【Grant-in-Aid for Scientific Research (S)】

Biological Sciences (Biological Sciences)

Title of Project : Elucidation of cortical neural circuits for meta-memory: Optogenetic manipulation of retrospection

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【Purpose and Background of the Research】

Elucidation of high-level cognitive functions is an important goal in neuroscience. Studies on the "memory systems in the narrow sense" (which executes memory encoding, storage and recollection) have dramatically progressed in the past ten years. However, to elucidate the neural basis of the "continuity of the individual conscious experience," clarification of the "meta-memory system" that introspectively monitors memory processing is essential. In this study, we aim to investigate the introspective aspects of memory that have been previously studied only in humans; we will introduce a non-human primate model, and will accomplish it by psychophysically controlling the animal's behavior and applying electrophysiological, optogenetic and magnetic resonance imaging (MRI) methods that have been developed in the previous studies on the "memory system in the narrow sense".

【Research Methods】

(1) Establishment of a meta-memory task using monkeys and identification of cortical meta-memory circuit

We adopt a meta-memory task, which combines a Yes/No-type recognition memory test (Memory stage) with a confidence judgment test using the post-decision wagering paradigm (Bet stage) (Fig.1). We will identify the "meta-memory-related brain areas" using functional MRI (fMRI) on monkeys, while they perform the meta-memory task. For identification of meta-memory-related brain areas, we will use two types of cognitive subtraction approaches. One approach relies on the calculation of fMRI-signal differences between the "High-Bet" condition and the "Low-Bet" condition. The other relies on calculation of the correlation between the meta-memory behavioral index (meta-d' index or Φ index) and the fMRI signal.

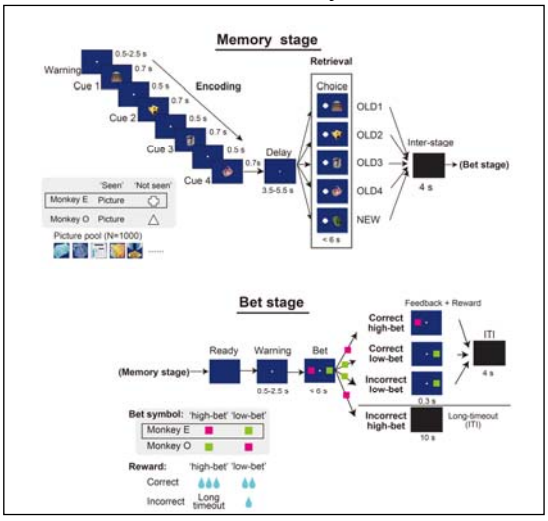

Fig.1 Meta-memory task

(2) Development of optogenetic methods in monkey cortex

AAV5.CAMKII.hChR2.GFP.WPRE.SV40 will be injected into the monkey temporal cortex. In a recognition memory task, we will measure the psychometric function related to Old/New judgment, by changing the Old/New valence of the stimuli. Effects caused by the illumination of 473 nm laser light (and 594 nm laser light as control) will be examined to assess whether the psychometric function of Old/New judgment shifts significantly or not.

(3) Optogenetic intervention of monkey cortical network during meta-memory performance

In the meta-memory-related brain area identified in (1), excitatory or inhibitory optogenetic vector constructs will be injected and the causal behavioral impact of the intervention will be psychophysically measured according to the procedure that was developed in (2).

【Expected Research Achievements and Scientific Significance】

This study aims to elucidate the introspective aspects of memory in an animal model, by utilizing invasive biological procedures. It will pave the way for the study of neuronal mechanisms for introspection and self-reflection of one's own mind.

【Publications Relevant to the Project】

・Takeuchi, D., Hirabayashi, T., Tamura, K. and Miyashita, Y. : Reversal of interlaminar signal between sensory and memory processing in monkey temporal cortex. ***Science*** 331, 1443-1447, 2011.
・Hirabayashi, T., Takeuchi, D., Tamura, K., and Miyashita, Y. : Microcircuits for Hierarchical Elaboration of Object Coding Across Primate Temporal Areas. ***Science*** 341, 191-195, 2013.

【Term of Project】 FY2017-2021

【Budget Allocation】 161,000 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.physiol.m.u-tokyo.ac.jp/