Title: Communicating with a locked-in patient by translating thoughts into light

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Structured Abstract:

Introduction: There is a tremendous interest in developing brain-computer interfaces (BCI) for locked-in patients since they lack the physical ability to respond to questions. Functional near-infrared spectroscopy (fNIRS) is an optical technique that is portable and ideal for such applications. A recent study by Chaudhary et al. used fNIRS to communicate with locked-in patients [1]. However, their approach required each patient to undergo multiple training sessions and only resulted in a successful response rate of 70%. Our team has been developing an alternative approach that is based on detecting activation in motor planning regions by having subjects perform a motor imagery task (i.e. imagine playing tennis) in response to commands [2]. The objective of this pilot study was to assess if a motor imagery fNIRS paradigm could be used to communicate with a locked-in patient who could only respond to questions by limited eye movement when his eyelids were held open.

Methods: The study was conducted in the intensive care unit at University Hospital using an in-house built four channel fNIRS system. The fNIRS probes were placed on the scalp over the supplementary motor area and the premotor cortex. The patient was instructed to imagine playing tennis as an affirmative to yes/no questions, otherwise to remain relaxed if the answer was no. Three questions were asked confirming his last name, if he was in pain, and if he felt safe. For confirmation, the patient answered the same questions through eye movements after the fNIRS study was completed. The fNIRS signals were analyzed by training a linear classifier to detect increases in the concentration of oxy-hemoglobin. Since all four channels were located over motor planning regions, at least one of them had to be classified as activated for a ‘yes’ response.

Results: Comparing the fNIRS and eye responses showed that fNIRS predicted the correct answer to all three questions: 'Yes' he heard his last name (based on 3 channels), 'no' he was not in pain (based on 4 channels), and 'yes' he felt safe (based on 4 channels).

Discussion: The ability to communicate with a locked-in patient without the need for substantial training highlights the potential of fNIRS as a BCI, and confirming the fNIRS results with eye responses provided a unique opportunity to accurately validate a BCI.

References:
[1] Chaudhary et al., PLoS Biology (2017). [2] Abdalmalak et al., BOE (2017).