Replication of Wu et al. (2004): A functional near-infrared spectroscopy (fNIRS) study

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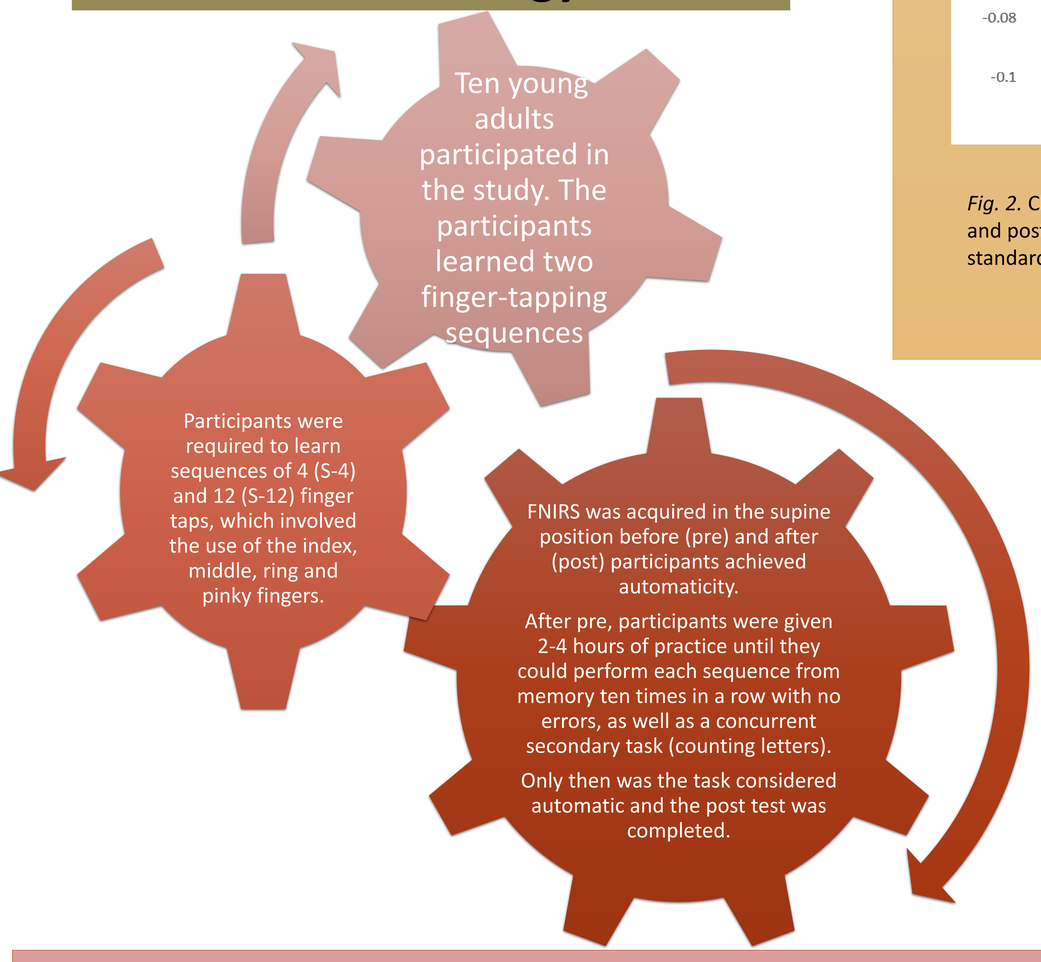
Introduction

Functional near-infrared spectroscopy (fNIRS), similar to functional magnetic resonance imaging (fMRI), is a non-invasive approach for examining functional activation through changes in the hemodynamic properties of the brain. FNIRS can quantify the concentration of oxyhemoglobin (HbO) and deoxyhemogloblin (HHb) by emitting light of different wavelengths into the brain (Perrey, 2008). When a movement can be performed with little attentional demand, a corresponding decrease in cortical activation is observed (Wu & Hallett, 2005a; Wu, Kansaku, & Hallett, 2004; Poldrack et al., 2005). However, only movements that can be performed in the supine position have been evaluated due to the confines of the fMRI scanner. Conversely, fNIRS not only evaluate gross motor tasks but provide a higher temporal resolution than its fMRI counterpart (Perrey, 2008).

Objective

The goal of this study was to validate the fNIRS by replicating the fMRI protocol and associated prefrontal cortex (PFC) findings reported in Wu, Kansaku, and Hallett (2004). We hypothesize that as the participants transition through the learning stages and the movement becomes automatic, there will be a corresponding decrease in HbO.

Methodology



Results

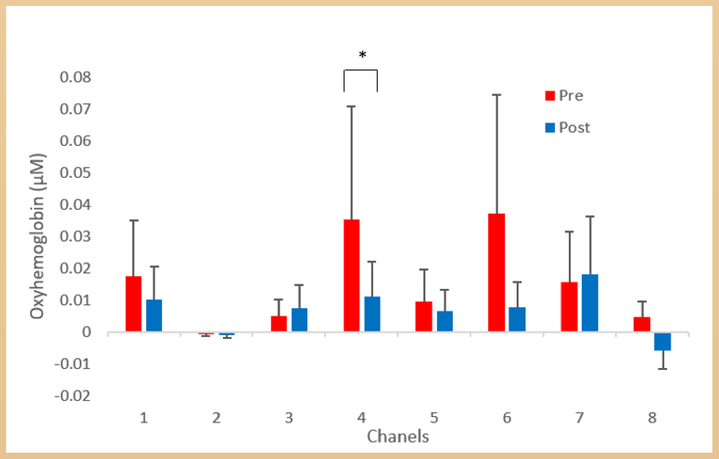


Fig. 1. Changes in oxyhemoglobin (HbO) in micromolar (µM) during pre and post for sequence 4 across 8 channels. Error bars represent standard deviation.

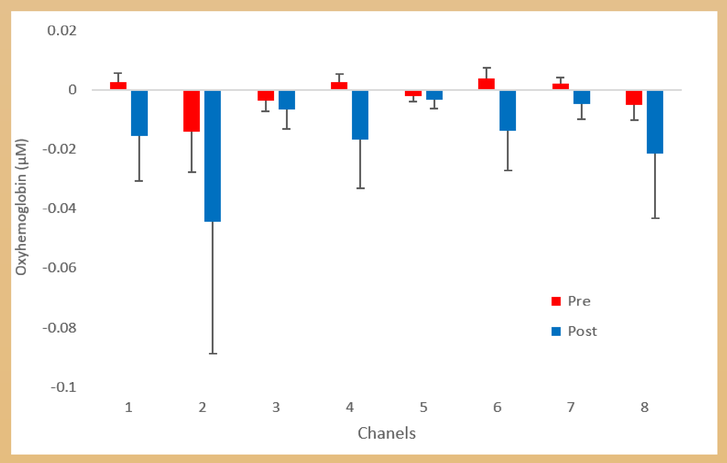


Fig. 2. Changes in oxyhemoglobin (HbO) in micromolar (µM) during pre and post for sequence 12 across 8 channels. Error bars represent standard deviation.

Results

- For S4, a paired t-test between pre and post revealed a trend towards statistical significance ($t(9) = 2.003$, $p = 0.076$) in channel 4. This suggests a decrease in HbO, in what we believe to the right, dorsalateral PFC.
- The other channels did not reveal significant differences ($ps > 0.05$). However, channels 1, 2, 5, 6 and 8 demonstrated a similar pattern to channel 4.
- For S12, the paired t-test revealed no significant differences across all 8 channels. However, visually all 8 channels demonstrated a decrease in HbO from pre to post (Fig. 2).

Discussion

- The reduced levels of HbO in post compared to pre may suggest that as the movement becomes established and automatic, there is diminished reliance on the PFC. This is in keeping with Wu et al. (2004).
- Currently, the fNIRS is not validated because the study lacks statistical power. Ten additional participants will be recruited.

References:

Perrey, S. (2008). Non-invasive NIR spectroscopy of human brain function during exercise. *Methods, 45,* 289-299.

Wu, T., & Hallett, M. (2005a). The influence of normal human ageing on automatic movements. *The journal of physiology, 562,* 605-615.

Wu, T., Kansaku, K., Hallett, M. (2004). How self-initiated memorized movements become automatic: A functional MRI study. *Journal of neurophysiology, 91,* 1690-1698.

Conclusion

These findings suggest that there less reliance on the prefrontal cortex as a movement becomes automatic. Also, these findings are similar to the findings of Wu, Kansaku, and Hallett (2004) but unfortunately are not significant and therefore fNIRS is not validated.

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