Practical considerations in deploying hybrid fNIRS-EEG system on frontal lobe: an emotion recognition case study

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INTRODUCTION

EEG excels in providing temporal information, while fNIRS is ideal for locating the activation source. We investigated the complementary nature of fNIRS and EEG in the frontal lobe for emotion recognition. We distil the main lessons learnt and guidelines for future deployment of hybrid fNIRS-EEG systems.

Fig 1: Participant wearing the hybrid EEG-fNIRS headset in the experimental room.

METHODS

Using affective video-, sound-, and music-stimuli, three studies were conducted with 30 participants in each. While wearing fNIRS and EEG probes, participants rated their feelings in response to the stimuli on the dimensional model of emotions over 24 trials/study (Fig 1). 16 electrodes and 8 optodes were placed on participants' head (Fig 2).

Both temporal and spectral features from both modalities were extracted. A binary classification of affective states was performed using a subject-dependent approach for each type of emotional content.

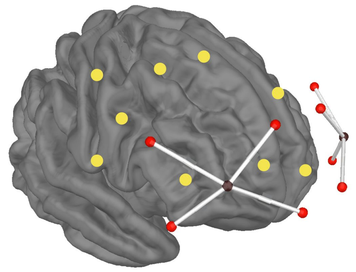

Fig 2: Sixteen EEG electrodes (yellow) on prefrontal cortex (PFC), Broca's area, and supplementary motor cortex; eight fNIRS optodes on PFC (red - fNIRS receivers, brown - fNIRS transmitter).

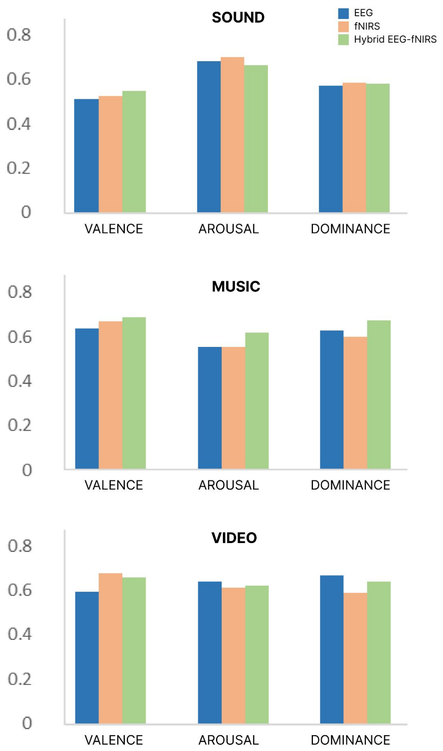

Fig 3: Average accuracy of test set in binary classification of the whole trial. No statistical significant difference between modalities.

RESULTS

Binary classification using the whole trial showed comparable accuracy between the two modalities, and the hybrid system (Fig 3). For example, valence state during video watching was correctly detected with accuracy of 59.1% (EEG-alone), 67.6% (fNIRS-alone), and 65.7% (hybrid system). A similar trend was observed for sound-stimuli and music-stimuli across the three affective states.

However, segmenting the whole trial into smaller segments of 8 second improved classification accuracy and began to present noticeable distinctions between modalities. Table 1 shows the average accuracy of cross-validation (CV) from training set and accuracy of test set for video-data.

	Arousal		Valence		Dominance	
	CV	*Test set*	*CV*	*Test set*	*CV*	*Test set*
EEG	0.918	0.923	0.917	0.922	0.923	0.920
fNIRS	0.949	0.950	0.948	0.949	0.953	0.954
Fusion	0.977**	0.980*	0.974**	0.972**	0.979**	0.987**

Stars indicate whether fusion results are significantly higher than one or both of the single modality results, tested using a paired t-test (= p<0.5, ** = p<0.01).*

DISCUSSION

We observed a significant improvement in classification when using the hybrid system (in comparison to single modality) on shorter trials This could be due to:

- A specific modality may be more effective in capturing specific emotional responses in shorter trials (e.g. EEG better captures rapid changes in neural activity while fNIRS captures sustained changes). Therefore, a hybrid system may facilitate the recording of both types of information.
- Segmentation reduces the impact of noise and artifacts on signals.

Learnings and practical considerations:

1. fNIRS provides information on emotions from the frontal lobe that is comparable to that obtained from EEG.
2. HCI studies can benefit greatly from the use of fNIRS over wet EEG headsets due to time-saving and convenience.
3. Optimal placement of electrodes fNIRS optodes may be highly dependent on the specific research question. Proper consideration of these factors may be crucial for achieving optimal complementarity between the methods.