論文内容の要旨

Memory encoding have been one of the central topics in cognitive neuroscience. We experience many events in everyday life, some of which are remembered, while others are forgotten. What neural mechanisms underlie this process? To answer this question, this dissertation provides two sub topics with a complementary goal to investigate the cognition and neural mechanisms underlying the memory encoding system. We focused on two of considerably current topics in neuroscience research including the role of intrinsic fluctuations or low frequency fluctuations (LFFs) of neural signal lower than 0.1 Hz in the brain and dynamic aspects of functional connectivity across whole brain, during memory encoding.

Growing evidence suggests that LFFs can account for much of the variability in task-evoked activation, and variability in behavioral performances. Thus, we hypothesized that LFFs may affect memory encoding processes and contribute to variability of memory performances. If so, LFFs of neural activity during experience encoding would predict either that experience will be later remembered or forgotten. In the present study, twenty-five participants performed an incidental encoding task in a magnetic resonance imaging scanner, and their memory encoding performance was assessed by a subsequent surprise memory test. The encoding trials were classified into successful encoding and unsuccessful encoding trials based on answers from the memory test. To investigate the role of LFFs in encoding process, in the first sub topic, LFFs independent from task-related

signal were extracted and tested whether these residual LFFs can predict subsequent memory performances. We found that LFFs amplitudes/functional connectivity at the time periods before the stimulus onset can predict whether the upcoming trial will be remembered. Specifically, higher amplitude of LFFs in the right fusiform gyrus, the left parahippocampal gyrus, the left middle frontal gyrus, and the left superior parietal lobule was observed before the stimulus later remembered (vs. later forgotten). In contrast, LFFs functional connectivity from the fusiform gyrus to brain regions inside cingulo-opercular (CO) network was stronger before the stimulus later forgotten. Our results lend new insight into the role of LFFs in memory encoding processes suggesting that LFFs was modulated with task-evoked responses and related to variability of memory performances. Remarkably, LFFs in the specific brain regions potentially facilitate memory encoding whereas the functional connectivity involving the CO network may bias toward bad memory.

Previous neuroimaging studies revealed that local activation/deactivation of specific brain regions predicts successful memory encoding. However, research on large-scale functional organization in the brain emphasizes a network view of the brain rather than local activation/deactivation, showing that patterns of functional connectivity across the brain are organized in specific ways and are relevant to behavior and cognition. Notably, recent studies have revealed that large-scale brain networks dynamically fluctuate in relatively short time periods, typically within a timescale of 30-40 s. Furthermore, these studies have shown that dynamic fluctuations of large-scale functional connectivity

patterns are associated with a variety of cognitive processes.

In the second topics, we employed recently developed time-varying functional connectivity analysis to examine large-scale functional connectivity patterns during memory encoding processes. We found that a dynamic reconfiguration of large-scale brain networks in a short timescale (< 1 min) is related to memory encoding performance. A graph analysis revealed that network integration rather than segregation is a hallmark of successful memory encoding. This effect was primarily driven by increased integration of the subcortical, default-mode, and visual subnetworks with other subnetworks. Moreover, multivariate analysis using the graph metrics of integration showed that functional brain networks could be reliably classified into the period of high (vs. low) memory encoding performance. Our findings suggest that a diverse set of brain systems dynamically interact to support successful memory encoding.

Together, this dissertation provides a better understanding of the neural mechanisms of memory encoding, emphasizing the effect of LFFs to memory encoding and highlighting the importance of orchestration across many distinct brain systems to support better memory encoding.