Title	記号および身体動作を用いた人間のコミュニケーションに関わる大域的な神経基盤の脳波解析
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Abstract

Human communication is one of the most widely discussed topics, including interactions using physical motions and symbolic language. In this study, I aim to elucidate the neural mechanisms underlying human communication through symbols and physical motions by investigating the global neural activity involved in these interactions in terms of EEG-based synchronization processes.

In this thesis, I have investigated the neural activities especially for two communication tasks. One is the "symbolic communication" task, which was performed as a laboratory experiment based on experimental semiotics, and focuses on the process of understanding each other's intentions and the establishment of communication through the exchange of symbols. On the other hand, the "Look This Way" task was designed to require intentional switching of physical motions and to generate different motor intentions. This task required coordination of the physical motion of "rock-paper-scissors" followed by Congruent or Incongruent motions.

In the former task, I first examined (1) how the amplitude of the receiving event differed from the fixation event by comparing the time-frequency and topographic amplitudes. The results showed that the amplitudes of the theta and alpha bands from 0 to 500 ms and the gamma band around 600 ms immediately after receiving a symbolic message were significantly higher in receiving events than in fixation events in the whole brain. In addition, I analyzed the phase synchronization between the success and failure groups to investigate (2) the presence or absence of functional connectivity between brain regions that are expected to be important for understanding symbolic messages. The results reveal that the success group showed frontal-parietal phase synchronization at 600 ms in the first 12 trials, while the failure group showed asynchronous phase synchronization. These suggest that the amplitude of the low-frequency band is related to the processing of short-term and semantic memory, and that the gamma-band amplitude and its phase synchronization in the whole brain may reflect the cognitive process of binding and understanding the association between figure and meaning.

In the latter task, I investigated the differences in neural activity among the three conditions (Scramble, Congruent, and Incongruent) by performing high-resolution power analysis of neural activity associated with movements and EEG signals through the the Hyperscanning EEG-Motion-Gaze recording systems. As a result, significant differences were observed between the three conditions, especially between the Congruent and Incongruent conditions, at the left central electrode in the alpha band and at the right parietal electrode in the gamma band. In addition, there was no significant difference in the alpha band compared to the gamma band in the time-frequency power expression. Thus, I propose that the left frontal center region is related to the mirror neuron system, while in the right central parietal region, the alpha band may be associated with perception of other' s motion, and the gamma band with switching of social coordination.

At the end of this thesis, it is suggested that symbolic and embodied communication have in common a complex neural basis for communication involving multiple brain regions, including the frontal and parietal regions. In addition, gestural communication, which was not considered in this study, is positioned between symbolic and embodied communication. In order to clarify the neural mechanisms of symbolic and embodied communication, we proposed a working hypothesis of a unified neural mechanism that takes into account the involvement of multiple brain regions. To validate this hypothesis, we proposed a framework in which cognitive experiments are conducted using the constructed model as a virtual partner.

Keywords: synchronization, symbolic communication, motor intention, hyper-scanning EEG, Experimental Semiotics