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Exploring the Impacts of Longitudinal BCI Training for Power Mobility in Children with Physical Disabilities

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Introduction: BCI learning, in which the user learns to generate brain activity that results in a desired device behavior, is a determinant to successfully operating BCIs [1]. Children with severe neurological and physical disabilities (e.g., quadriplegic cerebral palsy) are capable of using EEG-based BCI systems [2]. However, it is unknown how the plastic brains of such children may change over time in response to BCI training [3,4]. We are aiming to characterize neural mechanisms of functional changes in children with severe physical disabilities as they learn to control a BCI-operated power mobility system.

Material, Methods, and Results: One pediatric patient (male, age 11) with quadriplegic cerebral palsy has been analyzed within a large multi-site longitudinal study. The BCi-Move trial includes a structured training program in which pediatric participants with severe quadriplegic cerebral palsy learn to operate a power mobility wheelchair over 12 weekly sessions using a mental-command based BCI. Continuous EEG recordings were collected using the EPOC Flex Cap (EMOTIV, United States), a commercially available 32-channel headset with saline electrodes, of which 14-channels were selected for compatibility with the Emotiv Cortex Engine. Functional connectivity was analyzed via imaginary part of coherency (iCOH) from EEG data collected from participant training of a "neutral" mental command, a learned skill representing a state in which no purposeful mental activity occurs (Fig. 1A). A minimum spanning tree (MST) was then calculated (Fig. 1B), with graph theory metrics (average degree (AD), betweenness centrality (BC), average shortest path length (ASPL), and global efficiency (GE)) used to characterize network changes occurring across BCI learning sessions (Fig. 1A). These characteristics were then compared to behavioral performance. The resulting networks were successfully estimated and compared between the first (AD: 0.9, GE: 0.40, ASPL: 3.41) and last sessions (AD: 1, GE: 0.44, ASPL: 2.83).

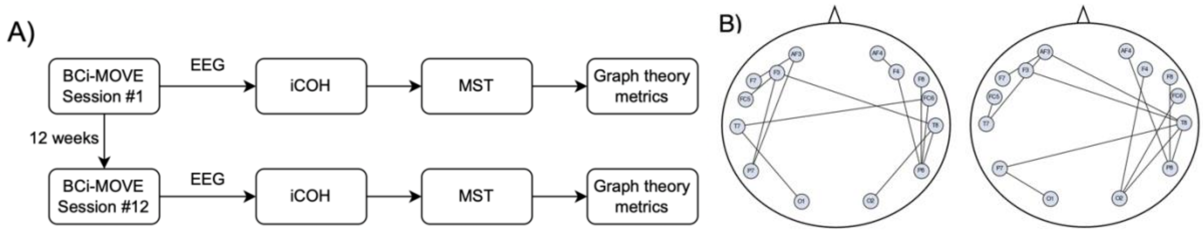

Figure 1. A) Methodology of analysis. B) *Binary graphs obtained via MST of participant during session 1 (left) and 12 (right).*

Discussion: These preliminary results support feasibility and provide an overview of an analysis pipeline for using network analysis to explore EEG-based mechanisms of BCI learning in children with severe disabilities participating in a longitudinal clinical training program. Understanding how functional networks reorganize with longitudinal BCI training in children with quadriplegic cerebral palsy may reveal patterns in functional network changes that correlate with BCI performance.

Significance: Despite BCI-learning being a core driver of success in BCI use, the mechanisms underlying BCI-learning in children with severe physical disabilities have not been explored. This novel study will investigate how functional reorganization of the brain occurs in children with severe physical disabilities during continuous BCI training.

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