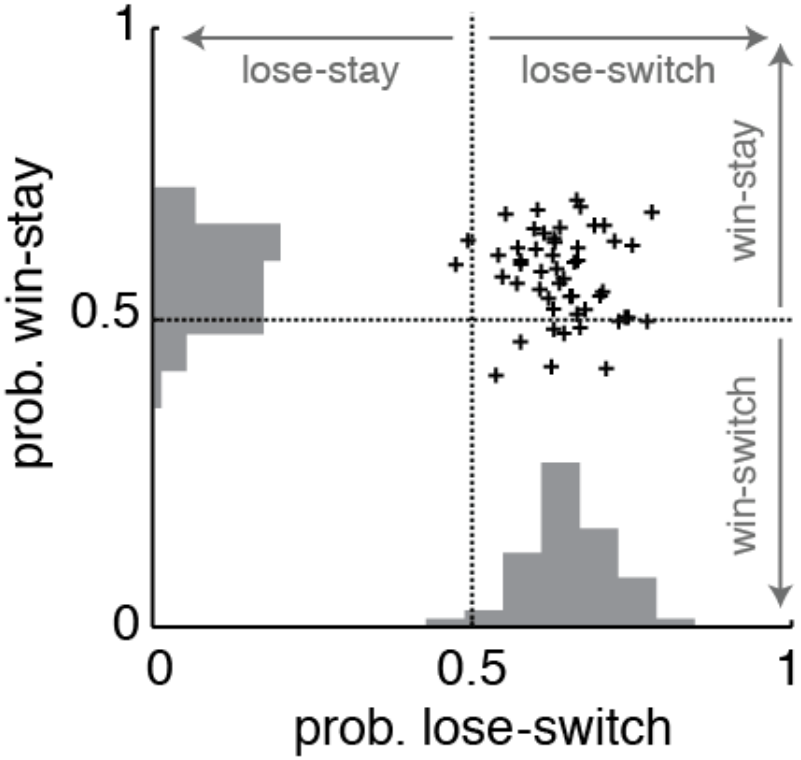
- Prevalent
- Uncorrelated
- Change with inter-trial interval (ITI)

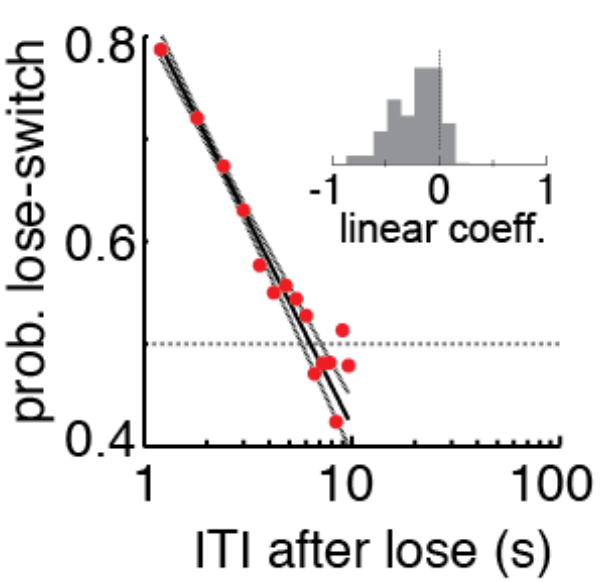


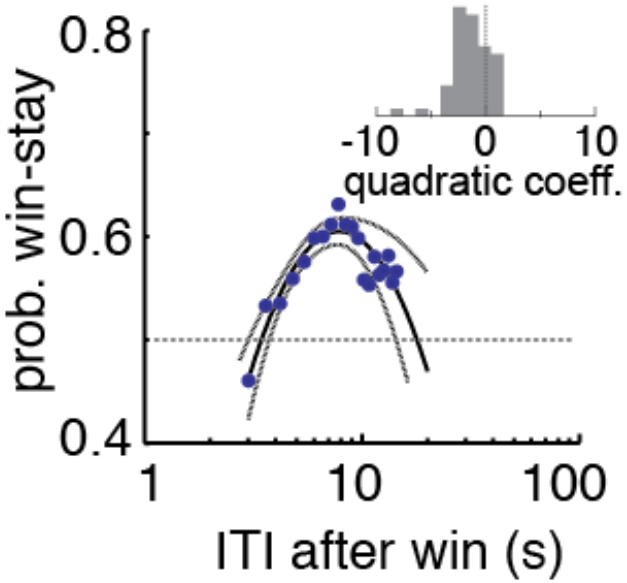
Lose-Switch decays and is independent of Win-Stay

Lose-Switch and Win-Stay are:

- Prevalent
- Uncorrelated
- Change with inter-trial interval (ITI)



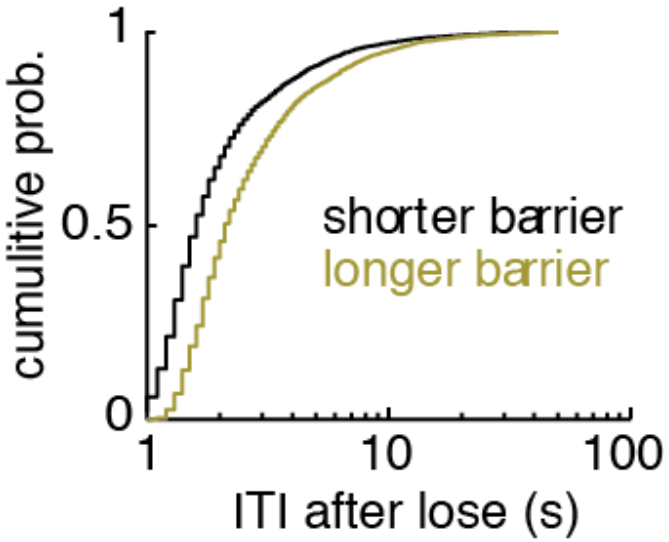


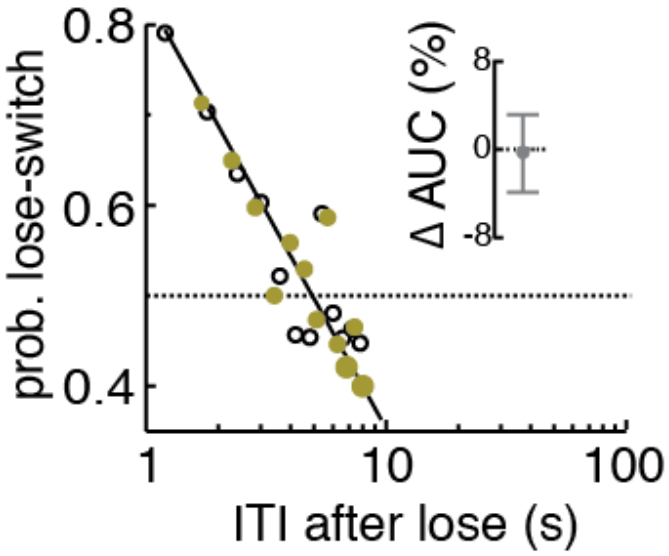


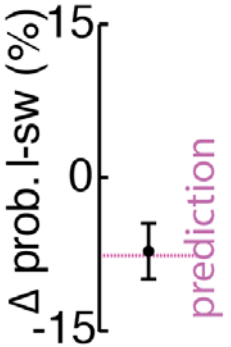
Lose-Switch decays and is independent of win-stay

Lose-Switch and Win-Stay are:

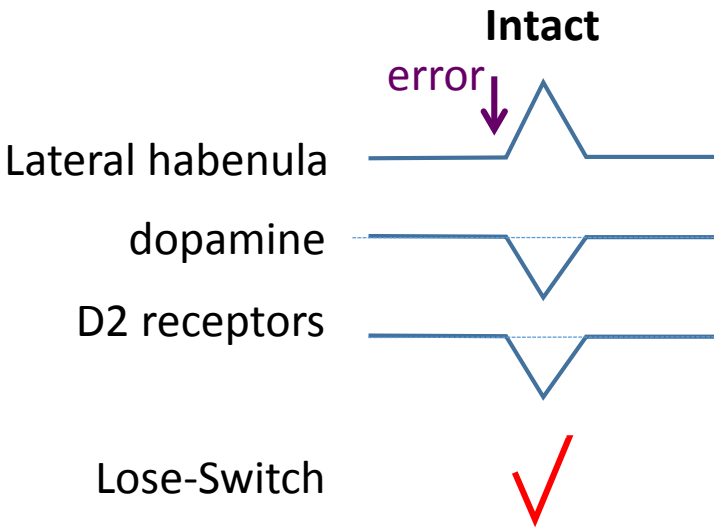
- Prevalent
- Uncorrelated
- Change across ITI



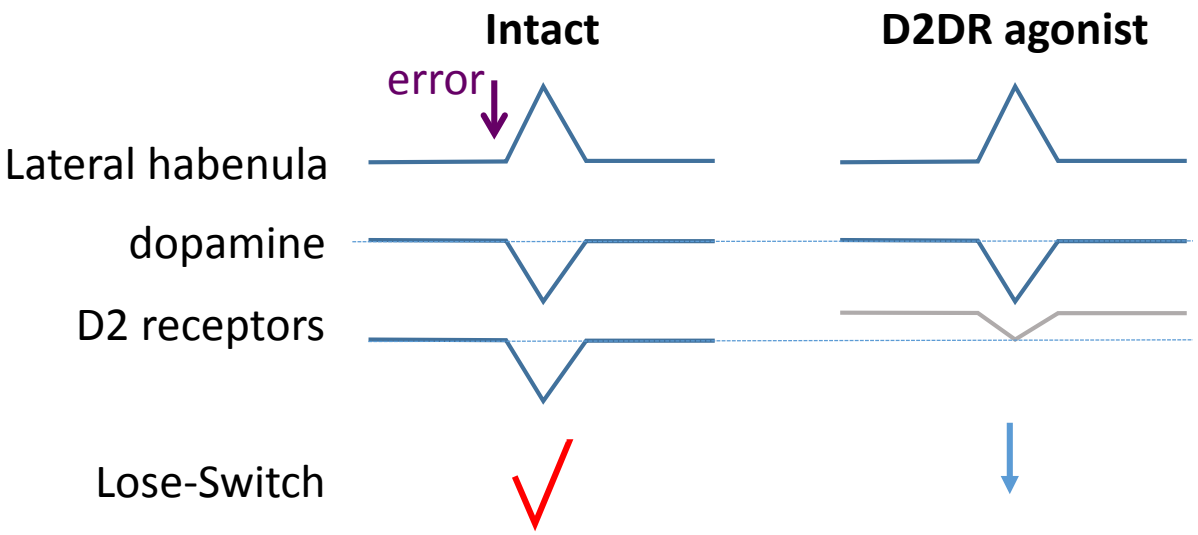




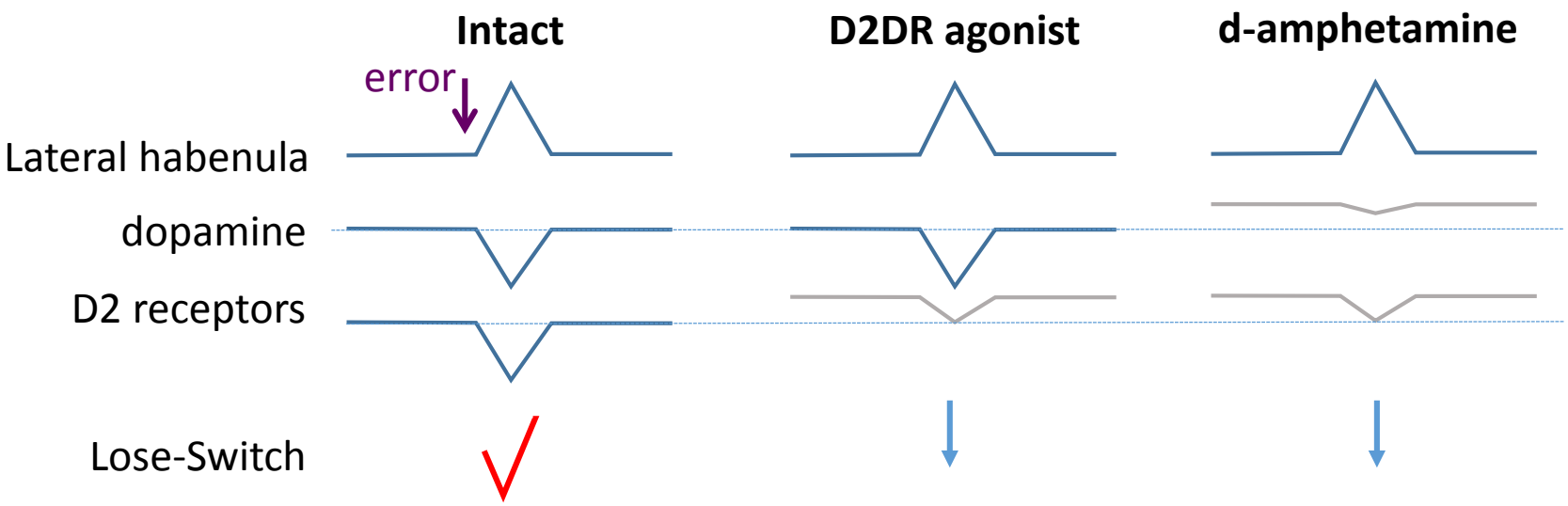
Lose-switch depends on negative RPE



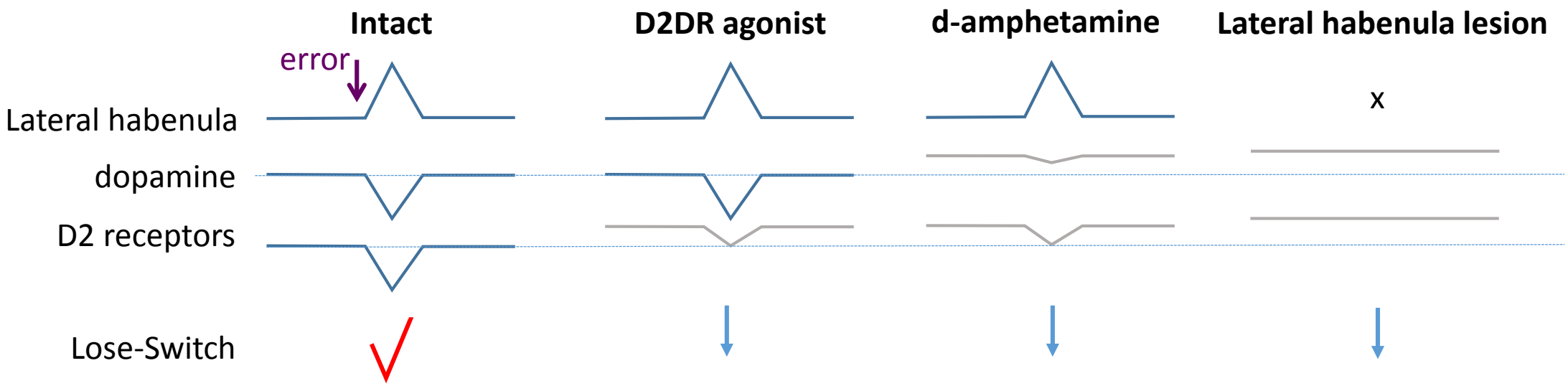
Lose-switch depends on negative RPE



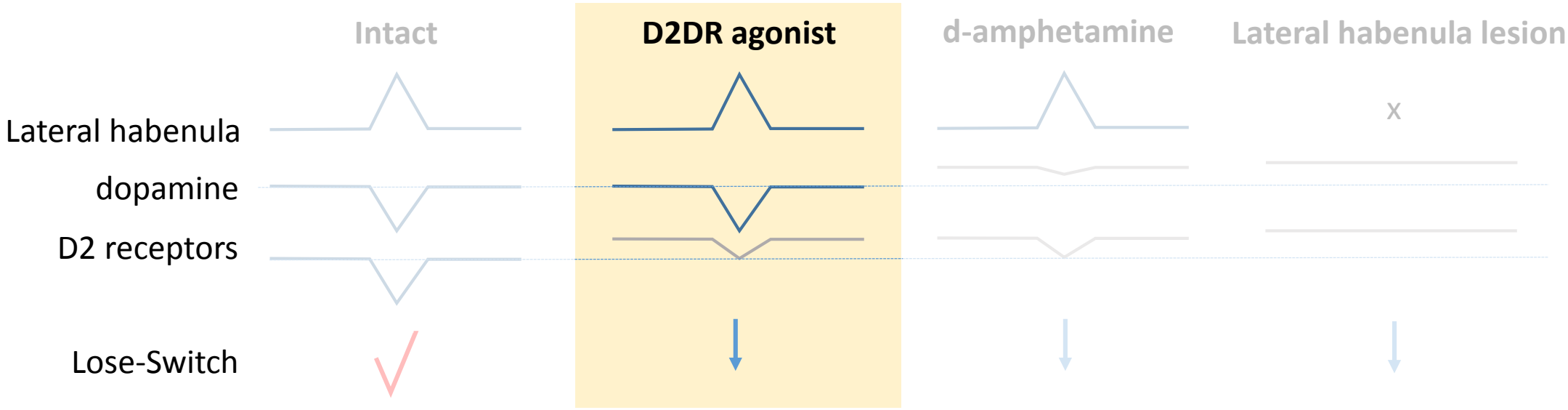
Lose-switch depends on negative RPE

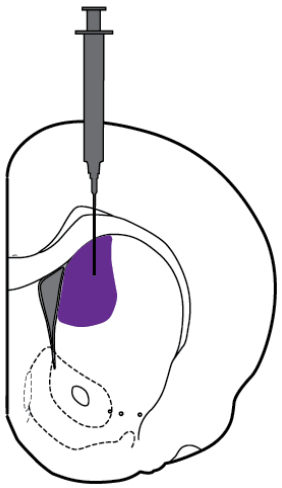


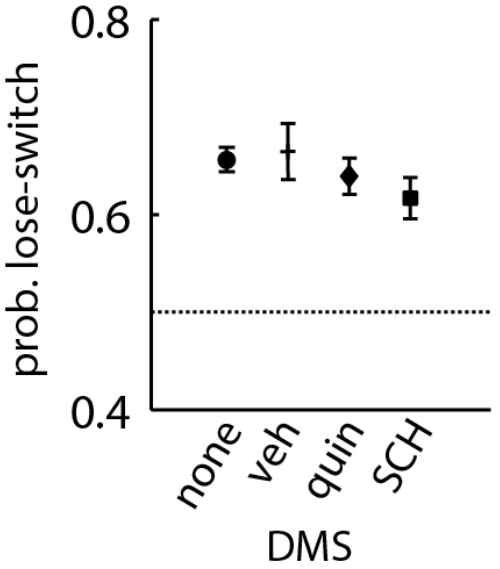
Lose-switch depends on negative RPE

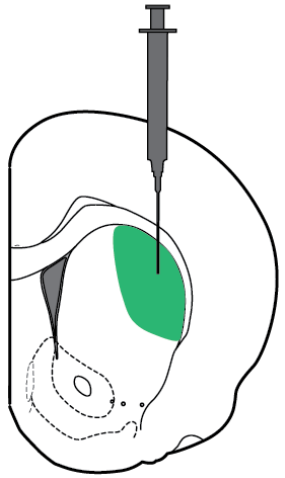


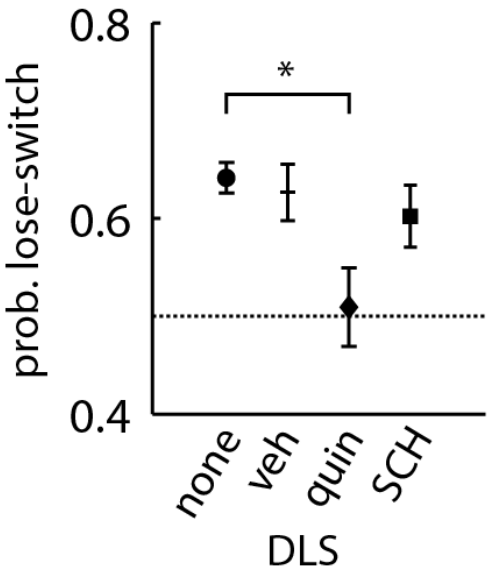
Lose-switch depends on negative RPE



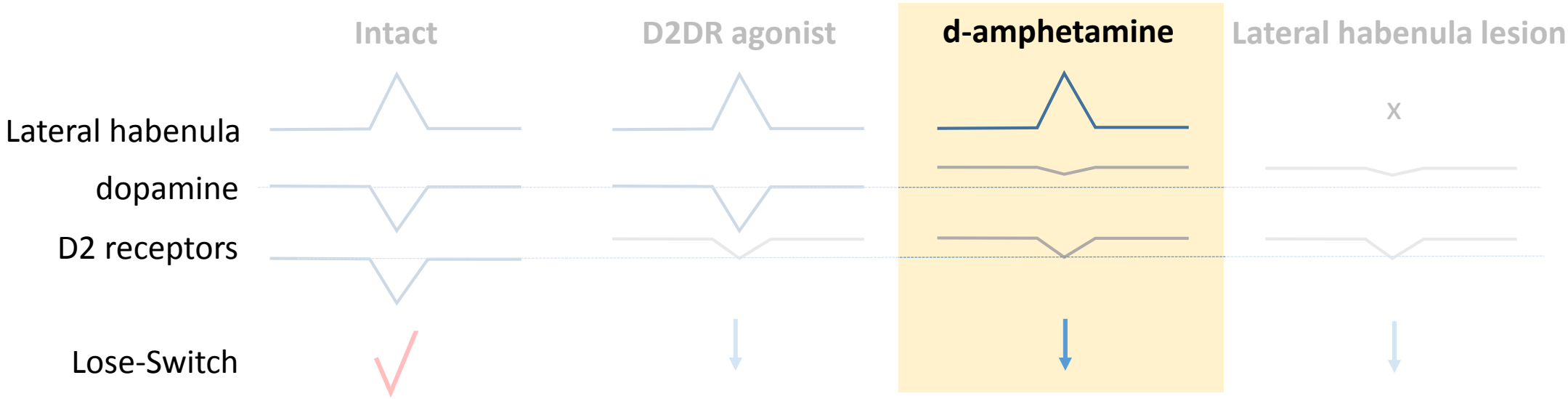


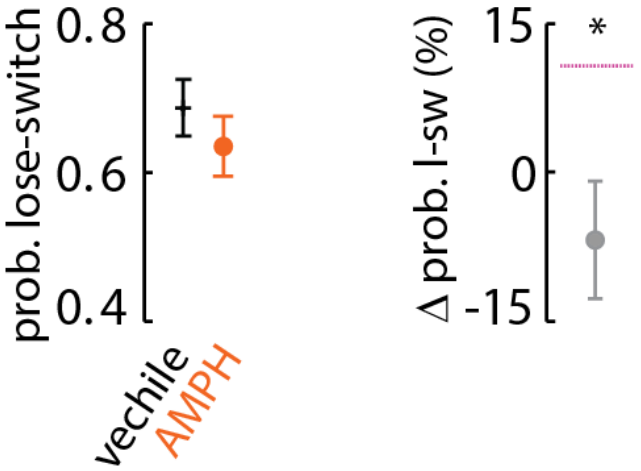




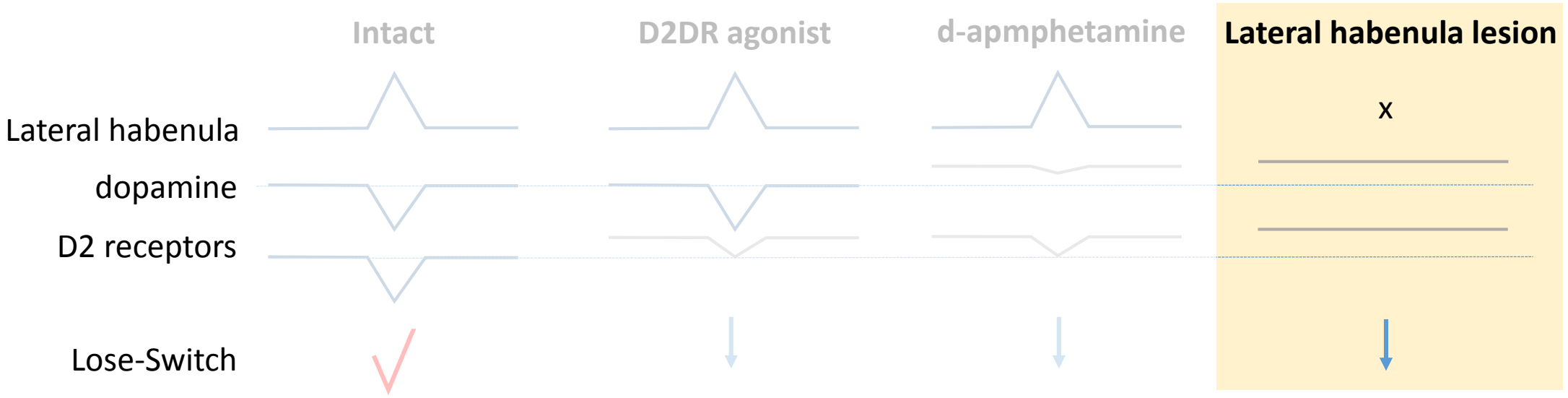


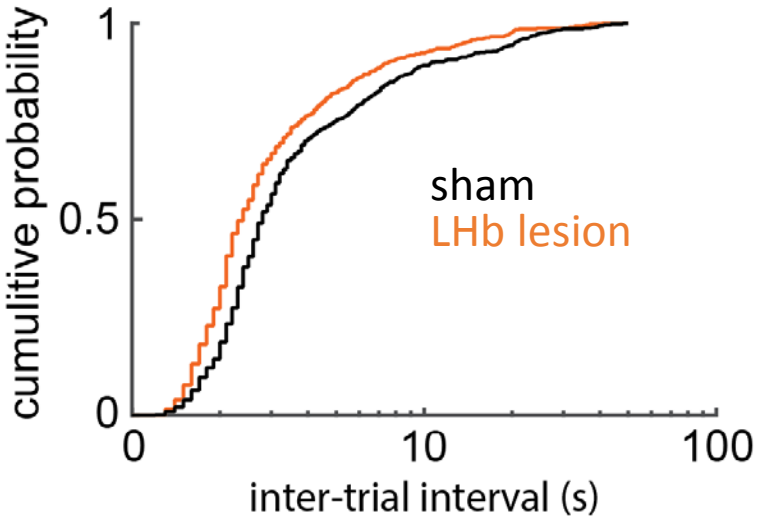
Lose-switch depends on negative RPE

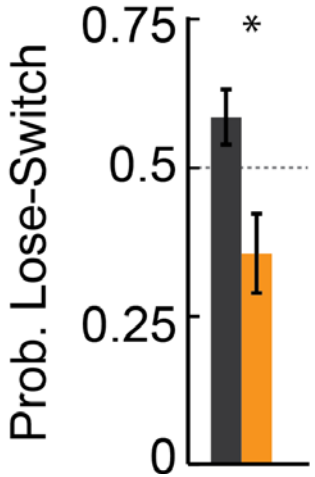




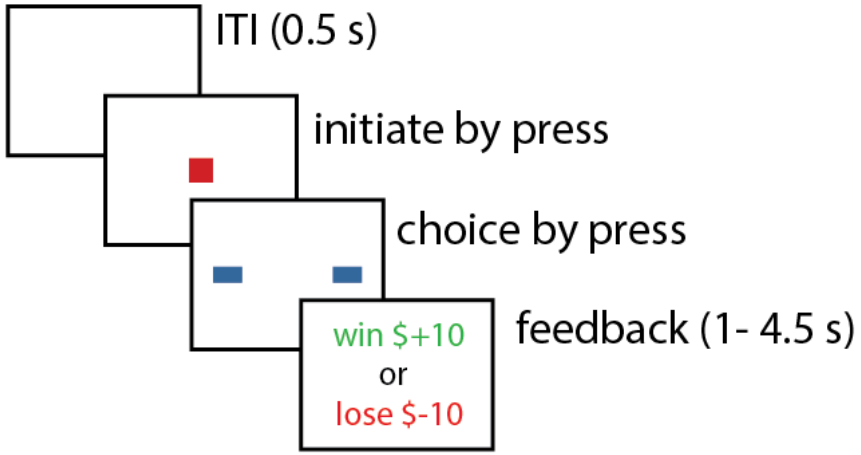
Lose-switch depends on negative RPE



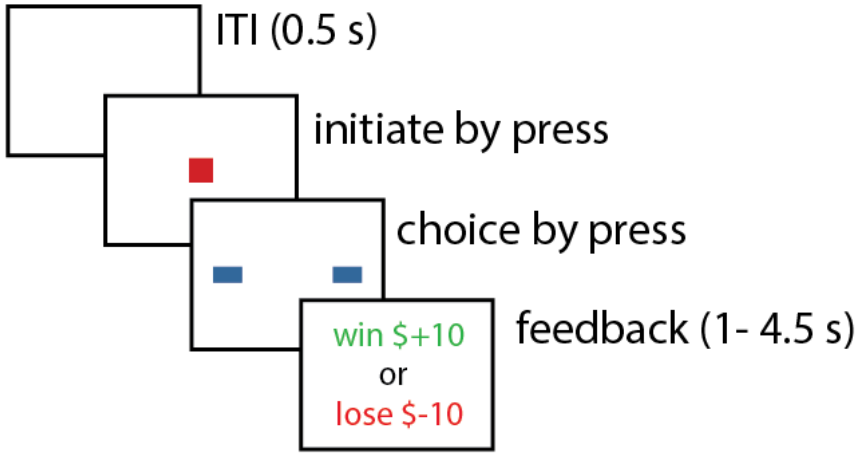


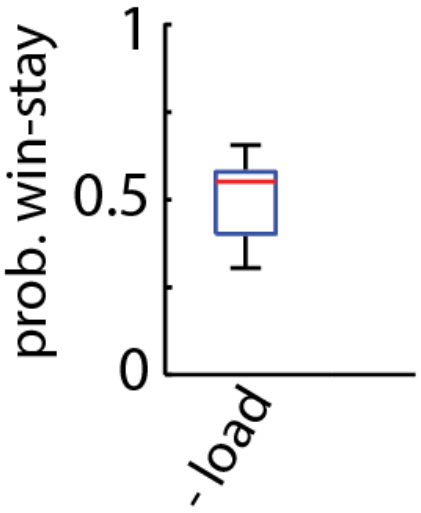


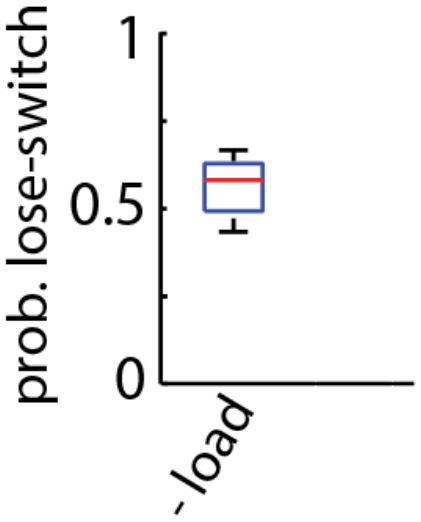
Increased Lose-switch in humans under cognitive load



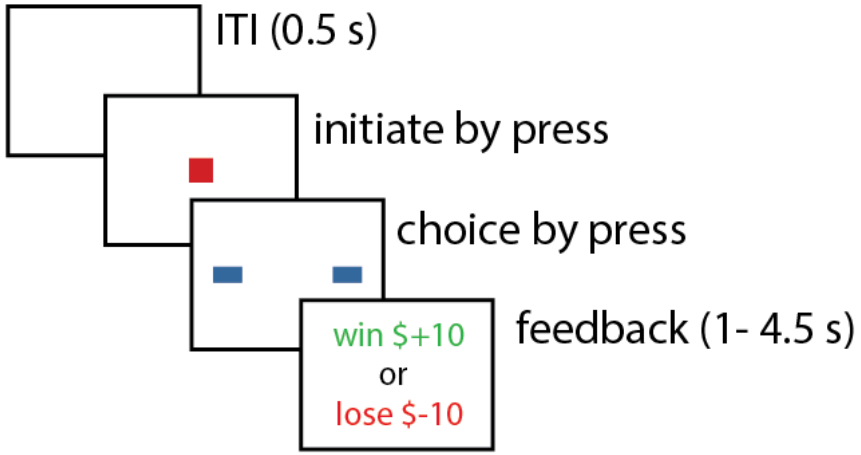
Increased Lose-switch in humans under cognitive load

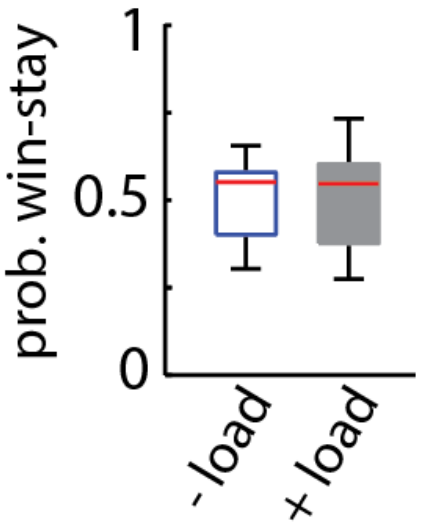


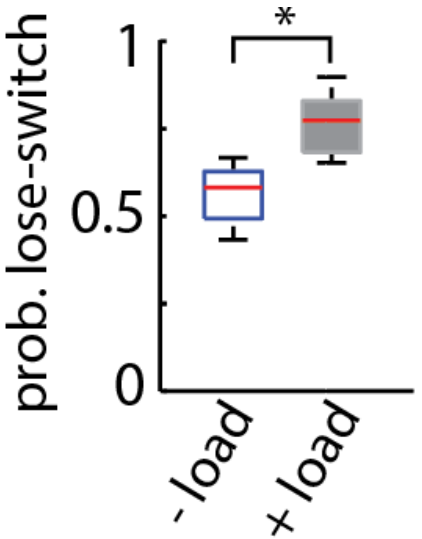




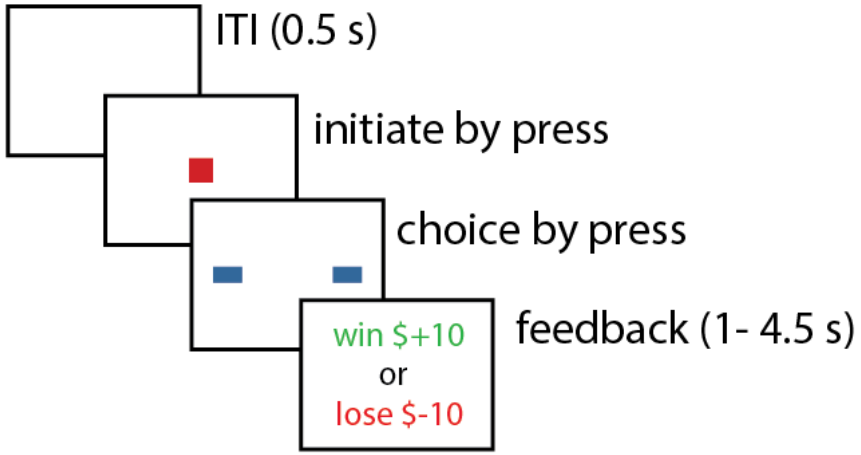
Increased Lose-switch in humans under cognitive load

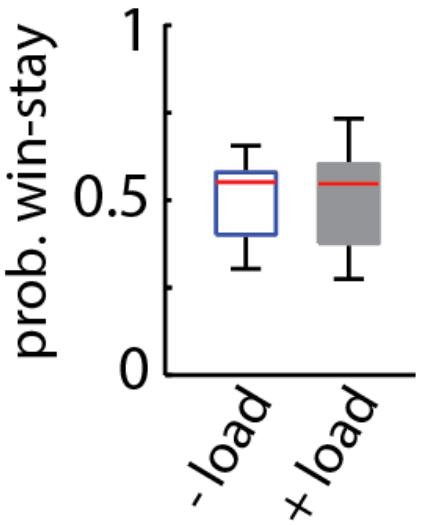


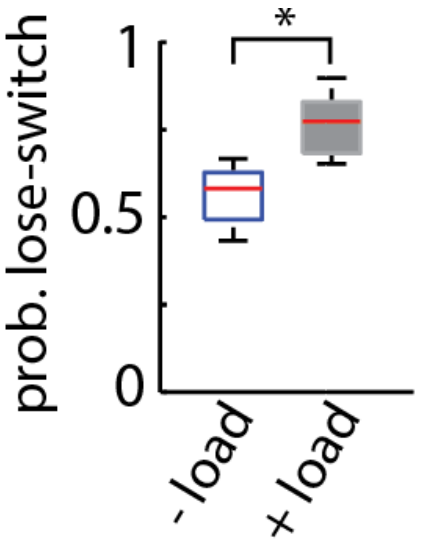


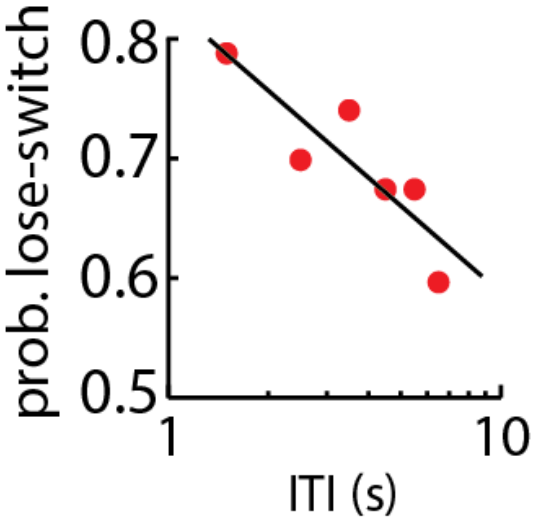


Increased Lose-switch in humans under cognitive load









Summary

- LS and WS are **predominant, persistent**
- LS and WS are **uncorrelated**
- LS depends on **negative RPE** in sensorimotor striatum
- LS emerges in humans under **cognitive load**
- LS **decays** over ~7-8 seconds in rats, and >10 s in humans
  - Much shorter than devaluation

Summary

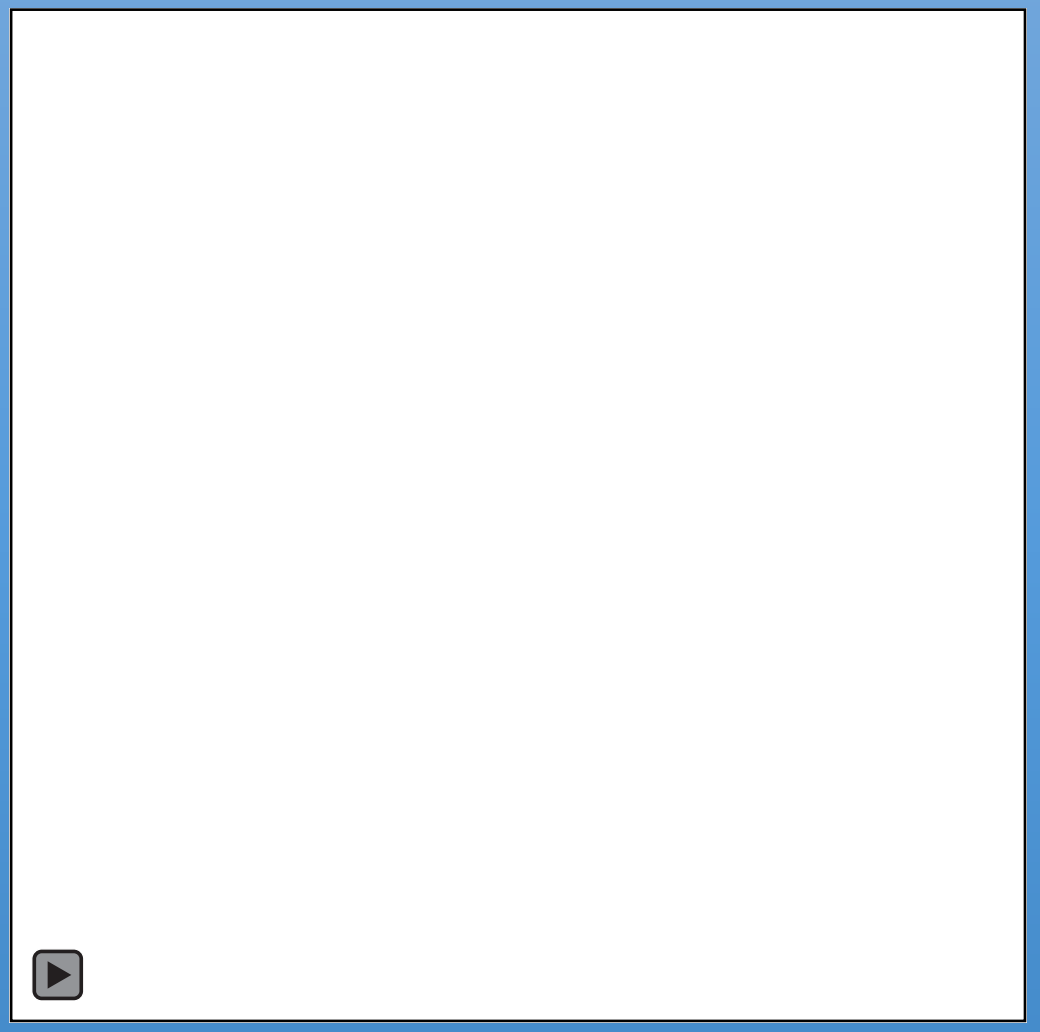
- LS and WS are **predominant, persistent**
- LS and WS are **uncorrelated**
- LS depends on **negative RPE** in sensorimotor striatum
- LS emerges in humans under **cognitive load**
- LS **decays** over ~7-8 seconds in rats, and >10 s in humans
  - Much shorter than devaluation

‘innate choice-reflex’ as intrinsic feature of striatal physiology

INNATE	**LEARNED**
Lose-Switch	skill
grooming	habit

Implications & Speculations:

- Confound in experiments, could improve RL model fits to behaviour
- LS may solve ethologically-relevant tasks
- LS will immediately and briefly promote exploration independent of changes in value or stochasticity
- LS may pause the current response policy so that other computationally-expensive systems can determine a new policy



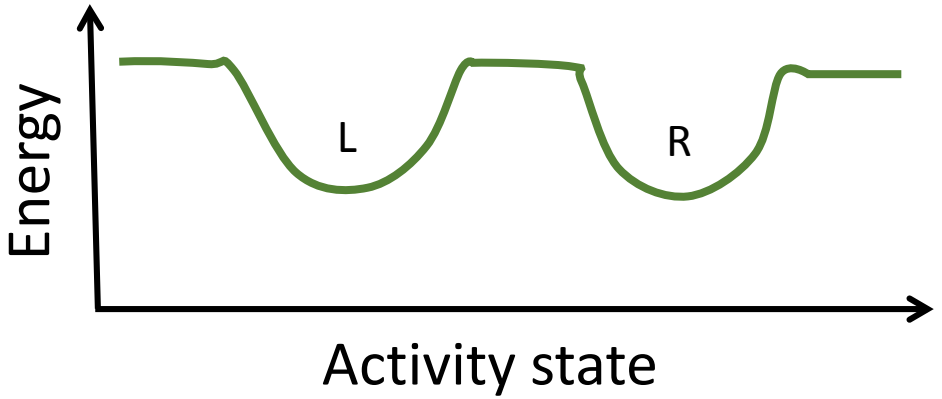
Courtesy of: James MacGlashan

Wild Speculations:

- How might this work in the brain?

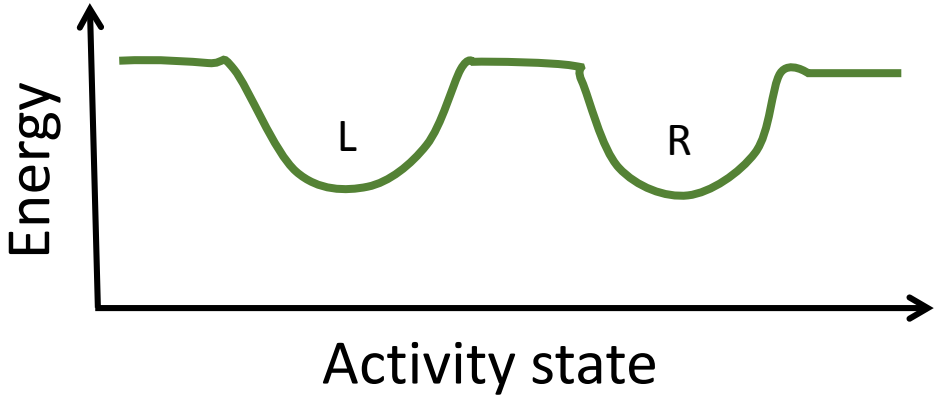
Wild Speculations:

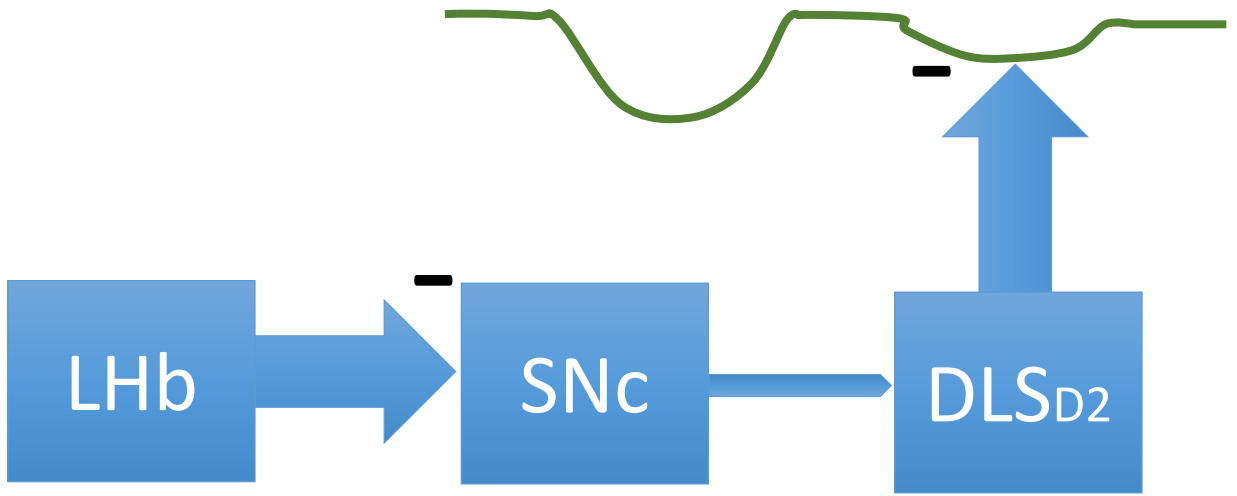
- How might this work in the brain?



Wild Speculations:

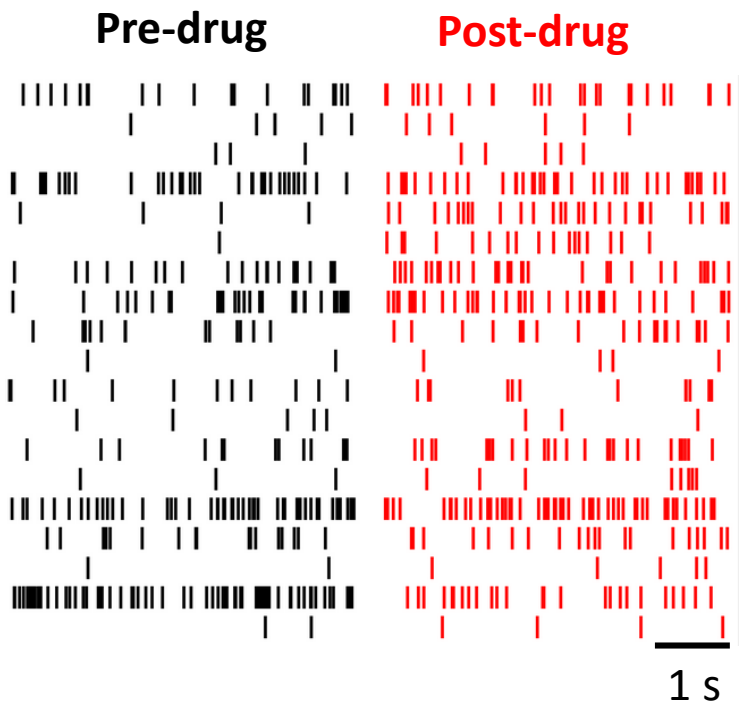
- How might this work in the brain?

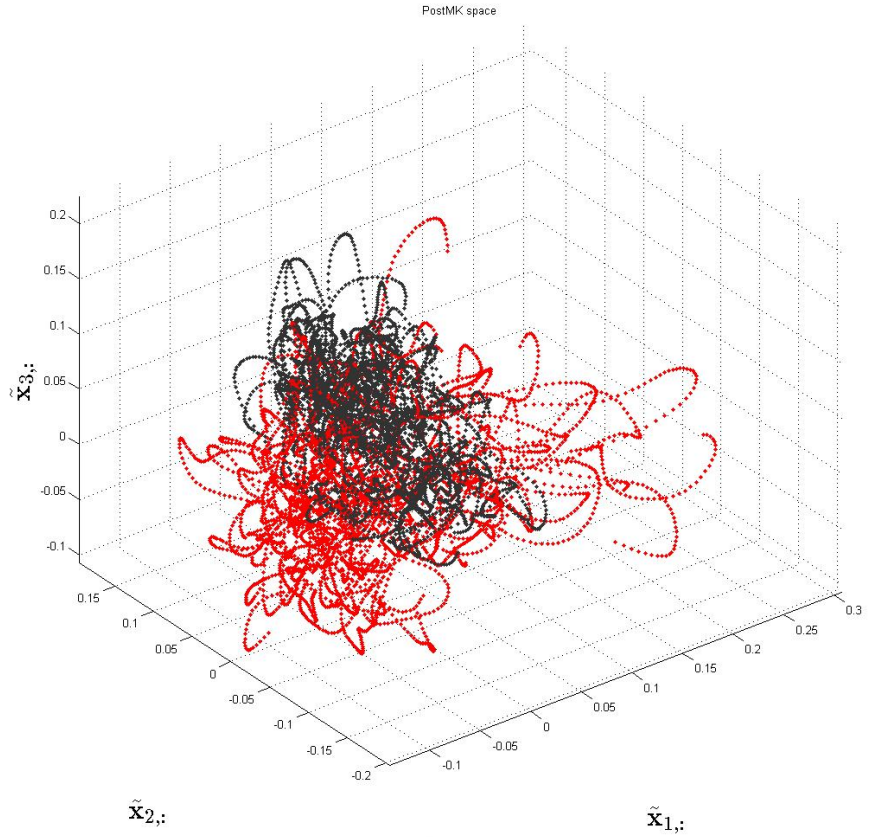




Ongoing:

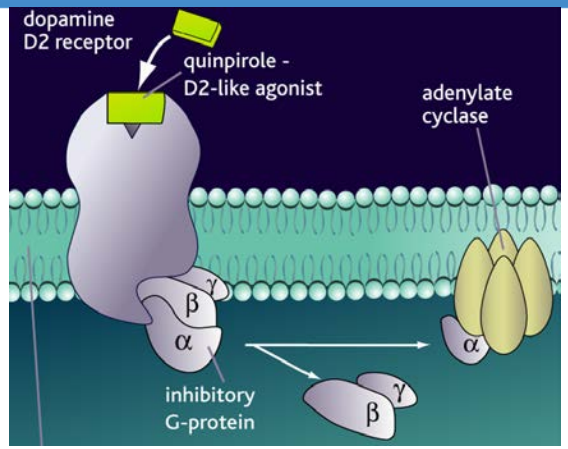
- Ramifications on network dynamics:



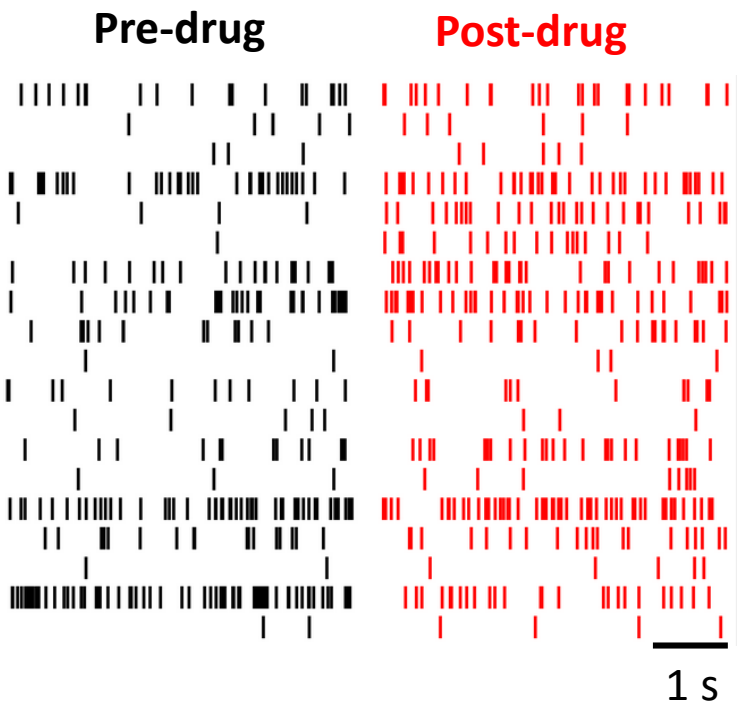


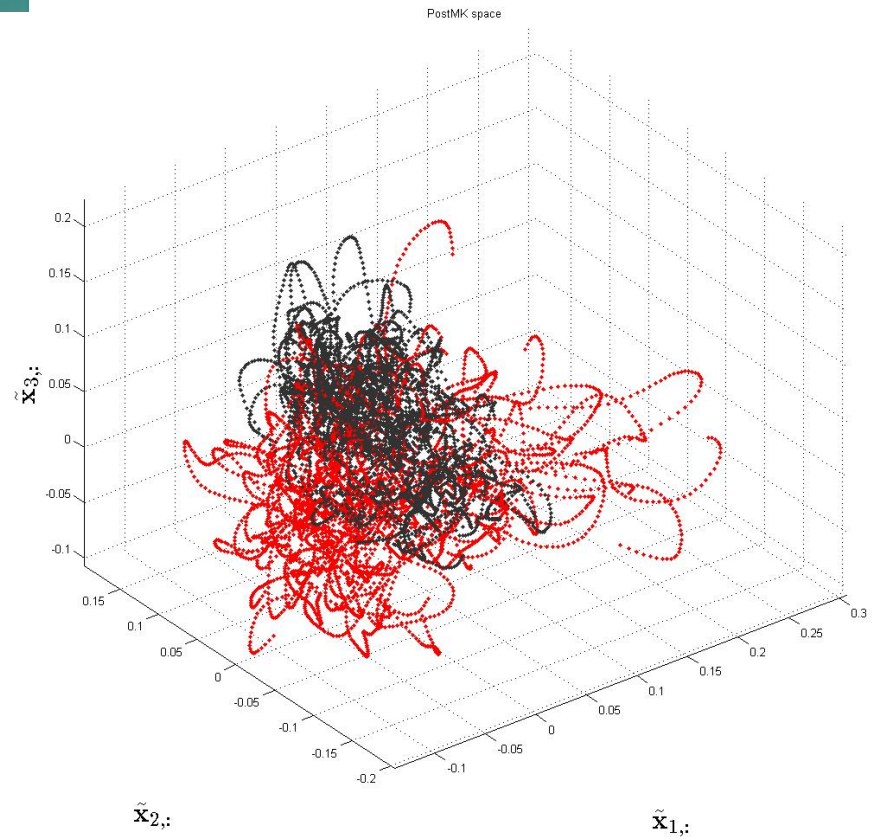
Ongoing:

- Cellular mechanisms:



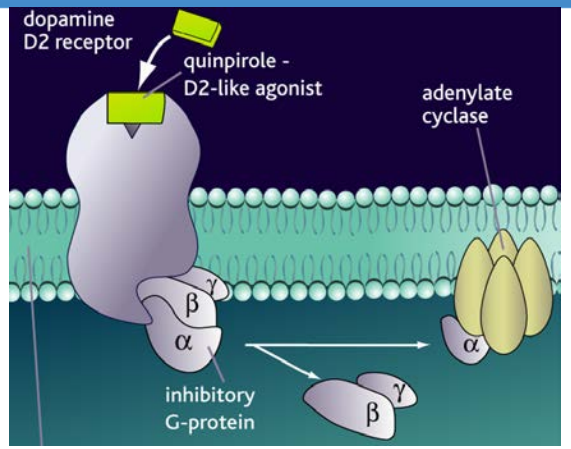
- Ramifications on network dynamics:



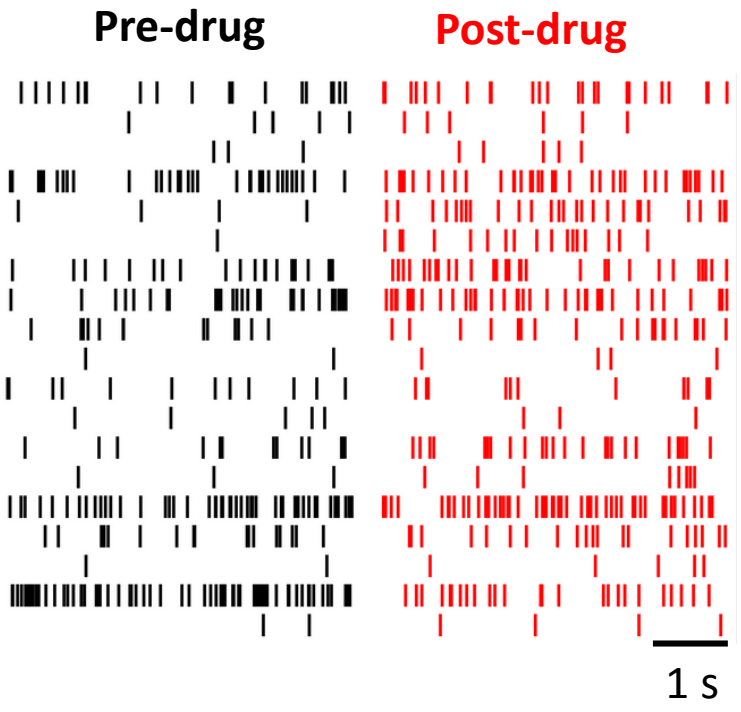


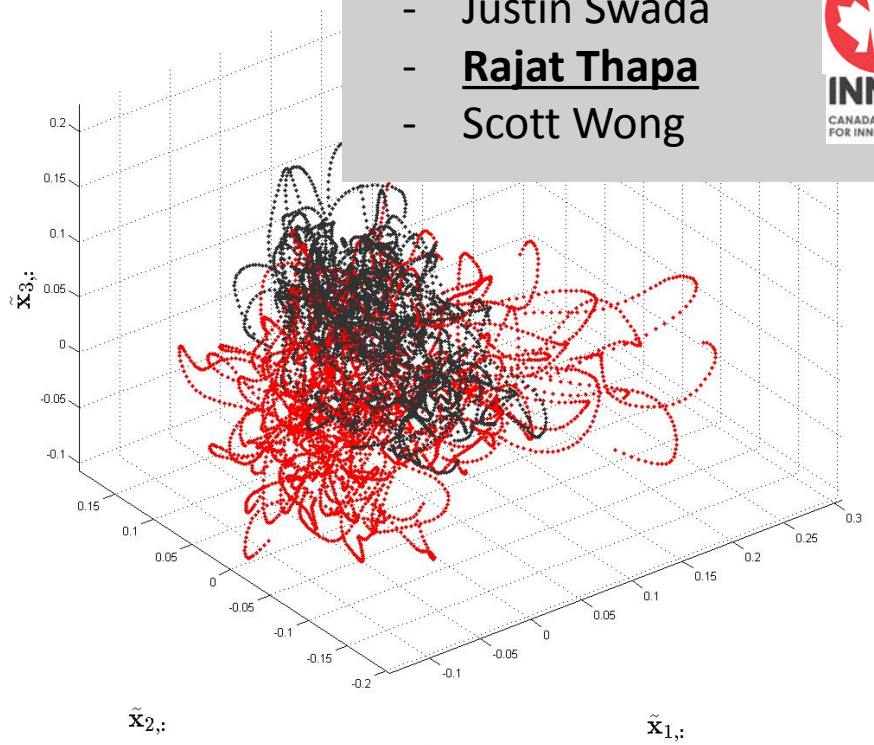
Ongoing:

- Cellular mechanisms:



- Ramifications on network dynamics:





Gruber Lab:

- **Parker Banks**
- Cecil Badenhorst
- Saeedeh Hashemniayetorshizi
- Vicky Ivan
- Afrooz Jalali
- **Ali Mashhoori**
- Sienna Randolph
- Justin Swada
- **Rajat Thapa**
- Scott Wong

Alberta Innovates Health Solutions

NSERC CRSNG

INNOVATION.CA
CANADA FOUNDATION FOR INNOVATION | FONDATION CANADIENNE POUR L'INNOVATION