Functional Brain Connectivity: A preliminary EEG investigation of cognitive-motor interplay

Background

Cognitive processes like attention, memory, and executive function are important for understanding task instructions, planning, and initiating movement. Despite the role of cognitive processes in motor function, these domains are typically assessed separately and the neural mechanisms subserving cognitive-motor interplay are unclear. Functional connections, or communication, between muscles and brain can help us to better understand how cognition impacts motor function. Previous work has indicated that resting-state connectivity can be informative of motor function. The purpose of this project was to investigate the relationship between resting-state connectivity and brain-muscle connectivity while performing a motor-weighted and cognitive-weighted task.

Methods

We recruited right-handed, unimpaired individuals 18-45 years old. Participants completed a resting-state EEG (rsEEG) scan where they focused on a nearby visual target. Participants also completed a task-based EEG recording where they performed either a submaximal isometric grip task (motor-weighted condition) and the same task with the addition of a Go/No-Go task (cognitive-weighted condition). Muscle activity from bilateral biceps brachii, flexor digitorum, extensor digitorum, and first dorsal interossei (FDI) were recorded during the task. Functional connectivity (cortico-cortical coherence) between EEG leads overlying dominant (left) and nondominant (right) prefrontal areas and between dominant prefrontal and primary motor areas were computed from rsEEG. From the task-based EEG, functional connectivity between dominant (right) FDI and EEG leads overlying dominant primary motor and prefrontal regions were computed (corticomuscular coherence, CMC). For cortico-cortical coherence and CMC, we focused on alpha (8-12 Hz) and low beta (13-20 Hz) frequencies given their involvement in cognitive and motor function. Executive function and attention were assessed using the Stroop Test and the Posner Cueing Test. Correlations between resting-state and task-based coherence measures and correlations between resting-state coherence and behavior were determined using Pearson correlations.

Results

Fifteen participants (28.6 ± 6 years, 9 females) were enrolled. Resting-state alpha coherence between dominant prefrontal and primary motor regions was negatively correlated with CMC between the dominant primary motor area and FDI during the motor-weighted condition ($r = -0.73$, $p = 0.0031$). Similarly, resting-state alpha coherence between dominant and nondominant prefrontal regions was negatively correlated with CMC between the dominant primary motor area and FDI during the motor-weighted condition ($r = -0.62$, $p = 0.0169$). Resting-state coherence values were not associated with behavioral measures of cognition or CMC during the cognitive-weighted condition.

Conclusion

These findings indicate that increased coherence between cognitive and motor areas of the brain at rest is associated with decreased CMC during a motor task, specifically in a cognitive frequency band. These results may reflect the differences in brain states and participant engagement between resting and task conditions, recruitment or utilization of neural substrates, and/or the relative cognitive demand of the motor-weighted condition. Future work will determine the clinical relevance of these findings and the effects of aging by repeating these procedures in those with stroke and in a cohort of unimpaired age-matched controls.