Using fNIRS to Map Functional Specificity in the Infant Brain: An fROI Approach

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Introduction

The adult brain is populated by regions with functional specializations (Kanwisher, 2010), but the developmental trajectory of such specialization is unknown.

Investigating the development of these specialized regions is difficult, in part because many neuroimaging methods are unsuitable for developmental populations.

Functional near-infrared spectroscopy (fNIRS) uses light absorption to measure hemodynamic responses to neural activity and is suitable for use with infant participants (Gervain et al., 2011).

Roadblocks to using fNIRS to study functional regions in infants include multiple sources of spatial blurring (optode placement, 10-20 to cortex variability, variability in the location of functional regions) and problems with statistical power.

We tested for selective responses to scenes versus faces in right occipital and temporal cortex, in groups of both adults and infants.

We compared a standard channel-based approach to an individual functional region of interest (fROI) approach that we hypothesized would reduce spatial blurring and avoid the typical multiple comparisons problem.

Data Analysis

Processing Stream

(Infants only: remove blocks where participant is looking < 66% of the time)

Intensity → Optical density (OD) transformation
Prune channels (signal strength, SD)
PCA Filter to remove motion artifacts
Band-pass filter (0.01-0.5 Hz)

OD → HbO, Hbr concentration transformation

Channel-based Approach

Compile block average HbO conc. (2 s post-onset for adults; 6 s post-onset for infants) for each trial type for each channel
Across subjects, compare face and scene responses in all channels (correct significance threshold for multiple comparisons)

Individual fROI Approach

Split each subject’s scene & face data in half
Use each half to identify most selective face and scene channels (highest t statistic, anatomical constraint)
Compile block average HbO conc. for each trial type from independent halves
Across subjects, compare face and scene responses in these individually chosen channels

Method

-Subjects: 19 adults, 18+ yrs, 8 female
  13 infants, 3-11 months, 6 female

-Stimuli: 81 s runs (x8 for adults; variable for infants), each with multiple blocks of three movie types

Faces
Scenes
Scrambled scenes

-Faces: cartoon faces, and cat faces as well as faces presented in different sizes, locations, and viewpoints (25, 26). Crucially, when relatively cartoon faces, and cat faces as well as faces presented in different sizes, locations, and viewpoints (25, 26). Crucially, when relatively

-NIRS system: TechEn CW6, 8 sources (690 & 830 nm), 8 detectors, 14 channels, sampling at 50 Hz

Regions of Interest

-Trans-occipital sulcus (TOS) (scene-selective in adults)
-Superior temporal sulcus (STS) (face-selective in adults)

Array Placement

Key

Individual fROI Approach

-Channel-based Approach

Face Channel
Scene Channel

Most significant channels
Face: t(19) = 3.04, P = 0.007;
Scene: t(19) = 2.66, P = 0.016

-Individual fROI Approach

Face Channel
Scene Channel

Most significant channels
Face: t(12) = 3.45, P = 0.005;
Scene: t(12) = 2.54, P = 0.026

Results

NS
P > 0.003

P < 0.003

NS
P > 0.003

P < 0.003

(face responses)

(scene responses)

Discussion

We found evidence of functional regions specialized for processing both faces and scenes in infants and adults. This extends other evidence for selective processing of faces (e.g. Lloyd-Fox et al., 2009) and is the first evidence for selective processing of scenes in infancy.

The detection of these regions was made possible by the individual fROI approach, which reduces spatial blurring and the need for multiple comparisons. This approach was possible despite a minimum of 90 s and an average of 147 s of data per condition per participant, making it a feasible approach for infant fNIRS research.

References


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