Title of Project : Adolescent Mind & Self-Regulation

Kiyoto Kasai
(Tokyo University Department of Psychiatry Professor)

【Purpose of the Research Project】

The most distinguished characteristic of human mental function is the ability of self-regulation, which is based on language acquisition and social reciprocity. Humans can utilize the self-regulation function to regulate their own mind & brain to pursue establishment of ego.

The self-regulation of mental function is unique to humans, which is realized by the highly developed prefrontal cortex, and is established in adolescence. Adolescence is the life stage where the prefrontal cortex matures and thus is the important period for establishing ego. In turn, an inappropriate maturation of the self-regulation in adolescence could lead to serious mental health problems prevailing in modern society.

Our research area proposes to establish a new interdisciplinary science by investigating the mechanism of self-regulation of the mind & brain in adolescence and developing the support strategy.

【Content of the Research Project】

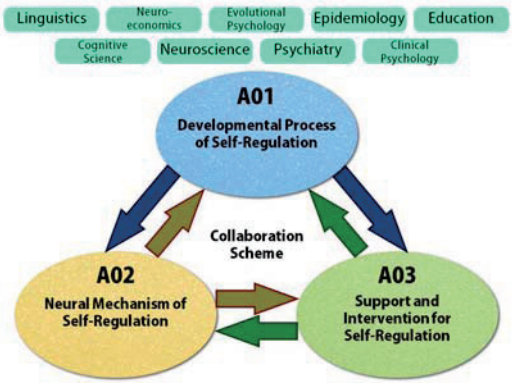

Figure 1. The Research Strategy

Our research area consists of three branches; A01: investigating developmental process of self-regulation in adolescence by management of teen cohort; A02: investigating neural mechanisms of self-regulation development in adolescence by comparative cognitive sciences; A03: developing support and intervention strategy through molecular, neural modulation, and psychosocial approaches.

【Expected Research Achievements and Scientific Significance

We will contribute to the society by providing evidence for education from the teen cohort and developing real-world strategy for supporting self-regulation maturation in adolescence. We will realize previously unmet challenge toward establishing interdisciplinary human science through intensive collaboration of various scientific fields.

【Key Words】

Adolescence: the life stage relatively unique to humans where the maturation of prefrontal cortex occurs to establish ego.

Self-regulation: The most distinguished characteristic of human mental function which enables regulation of their own mind & brain to pursue establishment of ego.

【Term of Project】 FY2011-2015

【Budget Allocation】 1,145,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://npsy.umin.jp/amsr/index.html

Title of Project : Synthetic Biology for the Comprehension of Biomolecular Networks

Masahiro Okamoto
(Kyushu University, Graduate School of Systems Life Sciences, Professor)

【Purpose of the Research Project】

In order to make the paradigm shift from the concept of "watched and analyzed biology" to that of "synthetic and analyzed or utilized biology", the innovative research named *Synthetic Biology* was started from 2000 in US, such as designing synthesized genetic circuit by combining known interrelated biomaterials, realizing a certain bio-functional behaviors such as switch, oscillation, *in vivo*, designing artificial metabolic pathways by incorporating genes coded enzyme from other origins into the cells. However, these attempts have been done on a small scale and with a trial-and-error method. The objectives of this research project is to establish the coordination between the fundamental technologies for synthetic biology in order to comprehend biomolecular networks by integrating the following three missions: 1) design artificial genetic circuit or metabolic pathway with using the methods of computational science, 2) construct the circuit *in vitro* with using the method of engineering, 3) construct the circuit *in vivo* or in the cell with using the methods of molecular biology.

【Content of the Research Project】

In order to construct and control a large scale of dynamic and complex artificial genetic circuit or metabolic pathways, the fundamental technologies for synthetic biology are essential as shown in Fig. 1. In the first stage (2-3 years), our mission is to construct dynamic and multi-elements synthetic genetic circuit, followed by the construction of differentiation-induced system against stem cell and by the realization of cell factory, in which cells can produce the target metabolites by themselves according to the cell environment in the last 2-years.

The research project is composed of the following four sub sections: (A01) fundamental technologies of molecular biology (experimental works), (B01) fundamental technologies of engineering (experimental works), (C01) fundamental technologies of computational science (theoretical works) and (X01) integrated section of A01, B01 and C01.

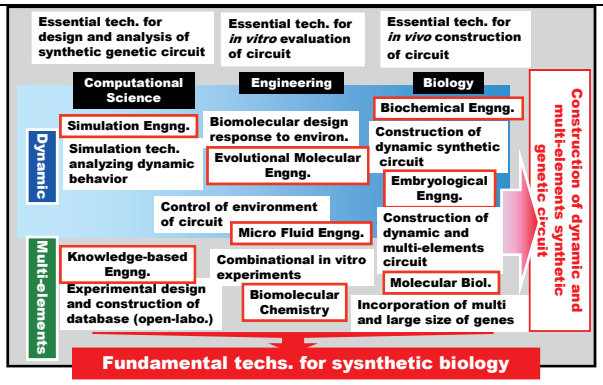

Figure 1 Fundamental technologies for synthetic biology

【Expected Research Achievements and Scientific Significance】

In order to scale up artificial genetic circuits and metabolic pathways, we have to establish the effective coordination of fundamental technologies lying in computational science, engineering and molecular biology. The conventional research in biology is so-called "watched and analyzed biology". Contrary to this, the synthetic biology is so-called "synthetic and analyzed or utilized biology". By constructing and incorporating interrelated artificial genetic circuits and artificial metabolic pathways into cells, we can comprehend biomolecular networks from the different view.

【Key Words】

synthetic biology, artificial genetic circuit, artificial metabolic pathways, simulation technology, knowledge based information science, evolutional molecular engineering, biomolecular chemistry, biochemical engineering, embryological engineering, molecular biology

【Term of Project】 FY2011-2015

【Budget Allocation】 880,300 Thousand Yen

【Homepage Address and Other Contact Information】

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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】

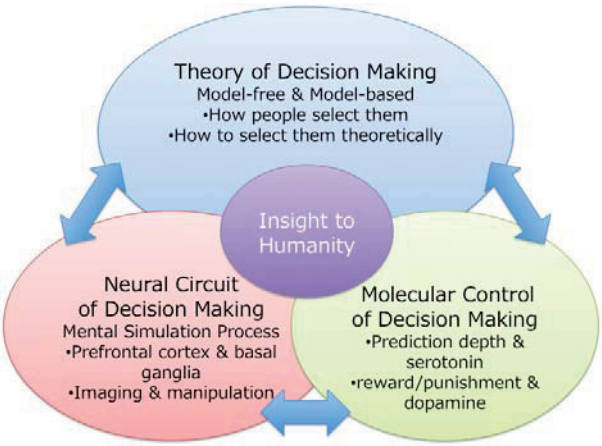
We work on three major research subjects with the following working hypotheses and methods.

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