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Differences in Regional Brain Activities during Memory Acquisition Depending on Individual Working Memory Capacity

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Abstract Individual capacity of recall memory varies greatly even among healthy young adults. Nevertheless, the difference in brain circuitry underlying varied memory capacity has yet to be fully investigated. We acquired electroencephalographic measurements from 43 healthy young adults while performing a demanding working memory task and studied the changes in regional cortical activity in relation to different levels of memory performance. The memory task involved sequentially presenting seven arrow pictures to a participant during the encoding period, who was then asked to recall the direction of one of the arrows in the sequence within the retrieval period. We divided the participants into three groups of high, intermediate, and low performance based on the weighted hierarchical grouping method. Regional brain activities were source-localized using multiple sparse priors method in the high- and low-performance groups, and group differences were determined by non-parametric permutation tests. Our findings showed that participants with higher memory performance exhibited wider distribution of cortical activity including the prefrontal and parieto-posterior cortices, whereas lower performance participants only exhibited stable activations across occipital regions. The results implied the importance of selective attention in order to attain optimal individual working memory performance. Furthermore, we suggest the potential role of the angular gyrus as an interplay between the prefrontal and posterior regions for the management of stimulus flow and signal control. Future works should focus on conducting more thorough connectivity analysis to investigate the relationship of cortical activations with individual working memory performance.

Keywords: electroencephalography, working memory, source localization, top-down modulation, individual differences.

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1. Introduction

Individual working memory (WM) capacity is limited but not fixed. Understanding the cortical changes across varied WM capacities of healthy individuals may reveal potential biomarkers for various high-level cognitive functions [1]. WM is broadly perceived to be regulated by a central executive component located in the prefrontal cortex (PFC), which is identified as the decision-making unit of WM modulation [2]. Executive circuitry within the PFC is responsible for maintaining behavioral goals such as task rules and adaptively encoding task-relevant information held in WM [3]. Then, different sensory information is assigned to various content-specific buffers across parieto-posterior regions. This memory-related brain circuitry is supported by several studies [4, 5], which indicate that the lateral PFC (lPFC) has a role in guiding the extrastriate cortex to accomplish goal-relevant representation by passing down sensorimotor signals to different sensory buffers for storage or temporary retention.

However, the extensive connections between the PFC and parieto-posterior regions during the memory process remain to be explored. Results from substantial electrophysiological and imaging studies [6, 7] have shown that successful encoding of low-level visual stimulus features such as image orientation and object identi-

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