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

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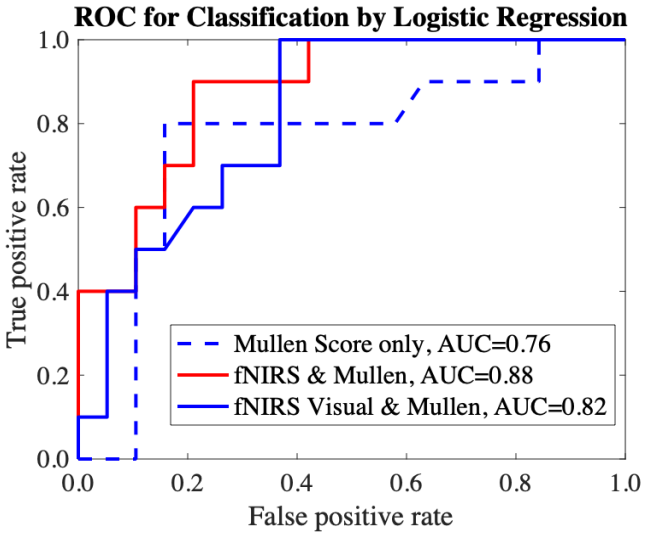
Abstract: One goal of research on developmental adversity is the early identification of children at risk for later adverse outcomes. While surveys and cognitive testing provide important metrics of development and risk, they can also be limited by their reliance on a child's cooperation with instructions or parents' accurate reports. We tested whether a classifier for fNIRS data, collected during a passive task at 6 months old could be used to predict developmental outcomes at 24 months. fNIRS improved prediction accuracy by 12% over using only Mullen scores at 6 months.

Introduction: Recent studies in Dhaka, Bangladesh have identified correlations between developmental risk factors (e.g., family conflict) and fNIRS responses of infants and toddlers in a passive social cognition task (Perdue et al., 2019; Pirazzoli et al., 2022). A key goal of such work is prediction: the ability to identify children most likely to experience adverse developmental outcomes months or years later. Behavioral measures offer one source of predictive power, but differences in neural responses can provide insight on processes that are not yet behaviorally realized, like language production or motor skills. We analyzed longitudinal data from 29 infants previously reported in these studies and asked whether multivariate analyses of fNIRS collected at 6 months old could enhance prediction of the children's behavioral outcomes at 24 months.

Methods: All children were assessed on Mullen Scale of Early Learning (Mullen, 1995). Each child completed a passive social cognition task (Lloyd-Fox et al., 2007, 2009) with fNIRS imaging over bilateral frontal, temporal and parietal regions. In this task, children saw images of vehicles and videos of a woman in three conditions: silent, paired with vocal sounds (laughing, coughing, etc.), and paired with nonvocal sounds (a fan, water, etc.). We co-registered each child's data to a 10-20 based scalp parcellation (Magee et al., 2023) and computed median HbO and HbR responses for each condition in the window 5-8 s (baseline 0-2 s). Multi-parcel response patterns for each child were Spearman-correlated with their same-age cohort (*n*-fold cross-validation) for pairwise classification of the four conditions (Emberson et al., 2018; Zinszer et al., 2023). We entered these six classification accuracies and five Mullen subscores from each child's first visit (6 m.o.) into a binomial regression to predict their membership in the lower third of Mullen scores at their second visit (24 m.o.).

Results: Predictions of Mullen scores at 24 m.o. based on 6 m.o. Mullen subscores (AUC=0.76) were significantly improved by the inclusion of the 6 m.o. fNIRS data (AUC=0.88, likelihood ratio=8.60, p=0.003). ROC curves for these predictions are depicted in the figure. Among fNIRS predictors, the visual social contrast (accuracy of Silent Videos vs. Cars) was the strongest predictor. A model including only this predictor alongside Mullen subscores also improved predictions relative to the Mullen data only (AUC=0.82, likelihood ratio=4.84, p=0.028)



Conclusion: Including fNIRS data from a single subject-level classification test of visual stimuli (cars vs. faces) significantly improved predictions beyond the information provided by behavioral testing. Individual differences in this kind of visual processing may underlie later differences in socially-relevant outcomes, such as language acquisition.