

POSTER PRESENTATION

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Optical imaging of motor cortical activation using functional near-infrared spectroscopy

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Functional near-infrared spectroscopy (fNIRS) is an optical imaging technique that allows real-time monitoring of the oxy-hemoglobin (oxy-Hb) and deoxy-hemoglobin (deoxy-Hb) levels in brain tissues in a noninvasive fashion [1,4,6]. The characteristic absorption spectra of oxy-Hb and deoxy-Hb recorded on the scalp can be used to detect the oxygen demands of the underlying brain tissues in the cerebral cortex. This allows real-time detection of brain activation based on metabolic events (neural hemodynamics). Brain imaging using fNIRS has many advantages over fMRI (functional magnetic resonance imaging), as it can detect changes in both oxy- and deoxy-Hb levels simultaneously, whereas an increase in fMRI BOLD (blood-oxygen level dependent) signal only accounts for a decrease in deoxy-Hb levels by an increase in regional cerebral blood volume (rCBV). Additionally, the multi-channel fNIRS signals can be sampled at much higher frequency (in KHz) even though a hemodynamic response may occur at a much slower rate than the sampling frequency. This high temporal resolution is particularly important for capturing dynamic movement activity, such as the high frequencies that result from maximal effort (ME) movements [2]. The latter necessitates the use of fNIRS over fMRI.

The present study uses multi-channel fNIRS to correlate brain activation patterns obtained from the motor cortex with volitional motor execution in healthy human subjects, in an attempt to identify brain-derived command signals that can be used to control a wheelchair. Ultimately, these signals will provide the necessary input to a portable neuroprosthetic device, which will

act as a brain-computer interface (BCI) and will enable mobility and navigation for quadriplegics.

In our experiment, subjects were asked to perform directional left-right, forward-backward hand movements while recording fNIRS signals from the motor cortex. Our results show that movement *execution* corresponds to hemodynamic changes seen in both the oxy- and deoxy-Hb signals. The movement is best represented by the summation of oxy- and deoxy-Hb signals, and reflects the total change in hemoglobin concentration (total-Hb), which is a more representative measure of rCBV changes [3] than BOLD rCBV [5]. Intended movement *direction* is correlated with differential changes in these signals, and depends on the specific location of the motor area. Thus, neural activation in the motor cortex can be identified uniquely by the spatiotemporal profiles of localized oxygen delivery, oxygen extraction, and blood flow. These findings provide evidence of the correlation between volitional limb movement direction and motor cortical activation profiles obtained by fNIRS, and support the possibility of a potential BCI neuroprosthetic device for brain-controlled navigation of a wheelchair.

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