Describing movement-related cortical dynamics using electroencephalography and diffuse correlation spectroscopy

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Brain-computer interfaces (BCI) show promise as a direct line of communication between the brain and the outside world. This has particular application for those with neuromuscular disorders and impaired motor function. BCIs offer a way to bypass interrupted neural pathways. Movement-related brain activity is commonly used as a BCI signal but how brain signals differ in motor planning, initiation, and execution is poorly understood. Improved characterization of cortical dynamics during movement could result in better BCI control strategies. In this project, to better interpret movement-related neurophysiological change, we propose to measure not only electrical activity through the electroencephalogram (EEG) but also cerebral blood flow (CBF) using a relatively new non-invasive technology, near-infrared diffuse correlation spectroscopy (DCS). In a single preliminary trial, EEG and DCS data were simultaneously recorded from a human subject during a cue-triggered hand grip task. Eight channels of EEG were acquired from frontal, central, and occipital regions, and DCS data from locations over frontal and motor cortex. Event-related desynchronization (ERD), a measure of task-related EEG band power changes with respect to a baseline, was observed just before hand movement and lasting until movement ceased. EEG from motor areas showed significant ERD of -7.1 % in the 8-13 Hz mu band, the idling sensorimotor rhythm ($p<0.001$). Additionally, mean CBF increased during the task in the motor location by 6.8% ($p<0.001$) and in the frontal location by 4.5% ($p<0.001$). These preliminary results hint at measurable changes that are worth exploring in a broader study that combines electrical and optical measurements, with the potential benefit of increased specificity of command signal classification. Since the functional use of BCIs are limited by the number of command signals, work to better classify movement-related activity could expand the real-world applications of this technology.

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