# Classification of infant fNIRS data improves prediction of cognitive development 18 months later

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## Introduction

***Goal:** Predict developmental outcomes*

- ➔ Identify children likely to have adverse developmental outcomes later
- ➔ Make inference *early* in life to improve opportunities for intervention

Differences in neural responses might reveal developmental processes that are not yet behaviorally evident, e.g. preverbal infants.

### *Social cognition task for fNIRS*

Videos of woman reciting nursery rhymes (Lloyd-Fox et al., 2009). Three conditions are based on the audio track:

1. **Silent** (no sound, video only)
2. **Vocal** sounds (coughing, laughing, etc.)
3. **Nonvocal** sounds (fan, water, bell)

Interleaved with blocks of photos depicting local modes of transportation ("**Cars**")


adapted from Pirazzoli et al., 2022, *Dev. Cog. Neuro.*

***Bangladesh Early Adversity Neuro-imaging project*** (**BEAN**, https://www.lcn-bean.org)

Recent studies have identified correlations between developmental risk factors and fNIRS responses of infants and toddlers:

fNIRS from brain regions that respond selectively to social stimuli correlates with psychosocial adversity (Perdue et al., 2019).

fNIRS data showed intimate partner violence, verbal abuse and family conflict impact the social information processing in children (Pirazzoli et al., 2022).

## Method

### *Participants*

Data from 29 infants from low-income families in Dhaka, Bangladesh:
**Session 1:** 6 months old
**Session 2:** 24 months old

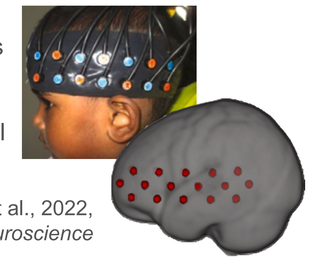

Risk factors in Mirpur neighborhood:

- Open sewers, shared community toilets
- Low quality construction materials for homes and/or dirt floors
- Crowded living conditions

### *fNIRS data collection*

NTS optical topography, 12 sources at 780 & 850 nm and 12 detectors

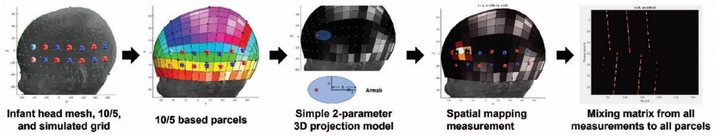
Sampling 32 channels over bilateral frontal, temporal, and parietal regions



Pirazzoli et al., 2022, *Developmental Cognitive Neuroscience*

### *Co-registration to parcel space*

Channels co-registered to a 10-5 based parcellation using Polhemus data to reduce between-subjects variability of ROIs




Magee et al., 2023, *Diffuse Optical Spectroscopy and Imaging IX*

### *fNIRS classification* (Emberson et al., 2017; Zinszer et al., 2023)

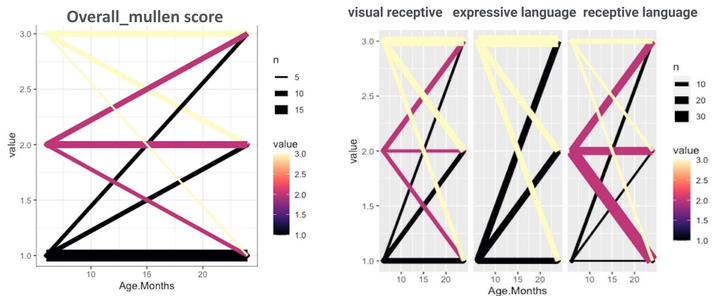
Preprocessed with Homer2, differential path lengths [5.25, 4.25]
Median HbO and HbR responses in each condition
window 5-8 s after stimulus
baselined from 0-2 s

*N*-fold (leave-one-child-out) CV of multi-parcel patterns

1. each child's pattern held out from the group average
2. Spearman-correlation of child vs. group response patterns
3. Pairwise classification using highest sum of correlations

## Results

### *Mullen scores at 6 and 24 months*




*fNIRS classification accuracy at 6 months old improves our prediction of whether a child's Mullen scores will be* ***in the bottom-third of their cohort at 24 months old.***

Lasso regression using 6 m.o. fNIRS classification accuracies, β

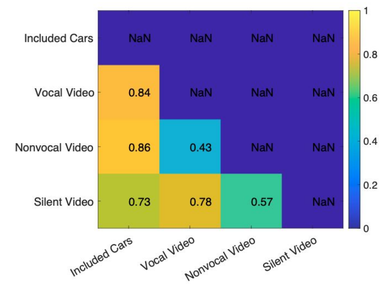
| Cars vs. Vocal | Cars vs. Nonvocal | Vocal vs. Nonvocal | Cars vs. Silent | Vocal vs. Silent | Nonvocal vs. Silent |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | -1.68 | 0 |

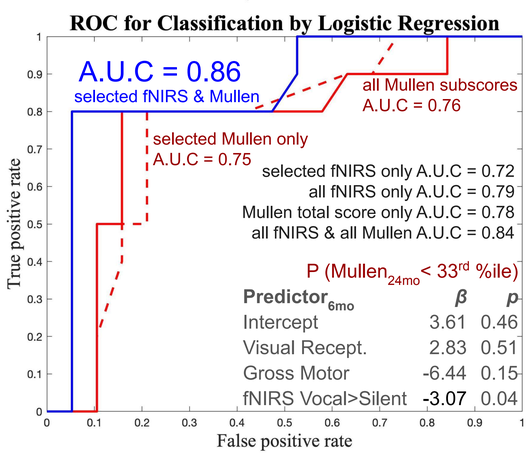
Lasso regression using 6 m.o. Mullen subscores, β

| Visual Reception | Expressive Language | Receptive Language | Gross Motor | Fine Motor |
|---|---|---|---|---|
| -0.80 | 0 | 0 | -4.11 | 0 |

### *Classification of 6 m.o. fNIRS data*

Classification accuracy for each child's data vs. group




## Discussion

### *Summary*

Using 6 month old infants' fNIRS responses vs. only using the information provided by behavioral testing (Mullen subscores):

improved the prediction accuracy of their Mullen scores at 24 months old (from 0.76 to 0.86)

reduced the false positive rate for predicting the lower 33% of peer group by ⅔ at 80% sensitivity.

### *Interpretation*

Individual differences in this kind of auditory processing may underlie later differences in socially-relevant developmental outcomes, such as language acquisition.

### *Future Directions*

Try decision tree modeling to improve interpretability of classification.

## References

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