Quantitative analysis of teaching modalities on autism spectrum disorder student engagement through frontal lobe activation using fNIRS

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Introduction

- Students with **Autism Spectrum Disorder (ASD)** have been shown to have lower levels of engagement and different forms of interactions with their environment during academic instruction compared to other students
- All students experience so called **"aha moments"** during learning where they suddenly have an understanding of a previously incomprehensible problem
- The purpose of this study was to determine the frontal lobe activation when these moments occur using **functional Near Infrared Spectroscopy (fNIRS)**

Figure 2. Student working while wearing a fNIRS cap[1]

Methods

- This project focuses on the analysis of 48-channel fNIRS data using **MATLAB** [version 9.12.0.1975300 (R2022a) Update 3]
- Participants wore the fNIRS NIRSIT systems (Soterix Medical, Inc.) during a 30-minute math lesson consisting of different modalities of teaching (tasks). Changes in oxygenated (HbO_2) and deoxygenated (HbR) hemoglobin levels were measured using 48 channels averaged into **eight, bilateral functional regions of interest**: ventrolateral, dorsolateral, frontopolar, and orbitofrontal prefrontal cortexes
- We calculated the area under the curve (AUC) for the change in HbO_2, HbR, and the difference across tasks We modified previously written code[2] to automatically parse through participants and tasks while creating more comprehensive graphs and data files. This allowed for analysis to be completed much quicker and thoroughly

Figure 3. Students working together while wearing fNIRS caps[1]

Conclusions/Discussion

- In the current literature environment, there is some ambiguity about how fNIRS data is reported. Some studies report an average of the oxygenated curves, whereas others report only changes in HbO_2
- This study reports the results using **AUC analysis of oxyhemoglobin levels**. This metadata can be used as an unbiased estimator of brain activity to generate more reliable data that can be used by future researchers and teachers to find periods of time that trigger "aha moments"
- Ultimately this will allow schools and teachers to **better accommodate** students with ASD

Figure 4a and 4b. Students and teachers in lessons while wearing fNIRS caps[1]

Results

- Successful data analysis resulted in **AUC graphs** for each region of interest for each task for each subject
- Areas of the graph where oxygenated hemoglobin levels are higher than deoxygenated hemoglobin levels indicates that brain activity in the area of interest increased and is a possible "aha moment"
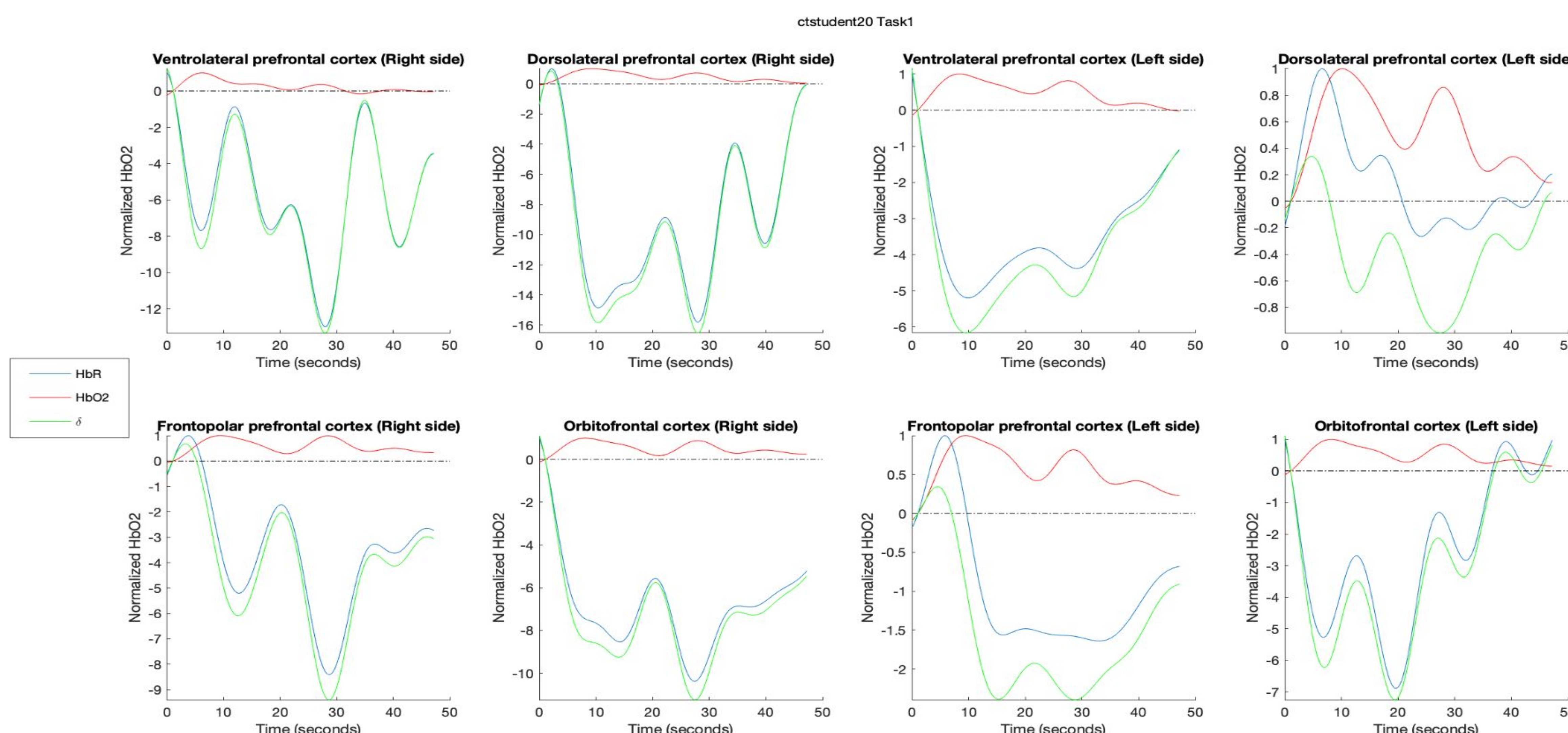

Figure 1. Analysis of Task 1 from subject ctstudent20
Trapezoidal Riemann sum was used to calculate AUC. HbR (blue) is deoxygenated hemoglobin and HbO_2 (red) is oxygenated hemoglobin. δ (green) is the difference (HbO_2 - HbR). Brain activity is increased when δ is higher because more HbO_2 is needed in activated areas of the brain

References

[1] Lahodny, Avery, et al. "Qualitative Analysis of the Role of Teacher Rapport on Autism Spectrum Disorder Student Engagement While Scanning for Frontal Lobe Activation Using FNIRS." *The FASEB Journal*, vol. 36, no. S1, 2022, https://doi.org/10.1096/fasebj.2022.36.s1.r5770.

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Acknowledgements