The Relevancy between Visual Cortex and Motor Cortex and Its Spatio-Temporal Neural Dynamics

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（脳皮質視覚野と運動野の関連性およびその時空間神経ダイナミクス）

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論 文 内 容 の 要 旨

Although the cerebral cortex has been divided into different regions according to their function in cognitive process, many researches in past decades have demonstrated that the neurons in a region do not just work locally; on the contrary, the correlation between neurons from different function regions, which can be observed as functional connectivity, happens frequently. In this thesis, we studied about the cerebral activity when normal healthy people were presented with visual stimulus, and the relevancy between occipital lobe and the other cortical areas, and revealed its features in both time and space.

Firstly, previous studies have reported that a series of sensory–motor-related cortical areas are affected when a healthy human is presented with images of tools. Obviously, these images caused a relevancy between the neurons here and at occipital lobe. This phenomenon has been explained as seeing familiar tools launching a memory-retrieval process to provide a basis for using the tools. Consequently, we postulated that this theory may also be applicable if images of tools were replaced with images of daily objects if they are graspable (i.e., manipulable). Therefore, we designed and ran experiments with human volunteers (participants) who were visually presented with images of three different daily objects and recorded their electroencephalography (EEG) synchronously. Additionally, images of these objects being grasped by human hands were presented to the participants. Dynamic functional connectivity between the visual cortex and all the other areas of the brain was estimated to find which of them were influenced by visual stimuli. Our results showed that manipulable objects caused a series of cerebral activity at several motor-sensory-related regions, corresponding with the two pathway of visual object recognition. Moreover, many evidence indicated that looking at images of interactions did not induct similar activity as seeing the same object alone, and so did images of hand. In addition, we also investigated the ability of using phase synchrony to track the two pathways of visual information.

With the findings in above research, we noticed the potential of estimating phase locking value to measure how much a cerebral region participated in current cognitive process. Therefore, we tried to apply it to solve a problem in the field of neurorobotics—make machines

be able to distinguish brain's activity when someone is imagining a movement from actually making a movement, and seeing a movement made by others. To collect data for training and evaluating a machine learning model, another brand new EEG experiment was created and run on 17 healthy volunteers. Based on the support vector machine (SVM), we proposed a data-driven method to searching for cerebral regions that were to the benefit of above classification. Consequently, the system we built achieved an average accuracy which has been significantly greater than random probability, and there is still room for improvement. In the meantime, several substantial differences of cerebral region activation were discovered by the approach of analyzing features selected by three classifiers. Results showed that when someone is watching, imagining, and executing a movement, the Broca's area, motor cortex, the Wernicke's area, and visual cortex performed differently. Finally, although the development of machine learning has been tremendous in recent years, its benefits have barely been brought to the studies in the field of cognitive neuroscience. This thesis proposed a viable methodology to cover this shortage preliminarily.