Decision making brain mechanisms

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In this talk, I will focus on a type of decision making (the decision to obtain reward), the role of a major brain circuit in this type of decision (the basal ganglia circuit), and a computational account of this type of decision making (reinforcement learning) in relation to a major brain circuit. After giving a general overview of the research on this topic, I will discuss some of our work in this area. If time permits, I will also discuss several implications of this study (e.g. addiction) and its broader context (more general concepts of decision making in neuroscience, e.g. decisions with emotion, general computational frameworks, etc). My abstract could end here, but I would like to add further explanation for easier understanding, given the broad range of backgrounds of the participants at this symposium.

Understanding brain mechanisms for decision making is an important pursuit in neuroscience. Computational and mathematical neuroscience, which is my specialty, is particularly interested in developing a computational account that quantitatively captures the decision-making behaviours of humans and other animals while remaining grounded in and consistent with neuroscientific evidence (such as characteristics of brain circuits and neural activities of different brain areas).

The decision to obtain reward is perhaps the most primitive kind of decision making. Here, for simplicity, we may regard the term “reward” as the basic needs of living such as food and water. The basal ganglia, forming a major sub-cortical neural structure consisting of several nuclei, play a major role in this kind of decision making. The basal ganglia have long been known to play an important role in motor control and learning. Furthermore, the basal ganglia are also known to possess an abundant projection of dopaminergic neurons, where in a very general sense those neurons are known to have strong neural activity in relation to reward.

Given these considerations, the basal ganglia are generally considered to play a major role in the decision to obtain reward, i.e. motivated or reward-oriented behavior. Extensive research conducted over the last decade, including ours, has made significant progress in understanding how the basal ganglia function in reward-oriented behavior, namely the so-called reinforcement learning hypothesis of the basal ganglia. This hypothesis states, to put it briefly, that dopamine neurons' activity represents reward prediction error and that this error signal is used as a learning signal in the basal ganglia, which guides decision making in reward-oriented behavior. Notably, reinforcement learning itself has also been extensively studied in machine learning, artificial intelligence and related fields. Those studies gave us insights and guidance for further investigation on the basal ganglia functions.

Research has progressed in several directions based on the reinforcement-learning hypothesis. As one example, we discuss our proposal, together with experimental validation, on the functions of the parallel cortico-basal ganglia circuit. Also, studies in nature on the reward-prediction error signal of dopamine neurons are discussed. These studies elucidated the nature of the basal ganglia functions in decision making to obtain reward, and furthermore gave insights on decision making in a broader sense, including decisions based on social context. If time permits, I will further discuss these implications as well, including the thorny issue of addiction.

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