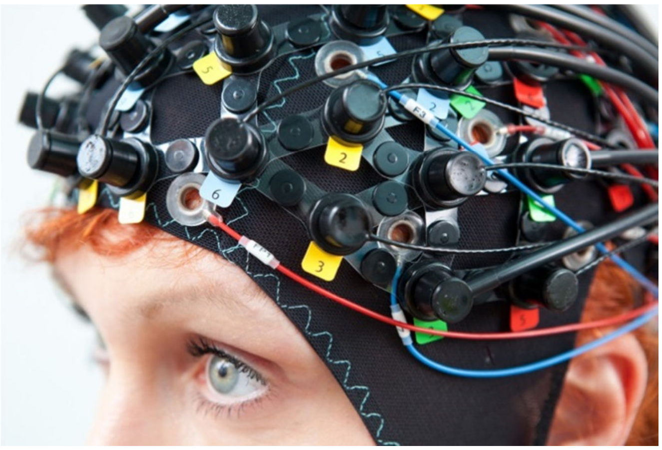
Concurrent fNIRS and EEG



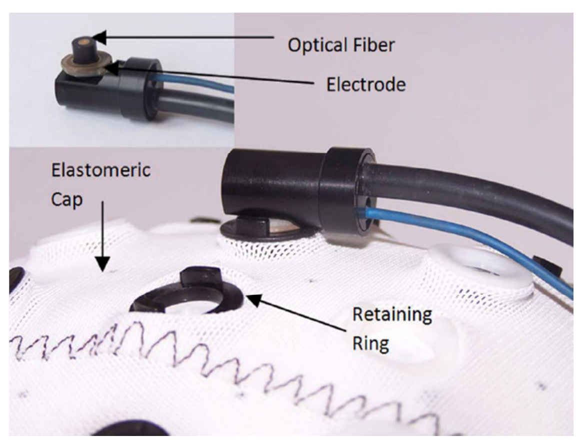
1. INTRODUCTION

A local increase in cortical blood flow accompanies almost all neuronal responses to stimulus in the brain. This relationship, termed neurovascular coupling, involves many steps from the initial firing of the neurons to release of chemical transmitters to final vasoconstriction or vasodilatation. Understanding this relationship between brain activity and the resulting changes in metabolism and blood flow remains a vital research area.

EEG and fNIRS capture signals inherent to different steps in this cascade of events, linked to the same neural activity. The combination of these two methodologies offers the possibility of examining the cortical activity more comprehensively. EEG and fNIRS have very different and complementary temporal resolution and functional localization features: while EPs detect the cortical response to a given stimulus with high temporal resolution, fNIRS localizes changes in oxygen metabolism that follow upon neural activation.

2. SENSOR PLACEMENT

Combining EEG and fNIRS is not only beneficial from the information content point of view, but is also, technologically, easily achievable. The optical nature of the signal, as well as its size, portability and robustness to movements, make fNIRS easy to combine with EEG, with the modalities not interfering with one another.



The sensor placement may be done on two different ways: (i) adjacent positioning, or (ii) co-located measures, as depicted in the figure above. Adjacent positioning allows for experiments with any kind of EEG electrode, as well as reduced setup time. Co-located measures, although allowing for higher sensor density configurations, are limited to EEG systems with ring electrodes and require transparent gel, which usually are non-conductive.

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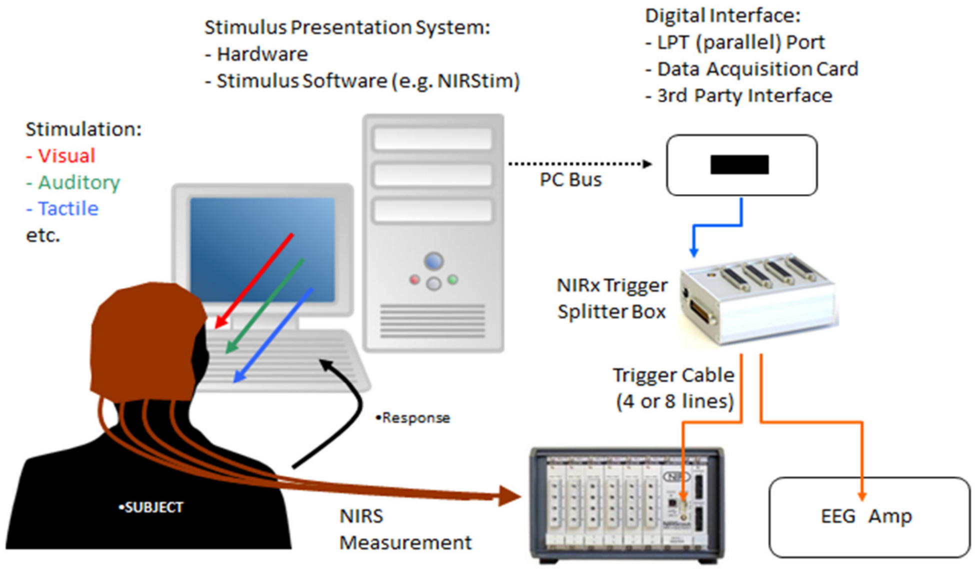
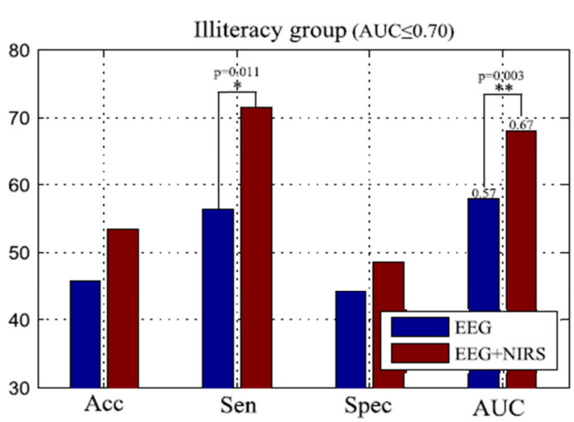
3. DATA SYNCHRONIZATION

As fNIRS and EEG measurements are recorded independently, it is important for the systems synchronization to have trigger markers simultaneously sent to both systems in order to precisely mark the data of interest for online and offline analysis. A precise synchronization can be easily achieved with the NIRx Active Splitter Box, which powers incoming signal via USB and splits single DB-25 (parallel port) input to four or more outputs. A general schematic of stimulus presentation and synchronization of fNIRS and EEG measures is depicted below.



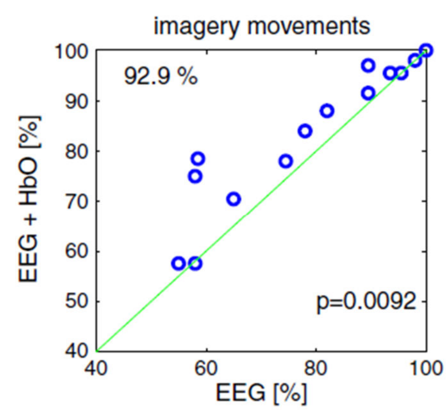
4. USE CASES

Two examples of results recently published by NIRx users obtained from fNIRS-EEG measurements are shown below. These illustrate how multi-modal applications can significantly render measurements more robust.



left: Comparison of BCI performance measures for group considered illiterate according to EEG-based classifier. **[1]**

right: Scatter plot comparing classification accuracy and significance value of combination of EEG+HbO. **[2]**



[1] Lee, M., Siamac, F., Mehnert, J., and Lee, S., "*Subject-dependent classification for robust idle state detection using multi-modal neuroimaging and data-fusion techniques in BCI*." Pattern Recognition 48, no. 8: 2725-2737 (2015).

[2] Fazli, S., Mehnert, J., Steinbrink, J., Curio, G., Villringer, A., Müller, K., & Blankertz, B.,"*Enhanced performance by a hybrid NIRS-EEG brain computer interface*," Neuroimage59(1), 519-529, doi: 10.1016/j.neuroimage.2011.07.084 (2012).