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Combination of EEG and fNIRS for the (Un)Conscious Discrmination during Anesthesia

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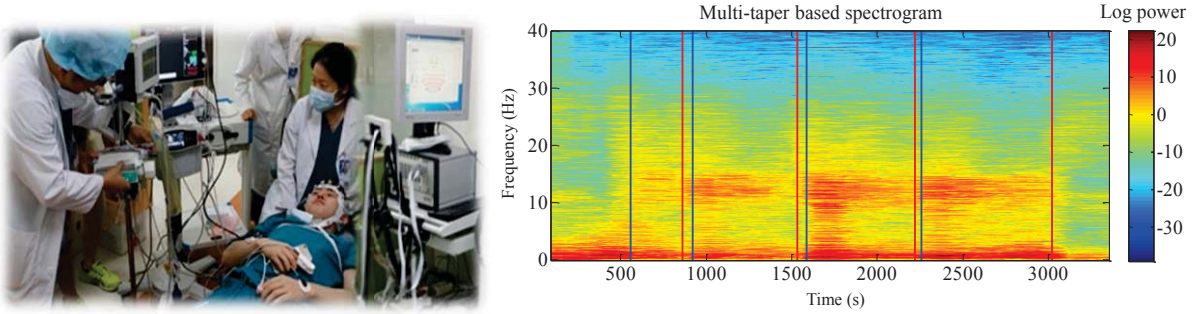
Introduction: Recently, electroencephalogram (EEG) and functional near-infrared spectroscopy (fNIRS) which are commonly used in Brain-Computer Interface (BCI) systems have been utilized into anesthesia study in neuroscience field to monitor depth of consciousness [2,3]. The objective of this paper is to show a feasibility of multi-modality based on EEG and fNIRS in experimental protocol of anesthesia and demonstrate the effect of brain dynamics of related with (un)conscious stage in the spectral domain of EEG data.

Material, Methods and Results: To investigate the relationship between EEG & fNIRS activity and depth of consciousness when the subjects' lose/recovery their consciousness, we recorded EEG with 62 channels and fNIRS with 14 channels acquired from 4 sources and 10 detectors simultaneously. Furthermore, we also measured bispectral index (BIS™, Covidien, Mansfield, MA) and extra vital signals such as blood pressure, end-tidal CO_2, etc. Throughout the experiment, subjects have to respond to prerecorded auditory stimuli by button per every 9-11s with closed eyes. When pressing the button, anesthetic agent (propofol) is infused into his/her vein by patient-controlled sedation application (see Figure 1-(a)). To evaluate brain dynamics, multi-taper time-frequency spectrum was utilized to estimate the brain dynamics under anesthesia with the filtered data from 0 to 40Hz in the frequency domain [4].



(a) (b)

Figure 1. *(a) Experimental setup with EEG and fNIRS systems, (b) Grand average EEG spectrogram based on multi-taper analysis over 5 frontal area with 19 subjects. Vertical blue and red line indicate time points related with loss of consciousness (LOC) and recovery of consciousness (ROC), respectively.*

Figure 1-(b) which only uses the trigger information by button demonstrated that according to the depth of consciousness, transition points related with LOC and ROC have specific differences in some frequency ranges such as alpha and beta oscillations.

Discussion: In our study, we found discriminative EEG/fNIRS patterns in the spectral domain, especially, alpha and beta oscillations. EEG has increased/decreased specific frequency bands at LOC/ROC point, while fNIRS has gradually increased oxy-hemoglobin concentration level aligned to LOC.

Significance: We proposed a novel paradigm in anesthesia study using a hybrid EEG and fNIRS measurements to find specific signatures related with depth of consciousness.

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