FORUM

Neural coding of computational factors affecting decision making.

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Abstract

We constantly need to make decisions that can result in rewards or punishments of different magnitudes and different probabilities. To characterize the neural coding of computational factors affecting value-based decision making, it is first necessary to understand how they are coded in the brain when no choice needs to be done. This is the approach we took in the past few years using intra-cranial recordings in patients with epilepsy and fMRI in healthy controls to understand how factors, such as reward magnitude, probability or uncertainty (maximal for reward probability=0.5) are coded in the human brain. In a number of Pavlovian conditioning experiments, we have characterized how the brain encodes different signals, such as the anticipatory value of the outcome that it expects to receive following a cue ("expected value"), the value of the actual outcome at the time of its reception ("outcome value") and the computation of a prediction error that measures the deviation between actual and anticipated values. We also investigated common and specific brain regions responding to expected outcome and experienced value for different types of rewards and punishments. During reward and punishment anticipation, a common ventromedial prefrontal cortex was engaged with the expected outcome, regarless of valence. At the time of the outcome, our results showed both a core reward system processing experienced value regardless of reward type and a functional organization in the orbitofrontal cortex along a postero-anterior axis according to reward type, with the anterior part responding to secondary rewards and the posterior and medial part responding to primary rewards. In a number of subsequent studies using model-based fMRI, we studied value-based decision-making in situations where we face a choice between several options. We characterized how the brain computes the subjective value of outcomes expected from alternative options, weighing the likely benefits and costs resulting from an action. Our data reveal that the human brain uses distinct valuation subsystems for different types of costs. In particular, the ventromedial prefrontal cortex and the anterior cingulate cortex reflect in opposite fashion delayed reward and future energetic expenses. In addition, we showed that genetically-influenced variations in dopamine transmission modulate the response of brain regions involved in anticipation and reception of rewards, and also provided evidence of neurofunctional modulation of the reward system by gonadal steroid hormones in humans. These findings establish a neurobiological foundation for understanding the impacts of genes and gonadal steroids hormones modulating dopamine transmission on vulnerability to drug abuse and neuropsychiatric diseases. Together, these results indicate that the combination of computational approach, molecular genetics, endocrinology and neuroimaging now helps to clarify the influences of basic biological mechanisms on reward and decision making processes.

Host: Hiro. Nakahara Lab for Integrated Theoretical Neuroscience