Title: A Computing Environment for Multimodal Integration of EEG and fNIRS

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Following the brain's own tendency to integrate multiple sensory modalities (visual, auditory, somatosensory, etc.), multimodal integration of neuroimaging techniques has been a recurring theme in the field. Here, the combination of electroencephalography (EEG) and functional near infrared spectroscopy (fNIRS) is considered. A principal reason for the interest in EEG-fNIRS is the expectation that evaluation of neurovascular coupling can have practical utility in, e.g., studies of the alpha rhythm [1], or of epilepsy [2]. In addition, noninvasive detection of an fast optical signal (FOS), having a time course similar to an event-related potential (ERP) and resulting from changes of scattering properties in neural tissue [3], has been a topic of considerable interest [4], but also of controversy owing to its low signal-to-noise ratio [5]. However, a recent report used simultaneous ERP and fNIRS measurements to demonstrate that concurrent EEG may facilitate FOS detection [6].

A requirement for integration of EEG and fNIRS, which depend on different physical properties (EEG – conductivities; fNIRS – absorption and scattering coefficients) of the same head tissues, is forward models that can be used for estimation of neuroelectric sources or cerebral hemodynamic states in a common anatomical space (e.g., derived from structural MRI). To address this need, we have introduced NAVI [7,8], a MATLAB-based environment that supports many of the principal data transformations common to evaluation of bioelectric and hemodynamic studies, and is geared mainly toward supporting atlas-based parametric mapping with full 3D tomographic capabilities. The package includes modules for image formation, display and analysis; an electronic ledger that automatically records metadata associated with the various data transformation resources; and a number of utilities modeled principally after strategies supported by SPM8 [9,10]: GLM-based parametric mapping of detected hemodynamic response functions; atlas-based mapping of image findings onto identified brain regions, with an automated anatomical labeling functionality; and examination of effective connectivity via strategies such as dynamic causal modeling [11]. The data analysis environment also includes the EMSE Suite (Source Signal Imaging, Inc.), which comprises software modules for integrating EEG with structural MRI [12]: spatial mapping of sensor positions and MRI co-registration; review of EEG data, with various spatial and temporal filters for treating artifacts; mapping signal-space measures topographically onto the head surface; computing and displaying solutions to the cortical current-density inverse-problem; display of MRI data, with tissue segmentation capabilities; mesh generation based on segmented MRIs; and statistical nonparametric mapping, via randomization of experimental conditions, in either signal space or source space.

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