Interdisciplinary Area

Title of Project : Elucidation of the Neural Computation for Prediction and Decision Making

Kenji Doya

(Principal Investigator, Neural Computation Unit,Okinawa Institute of Science and Technology)

【Purpose of the Research Project】

The purpose of this research area is to elucidate the principles and the brain mechanisms of human decision making through combination of the theories in logics and statistical inference, analyses of human behaviors and functional brain imaging, measurement and manipulation of brain activities in experimental animals, computer simulations, and robotic experiments. There are two basic mechanisms for decision making: model-free mechanism that is reactive and habitual, and model-based mechanism that is predictive and flexible. Through innovative experimental and computational approaches, we will clarify how these two mechanisms are selected or combined, how "mental simulation" for the prediction of action outcome in model-based decision making is realized by neural circuits, and how those mechanisms are regulated by molecules and genes.

【Content of the Research Project】

We work on three major research subjects with the following working hypotheses and methods.

1) Theory of Decision Making

Model-free decision making is simple in computation but not flexible in adaptation. Model-based decision making can utilize the knowledge from experience more flexibly but requires more computation. We postulate that humans and animals choose and combine the two methods based on the reliability of their predictions subject to the evolution and development of the brain, individual experiences, and real-time constraints for decision making. We derive algorithms for selection and combination the methods based on the theories of logics and machine learning and test their predictions though analysis of human and animal behaviors.

2) Neural Circuit of Decision Making

We postulate that mental simulation is realized by predictive models in the cerebellum and probabilistic inference by the prefrontal cortex. They are combined with the valuation mechanisms of the striatum, the amygdala, and the habenular nucleus for action selection. We will clarify the exact computational processes of mental simulation through identification of responsible areas by neural recording, testing
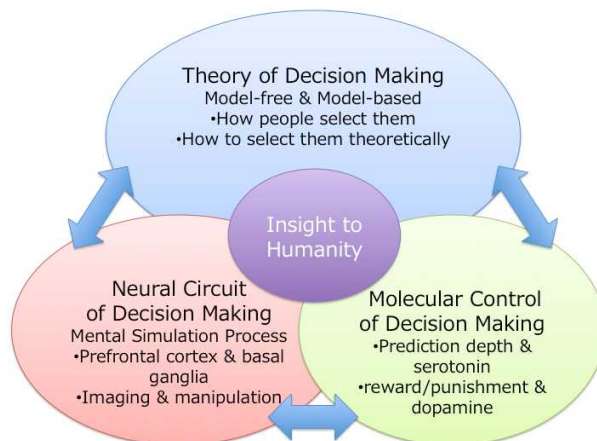
their functional relevance by stimulation and manipulation, and optical recording of neural activities in the local circuit.

3) Molecular Control of Decision Making

We postulate that the time scale of reward prediction is regulated by serotonin and that the balance of reinforcement by reward and aversion by punishment is regulated by different dopamine receptor systems. It is theoretically predicted that the features of decision making are regulated depending on the animal's environment and experience. This will be tested through behavioral analysis under various environmental conditions and pharmacological and genetic manipulations.

【Expected Research Achievements and Scientific Significance】

Elucidation of the brain's mechanisms for decision making will provide deeper insights into the physical basis of human mind. It will enable new developments in therapies for psychiatric disorders, methods for education, designs of socio-economical policies, and human-friendly IT products.

【Key Words】

Model-based: methods using prediction of how the situation changes by an action.

Mental simulation: the brain mechanism for predicting the outcome of hypothetical actions.

【Term of Project】　FY2011-2015

【Budget Allocation】　1,177, 900 Thousand Yen

【Homepage Address and Other Contact Informatio】

http://www.decisions.jp