How do dopamine neurons and striatal populations interact during decision-making?

ABSTRACT:

Background
Striatal dynamics and dopamine (DA) neuron activity have been shown to correlate with animals' judgments of duration.

Aims
To determine whether DA projecting to different regions of the striatum carry similar signals, To test hypothesis that DA neurons and striatal population functionally interact during timing judgments, to causally test hypotheses emerging from aim 2 by ontogenetically activating DA neuron terminals while recording from local striatal populations.

Method
A combination of behavior, fiber photometry, optogenetics, computational modeling, and electrophysiological recordings.

Results
We found that while DA neurons in the SNc that project to dorsal striatum correlate with and can cause changes in animals' timing judgments, DA neurons in the VTA that project to ventral striatum do not correlate with or cause changes in judgments. Furthermore, computational reinforcement learning modeling (RL) demonstrates that DA responses in SNc are explained if mice used efficient and compressed representations of task variables. Furthermore, subsets of striatal neurons belonging to the direct and indirect pathways subserve broadly opponent aspects of action suppression and production during the task, with the indirect pathway being necessary for accurate decisions. These data suggest that the influence of DA neurons on striatal populations may act through D2 type dopamine receptors on indirect pathway striatal neurons. Lastly, we have found that optogenetically activating dopamine neurons can cause a slowing of striatal response dynamics, consistent with DA's effect on decision-making being mediated by a direct effect of DA on striatal populations.

Conclusions
In sum, in line with the broad aims of the grant, we have collected multiple types of data that have helped refine our understanding of how dopamine neurons act on striatal populations of neurons during decision-making, and in doing so have revealed fundamental new principles of both cognition (efficient coding) and motor control (action suppression and production).

Keywords

Neuroscience, Basal ganglia, Decision-making, Timing, Reinforcement learning

Published Work:

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