Neural dynamics during dimensional label learning predicts dimensional attention performance in early childhood

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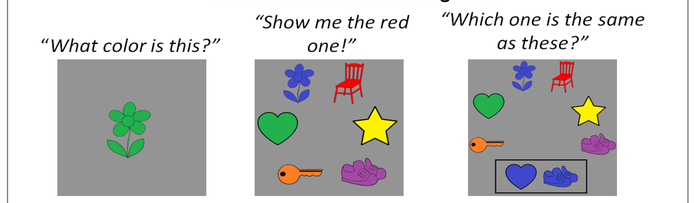
Introduction

Previous research suggests that children's ability to label visual features (e.g., "green") and dimensions (e.g. "color") can change aspects of their dimensional attention (Buss & Kerr-German, 2019). Based on this research, the goal of this study is to investigate whether children's dimensional attention can be predicted by the neural dynamics of dimensional label learning. We used functional near-infrared spectroscopy (fNIRS) to measure hemodynamic changes in left frontal, left parietal and left temporal cortices previously implicated in dimensional attention (Morton et al., 2009; Buss & Spencer, 2018) while participants completed a battery of dimensional label learning and dimensional attention tasks. Dimensional attention was measured using the dimensional change card sort task (DCCS) which measures flexible dimensional attention, a dimensional attention priming task which measures attentional stability, and the triad classification (TC) task which measures children's selective attention.

Materials

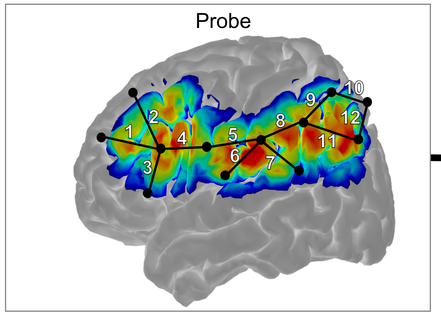
Dimensional Label Learning Tasks

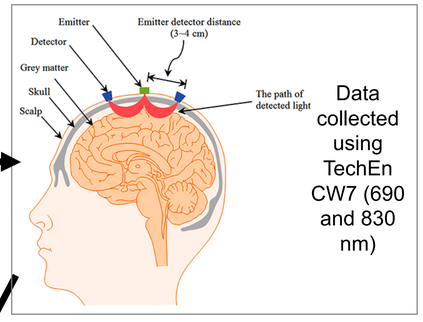


- Thirty preschool aged children
- 40 and 51 months of age
- 15 males; M=46.6 months

Dimensional Attention Tasks

fNIRS Data Collection and Analyses



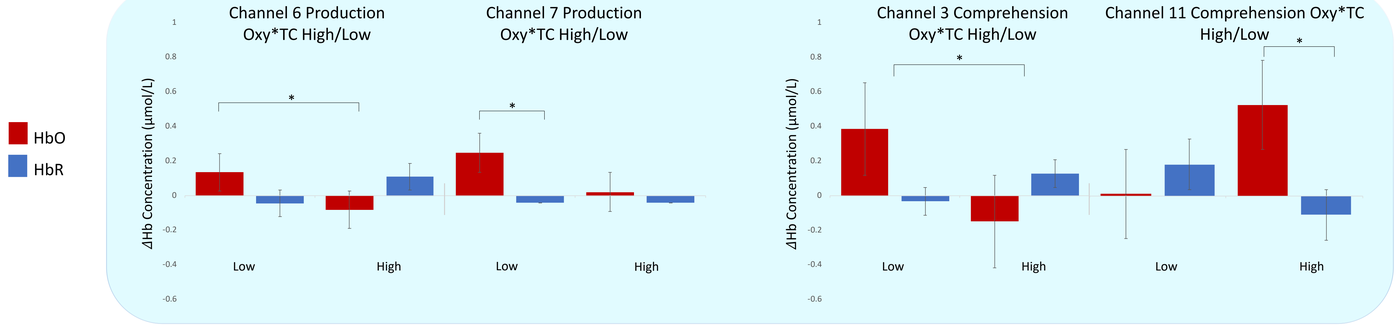


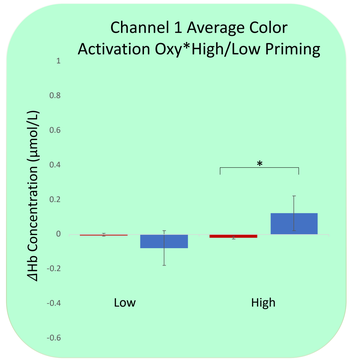
Data collected using TechEn CW7 (690 and 830 nm)

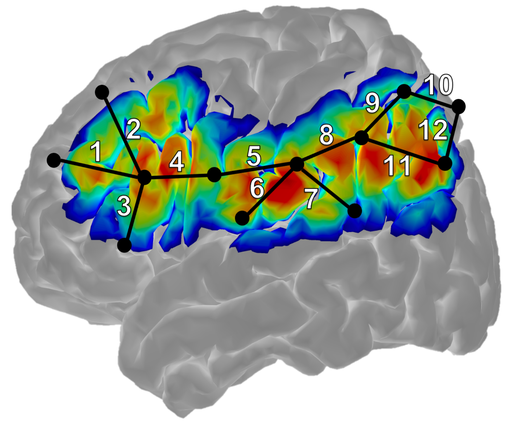
Standard pre-processing in EasyNIRS:

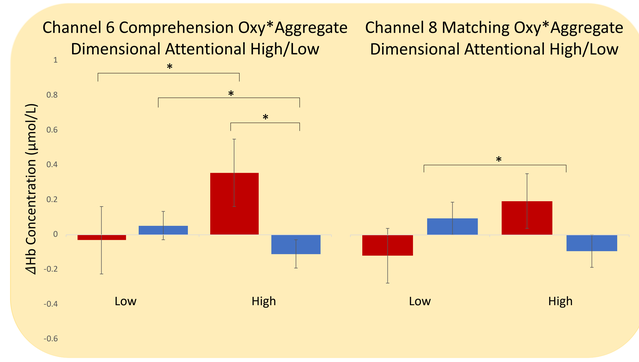
- Convert to optical density
- Wavelet motion filtering (iqr=0.5)
- Conversion to concentration values using modified Beer-Lambert equations (dpf=ppf=6.0)
- Average HbO and HbR calculated within 4-9s time window for each Dimensional Label Learning task

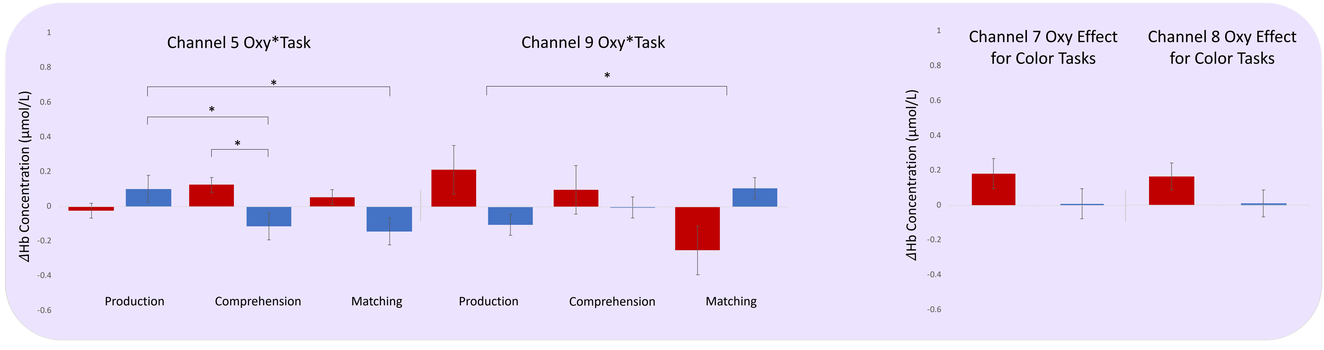
Results











Behavioral Results

Task	Production	Comprehension	Matching	Priming	Triad Classification (identity vs holistic)	DCCS (pass vs fail)
Performance	0.94	0.93	0.71	0.89	0.65	0.56

Conclusions

- Previous studies show that older children have stronger activation in parietal and temporal cortices when compared to younger children (Buss & Spencer, 2018)
- In the current study, activation during dimensional label tasks predicted quality of dimensional attention performance: high performers activated the posterior/parietal regions as well as deactivation in the frontal cortex which may reflect a refinement of brain networks.
- For Comprehension, temporal regions are activated for higher performers which may reflect object-label binding.

References

Buss, A. T., & Kerr-German, A. (2019). Dimensional attention as a mechanism of executive function: Integrating flexibility, selectivity, and stability. *Cognition*.

Buss, A. T., & Spencer, J. P. (2018). Changes in frontal and posterior cortical activity underlie the early emergence of executive function. *Developmental Science*, *21*(4), 1–14.

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