The Chinese University of Hong Kong
Department of Biomedical Engineering

Graduate Seminar – PhD Oral Defence

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Supervisor : Prof. Raymond Tong
Date : 10 August, 2021 (Tuesday)
Time : 4:00 pm
Zoom Link : https://cuhk.zoom.us/j/99292903465?pwd=ek9CL2M5TlEvbytteDMwVUd6NHlidz09
Meeting ID : 992 9290 3465
Password : 914280

Title: Neuroplasticity modulation after BCI-guided robot hand training and transcranial electrical stimulation in chronic stroke investigated by EEG and fMRI

Stroke is still a leading cause of motor disability worldwide nowadays. Neuroplasticity, which describes the property of the human brain to adapt to environmental pressure, experiences, and challenges, including brain damage, might facilitate stroke patients in restoring functional abilities. The external interventions, including physical training therapies and transcranial electrical stimulation, can bring about brain functional reorganization. This thesis utilized multiple neuroimaging techniques to investigate the neuroplasticity induced by two specific kinds of interventions, brain-computer interface (BCI)-guided robot hand training therapy and transcranial alternating current stimulation (tACS), respectively, for chronic stroke patients.

BCI has been integrated with FES and numerous robot devices mainly related to the wrist and elbow parts. However, few studies combined BCI with the robot hand and applied it in stroke rehabilitation. More importantly, BCI-guided robot hand training is expected to strengthen the sensorimotor loop, and a comprehensive understanding of the neural mechanism is essential and meaningful. First, simultaneous EEG/fMRI was collected before and after the training for chronic stroke patients. We found that the training effect significantly correlated with the changes of nondirectional functional connectivity and directional information flow among motor-related brain regions. Furthermore, we adopted the EEG-informed fMRI technique to explore the functional regions sensitive to the training intervention. Our findings suggested that multiple functional brain regions that are not limited to motor areas were involved during the recovery process. It also indicated the essential role of interhemispheric interaction and potential structural substrate of the transcallosal connection. Meanwhile, our study also demonstrated the feasibility and consistency of combining multiple neuroimaging modalities to investigate the neuroplasticity change. To our best knowledge, this is the first time to propose a systematic framework to investigate the training effect combing multiple neuroimaging modalities and uncover the potential neural correlates related to BCI-guided robot hand training for chronic stroke patients.

Except for physical therapies that induce brain reorganization in a round-about way, tACS has emerged as a promising technique to modulate the endogenous oscillations in the human brain non-invasively. Despite its clinical potential in routine rehabilitation therapies, the underlying modulation mechanism has not been thoroughly understood, especially for patients with neurological disorders, including stroke. In this study, we aimed to investigate the frequency-specific stimulation effect of tACS in chronic stroke. Resting-state fMRI data were collected when stroke patients underwent tACS with various frequencies (sham, 10Hz, and 20Hz). The graph theoretical analysis indicated the heterogeneous modulation effects of integration and segregation property in motor-related regions and at the whole-brain level. Specifically, 20 Hz tACS could help the lesioned brain back to the optimal balance between the local segregation and global integration, which illustrated the potential of 20 Hz tACS to be applied as an adjuvant tool to further facilitate motor recovery for stroke patients.

In summary, this thesis expands the understanding of potential neuroplasticity responding to two specific external interventions applied to chronic stroke patients. It shed light on the mechanism of neural response to external interventions and might facilitate designing effective rehabilitation protocols for stroke patients in the future.

***** ALL ARE WELCOME *****

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