Title of Project：Brain information dynamics underlying multi-area interconnectivity and parallel processing

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【Purpose of the Research Project】

The brain acquires information of the external world as multimodal sensory inputs and performs an enormous amount of information processing within and across areas, while compressing and storing it by appropriately transferring it between layers through parallel mechanisms. A central issue of today's neurobiology is to elucidate and reproduce the substance of this "brain information dynamics" using state-of-the-art techniques of measurement and manipulation and to decipher behavioral principles that rely on circuit-based mechanisms of memory, prediction, and decision-making. The aim of this Consortium Research Project is to establish a novel multidisciplinary research field, “brain information dynamics”, which encompasses a wide range of challenges from high-definition cytoarchitecture reconstruction to mapping of circuit models that define information transfer and storage in the brain, high-resolution measurement and manipulation of multi-areal network dynamics, and verification of computational models and theories leading to closed-loop control of recursive networks.

【Content of the Research Project】

We will investigate brain information dynamics that underlie information transfer through multi-area interconnectivity. We will create analytical pipelines to measure information dynamics from high-precision, high-quality large-volume image datasets. We will share the data, making them accessible to all members of this Consortium.
Research Aim A01 Brain information decoding: We will decipher basic circuit features related to higher brain function: basic cell type, connection motif, I/O conversion, and synaptic plasticity.
Research Aim A02 Brain information recording: By performing functional cellular and circuit recordings through imaging and electrophysiology across a large number of cells, we will identify how information is expressed, transferred and converted in a variety of cell ensembles that communicate between multiple areas.
Research item A03 Brain information network construction: By analyzing the fMRI signal from the human brain, we aim to tease apart how the brain higher-order functions emerge from communication between different cortical areas. We will also develop brain-inspired computing algorithms for neural-circuit type hardware.

【Expected Research Achievements and Scientific Significance】

In recent years, artificial intelligence (AI) technology based on deep learning, a neural network-based information processing algorithm, has made a dramatic progress. However, the current AI principles are limited: they cannot properly model recursion within a network, and they are not able to compute based on incomplete contextual information and deduce intensions of others. Understanding basic properties of brain information dynamics will pave the way to decipher information transfer and processing principles that the brain use to memorize, make a decision and take actions. Brain-inspired information processing algorithms will facilitate development of a new engineering neural network algorithm, which we expect can then be applied to the "next generation" AI or interactive agents.

For social higher animals such as humans, it is easy to achieve their goals by estimating the intention of others and predicting their behavior. If a helper AI that imitates part of higher brain functions become possible, "augmented reality", "augmented motion ", and "augmented cognition" might be within reach. Furthermore, if brain information dynamics is elucidated at the circuit level in this research project, we anticipate to gain insights on autism’s core symptoms, which is regarded as a disorder of information transfer and information dynamics across multiple brain areas.

【Key Words】

Brain information dynamics:
Dynamic form of transformation, integration, and storage of information over multiple brain areas.
Parallel processing:
Processing in which each module performs parallel computation. Parallel processing in the brain may guide new AI computational algorithm.

【Term of Project】 FY2017-2021

【Budget Allocation】 1,235,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://brainfodynamics.umin.jp/