Simultaneous measurement of functional near-infrared spectroscopy (fNIRS) and electroencephalography (EEG): a DIY pilot project

Nuttapong Lertchaipattnakul
Chulalongkorn University International Medical Program, Faculty of Medicine, Chulalongkorn University, Bangkok 10330, Thailand; nlert@docchula.com

Background

- A **multimodal functional neuroimaging** would allow simultaneous measurement of 2 or more complementary features of brain activity. As these features arise from different physiological processes, once combined it can give a more comprehensive picture of the brain.
- **Electroencephalography (EEG)** passively records the electrical signals associated with cortical neuronal activity using scalp electrodes. However, EEG has low spatial resolution due to interference from different anatomical layers between the brain and the electrode on the scalp.
- **Functional near-infrared spectroscopy (fNIRS)** assesses cortical hemodynamic blood flow changes. However, fNIRS has poor temporal resolution due to its intrinsic value of detecting low frequency response.
- Combining EEG and fNIRS together can yield a more comprehensive image of the brain.
- Currently, there are specially designed caps on the market that combines the 2 technologies together, however, it is expensive.

Methods

Design

- **Pre-post observational design** with 10 participants.

Equipment

- The fNIRS device used was **ETG-4000**. The EEG machine was from **Eemagine** medical imaging solutions using **flat snap cable** type.
- **Pre-gelled 24mm disposable electrode** was used to connect to EEG flat snap cable.
- **Nuprep** was used to clean the site prior to EEG electrode placement.
- **Ten20 cream** was used to connect EEG electrode that was not able to conduct will using the disposable electrode.

Figure 1a: Shows fNIRS probe cap. The red dot in the gap between the probes shows potential EEG electrode site. The orange port are for the infrared probe whereas the blue ones are for the receiver.

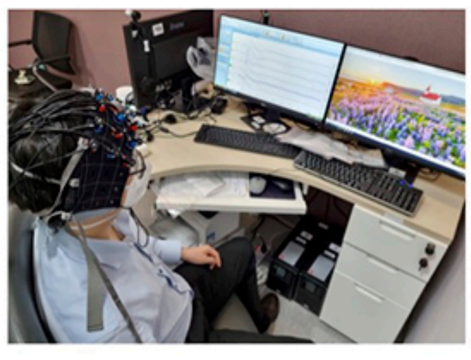

Figure 1b: Shows fNIRS-EEG hybrid setup.

Procedure

- The electrodes for the **EEG** were placed using **the ten-twenty arrangement system**, whereby only **Fp1, Fp2, F7, F3, Fz, F4, and F8** was used. The reference and ground electrodes were placed behind left and right ear respectively.
- The **fNIRS probe was then placed over the EEG** electrodes, which the electrodes being at the **gap between fNIRS probes**.
- Participants were then asked to look at a neutral stimulus for first **five minutes for baseline** value. After that the participants were asked to complete the **Tower of London** cognitive task for five minutes. Then the participants were asked to look at the neutral stimuli again for 5 minutes.

Results

- **Fast fourier transform (FFT) analysis** was used for wave analysis splitting the waves into 9 different wave bands (**Delta**, Theta, **Alpha**, Beta 1, **Beta 2**, Beta 3, Gamma 1, Gamma 2, and Gamma 3). The signals were then organized into different testing time: Pre-test, Test, and Post-Test.
- For **fNIRS**, the **mean and 95% confidence interval** for each probe was calculated and organized according to the location and testing time.
- **Figure 2 and 3** shows the data from EEG and fNIRS probes and electrodes in the same location at different time point.

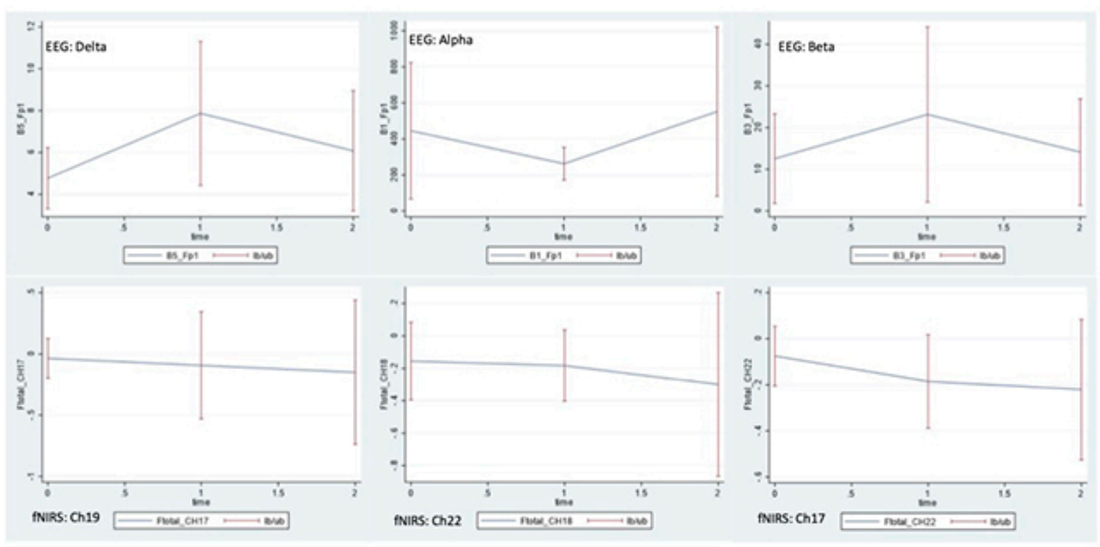

Figure 2: The mean value of EEG and fNIRS in the Fp1 area. Top row shows data from the EEG and the bottom row shows data from the fNIRS. The error bars depict the 95% confidence interval

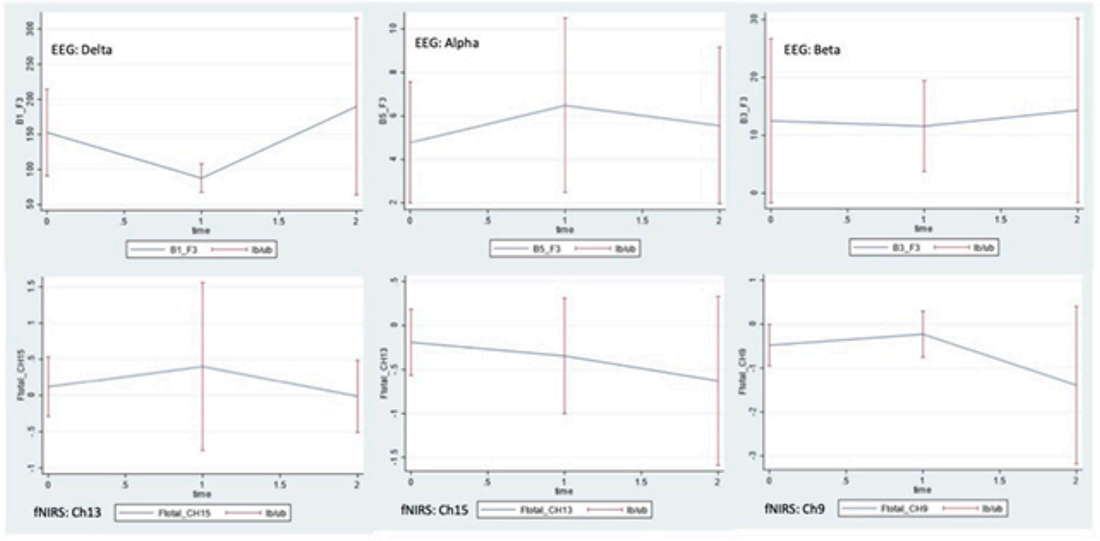

Figure 3: The mean value of EEG and fNIRS in the F3 area. Top row shows data from the EEG and the bottom row shows data from the fNIRS. The error bars depict the 95% confidence interval

Conclusion

- There seems to be a **change in both fNIRS and EEG**, suggesting that both EEG and fNIRS can detect some cortical activity at the same time.
- **More research** is needed to quantify the signal change pattern in order to correlate the data from fNIRS and EEG together.

Future Directions

- Expand the research from frontal lobe to other parts of the brain.
- Add in different cognitive tasks.

Acknowledgement

I would like to acknowledge Chula neuroscience center and Chulalongkorn Comprehensive Epilepsy Center of Excellence for providing equipment and facilities. As well as Dr. Chavit Tunvirachaisakul, M.D., Ph.D. for his guidance throughout the project

References

- Chiarelli, A. M., Zappasodi, F., Di Pompeo, F., & Merla, A. (2017). Simultaneous functional near-infrared spectroscopy and electroencephalography for monitoring of human brain activity and oxygenation: a review. *Neurophotonics, 4*(4), 041411.
- Khan, M. U., & Hasan, M. A. (2020). Hybrid EEG-fNIRS BCI fusion using multi-resolution singular value decomposition (MSVD). *Frontiers in Human Neuroscience, 14*(1), 536-548.
- Mohamed, M. E., Mohamed, N., Kim, M., Yun, J. D., & Kim, J. G. (2021). Development of an Integrated EEG/fNIRS Brain Function Monitoring System. *Sensors, 21*(22), 7703-7727.