Neural correlates of action decisions in a cortico-basal ganglia network

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Abstract

Computational studies often propose that decision-making recruits multiple interconnected brain structures encoding specific aspects of the choice process. However, neurophysiological data in support of such mechanisms emerging from network-based operations is lacking.
I recorded neurons in the dorsal premotor cortex (PMd), the primary motor cortex (M1), the dorsolateral prefrontal cortex (dlPFC) and in the external (GPe) and internal (GPi) segments of the globus pallidus of two monkeys trained to perform a probabilistic reach decision task in which sensory evidence continuously evolves within each trial.

With single-neuron and "state-space" analyses of the neural responses, I'll show that while animals deliberate between the two reach targets, dlPFC, PMd and M1 neurons continuously reflect the evolving sensory evidence guiding the decision. By contrast, the effect of sensory evidence is much weaker in GPe and nearly absent in GPi. Instead, GPe and GPi cells exhibit build-up and decreasing activities consistent with a time-varying signal reflecting the growing urgency to commit. About 280ms before movement onset, we see what appears to be a neural correlate of the moment of commitment, consisting of a prominent peak in PMd activity accompanied by an increase of tuned activity in GPe/GPi. Interestingly, we do not observe any signature of commitment in dlPFC.
These results are captured by a dynamical attractor model in which cortical activity reflects a biased competition between actions, which is gradually amplified by an urgency signal from the basal ganglia that effectively controls the amount of evidence needed before the animal commits to the currently favored reach choice.

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