Simulating the Effects of Dopaminergic Plasticity on Cortico-Basal-Ganglia-Thalamic Networks

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Implement sustained cortical input to winning channel after decision is made

Background

Cortico-basal-ganglia-thalamic (CBGT) networks facilitate adaptive decision-making via direct/indirect pathways [1].

Applicable to understanding of mental and movement disorders [2]:

- Parkinson's disease
- Huntington's disease
- Tourette's syndrome

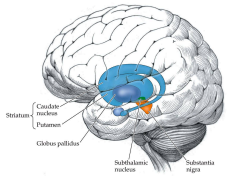
Objectives

Model: *Spike timing-dependent plasticity (STDP) rule* shows how dopaminergic plasticity at corticostriatal synapses alters pathways [3].

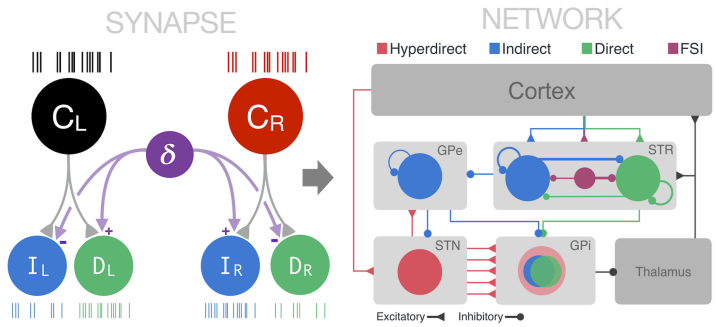
Issue: Current plasticity models use a very simplified network, both channels receive cortical input after decision is made

Sustained cortical input → More naturalistic learning scheme

Dopaminergic modulation of cortical inputs
↓
Long-term plasticity within networks
↓
Feedback-based changes in behavior



Cortico-striatal connections divide into direct and indirect pathways



Synapse → Network

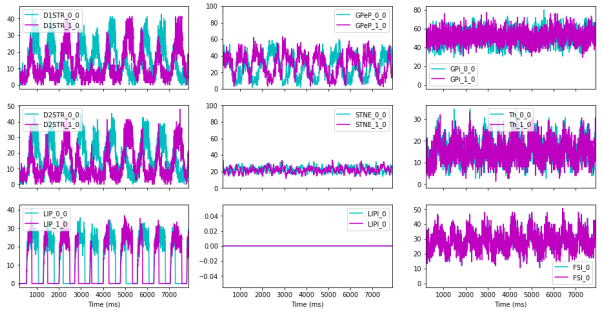
- Characterizes effects of DA feedback on weights of cortico-dMSN/iMSN connections in L/R action channels during value-based decision task
- Once thalamic population firing rate of first action channel hits threshold of 30 Hz, choice is made and dopamine burst is activated

Implementing cortical delay:

- 300 ms delay to release dopamine once decision is made
- Allows for greater accumulation of evidence

Expansion of architectural complexity to simplified STDP plasticity model

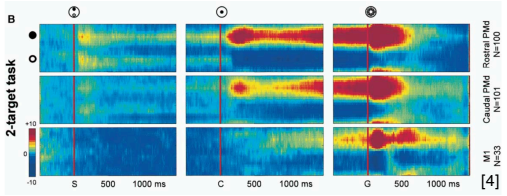
- Parameter tuning (corticostriatal synaptic weights, efficacies, probabilities)
- Lesion connections between GPi and Thalamus
  - Basal ganglia is biasing decision, lesioning GPi inhibits learning



31 population connections w/ efficacy and connection probability values

25 dopaminergic learning parameters

Sustained cortical input to winning channel after decision is made
Losing channel input is turned off



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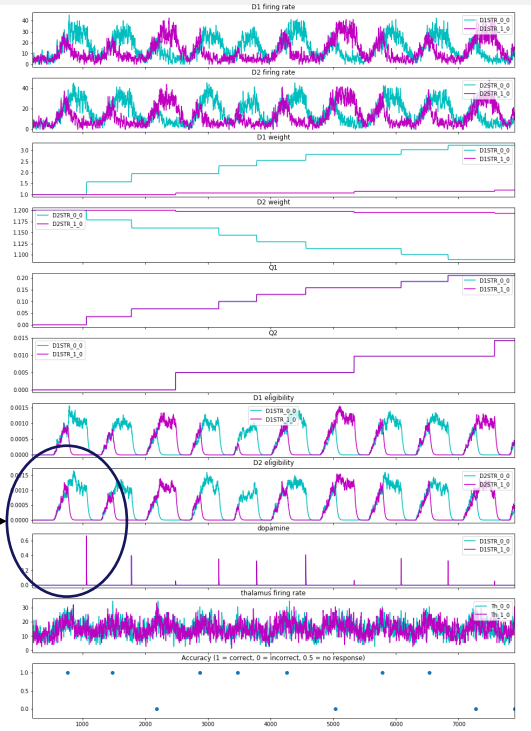

Summary and future directions

Summary:

- Current plasticity models used a very simplified framework
- Adding more complex connections and a realistic timeline moves the network in a more naturalistic direction
- By doing these tweaks we can implement this complicated learning role in the model

Future Directions:

- Thalamic feedback at action selection
- Tonic/phasic dopamine timing
- Switching of the reward contingency
- Up/down status in MSNs

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References

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