Brain Region of Importance for the Auditory N-Back Task via Machine Learning

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INTRODUCTION

The domain-general account of language development suggests that attention and memory influence language development. We compared monolingual (Typically-developing and Developmental Language Disorder groups) and bilingual (Chinese/English and Spanish/English groups) on a N-back task.

- **Question 1**: Could a random forest, trained on an individual, identify what brain regions related to language and memory are the most important for children performing auditory 0-back, 1-back, and 2-back tasks.
- **Question 2**: Which brain regions mattered most for predicting task performance for the six ROIs (left and right DLPFC, IPL, IFC, STG, SA).

METHODS

Participants
- 82 children
- 42 Males and 40 Females
- Ages 9-14

Four Groups
- Bilingual Chinese(BCH) N=18
- Developmental Language Delay (DLD) N=14
- Bilingual Spanish (BSP) N =19
- Typically Developing (TD) N=31

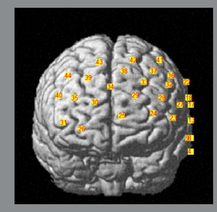
Behavioral Data						
Group	0-back Acc	1-back Acc	2-back Acc	0-back RT	1-back RT	2-back RT
BCH	0.94	0.65	0.42	148.19	315.268	481.6458
BSP	0.85	0.56	0.37	243.7615	318.747	381.933
DLD	0.7	0.38	0.33	274.656	369.115	326.336
TD	0.78	0.52	0.4	242.476	367.649	375.551

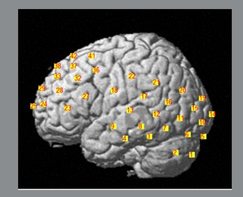
ANALYSIS

Instrument
- fNIRS Hitachi ETG-4000
- 44 channels
- ROIs selected via Polhemus PATRIOT digitizer
- MNI channel registration analyses

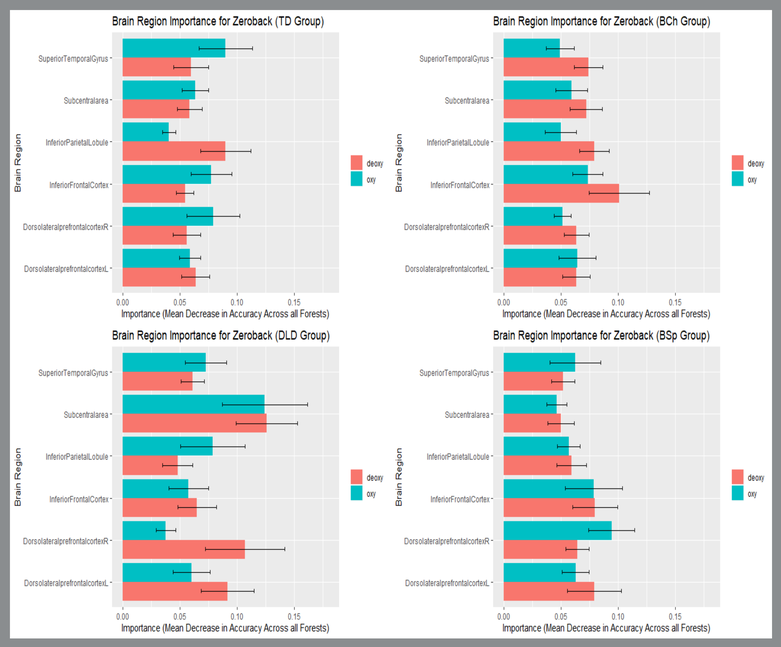
Analysis

- To perform task-level classification, we trained a separate Random Forest for each individual in the study.
- Each individual had approximately 30 three to four second trials within the separate n-back tasks, measured across 6 brain regions.
- 80% of the trials for each individual were used as the training data set, while the remaining 20% of trials were used as a test data set to validate the Random Forest's ability to predict onto unseen data (i.e. it's ability to generalize within an individual.
- The measurements within each brain region and trial were then normalized and averaged across the entire trial resulting in a single measurement per brain region per trial.
- We measured the mean decrease in the accuracy of the predictions associated with permuting the values in each brain region independently.
- Using this, we explored the variable importance metrics available in the Random Forest method to visualize the importance of these brain regions for predicting the different n-back tasks.

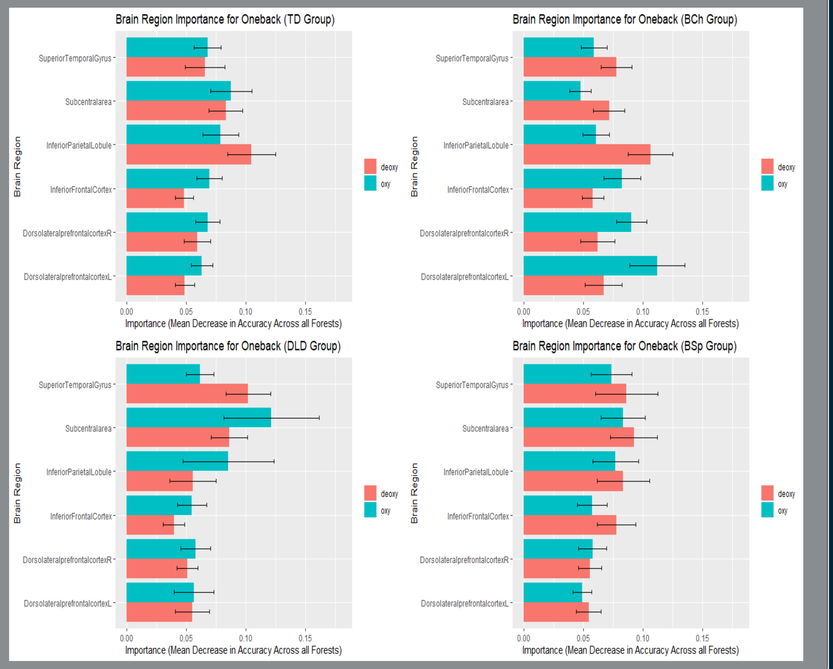




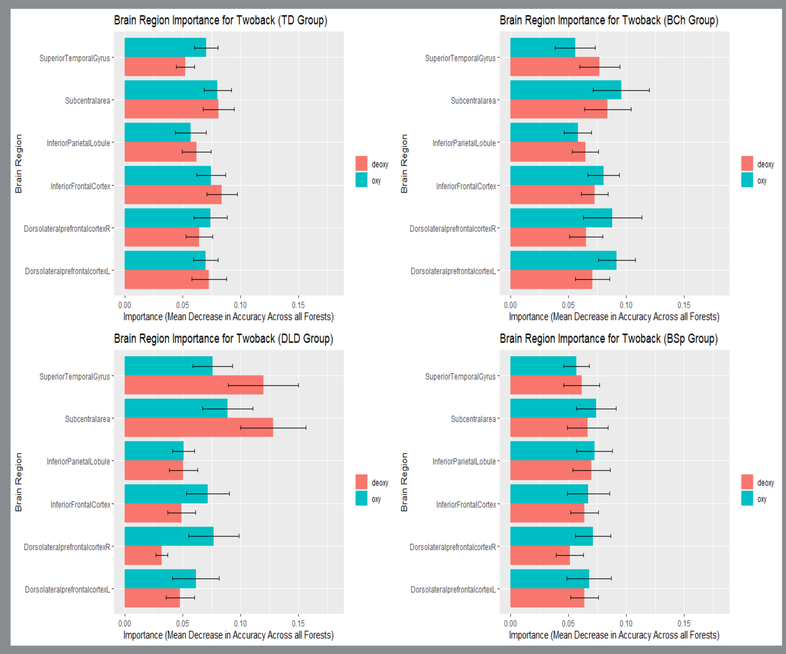
0-BACK



1-BACK



2-BACK



RESULTS

- The test set accuracy for tasks averaged across their respective groups are shown in the table.
- 0-back: STG, IFC, RDLPFC, and IPL showed more importance.
- 1-back: showed more reliance on SA, STG, IPL.
- 2-back: showed more uniform distribution among regions
- Across groups, STG, SA, showed higher areas of importance in the DLD group.

Random Forest Test Set Accuracies			
Group	0-back	1-back	2-back
TD	91.37%	89.62%	91.05%
DLD	91.51%	89.69%	93.68%
BCh	92.48%	92.00%	91.21%
BSp	89.18%	90.47%	90.74%

DISCUSSION

- While these models show strong predictive performance, the ability to predict task from fNIRS measurements alone is not informative, as the task being performed is well-known.
- These high accuracies illustrate that fNIRS measurements across these brain regions contain enough discriminative information to effectively classify the task being performed.
- STG, SA, and IPL appear to play an important role in auditory n-back and may contribute to capacity limitations in children with DLD.

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