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 group average 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)

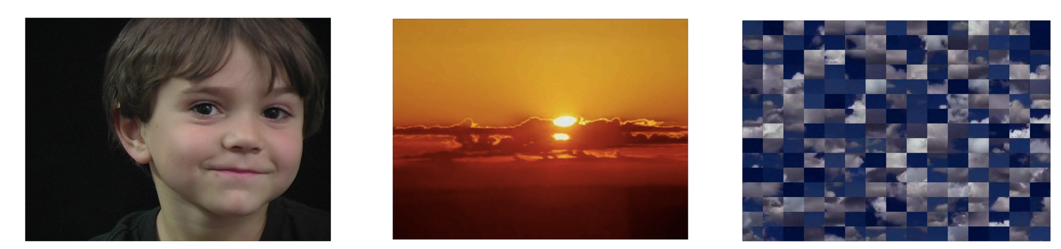
Compile block average HbO conc. for each trial type from independent halves

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

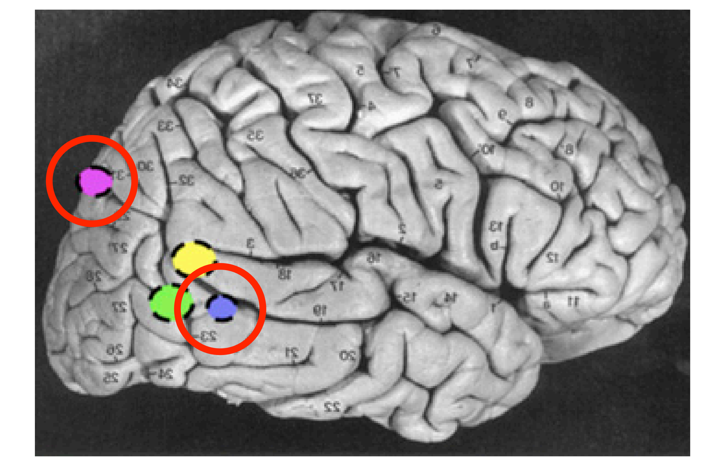
-Stimuli: 81 s runs (x8 for adults; variable for infants), each with multiple blocks of three movie types



Faces | Scenes | Scrambled scenes

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

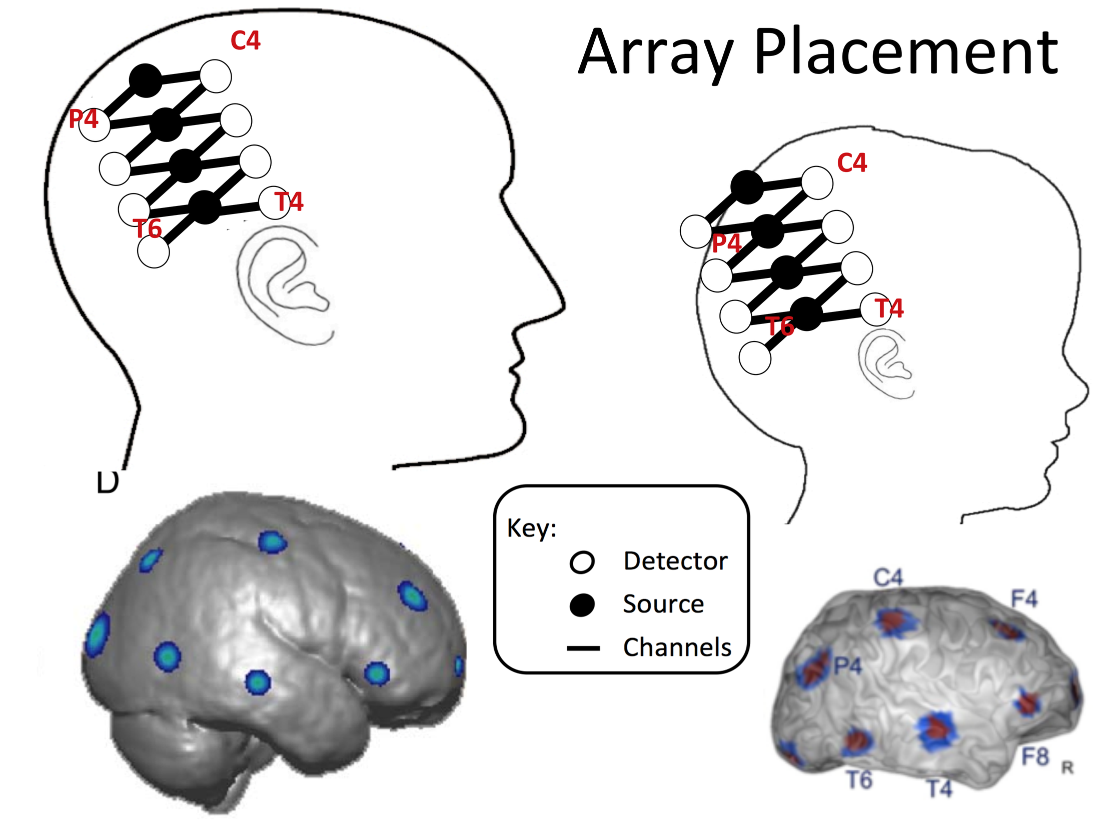
Regions of Interest



Kanwisher, 2010

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

Array Placement

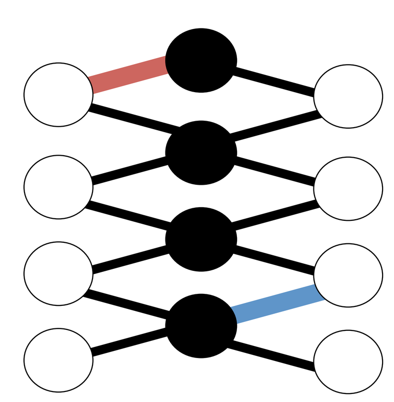


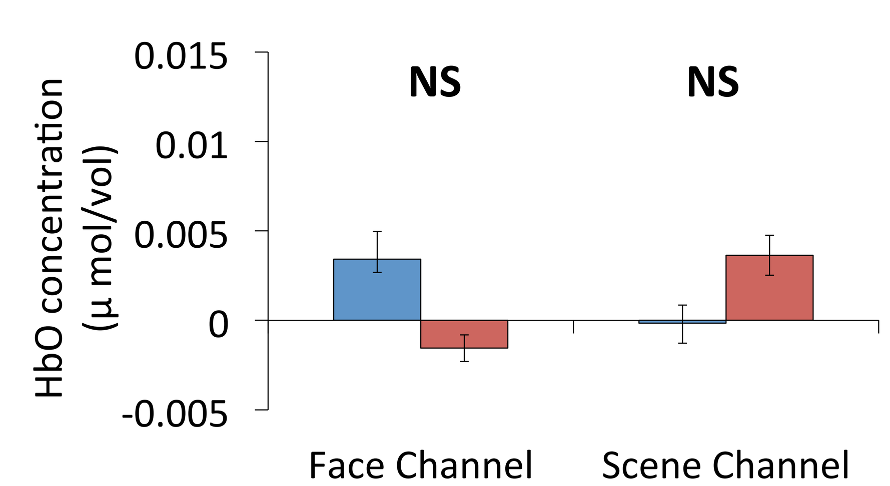
Okamoto et al., 2004 | Kabdebon et al., 2014

Results

Channel-based Approach

Adult Data

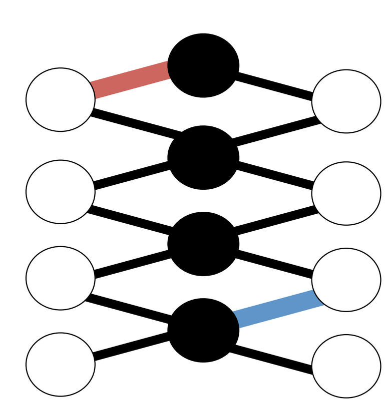


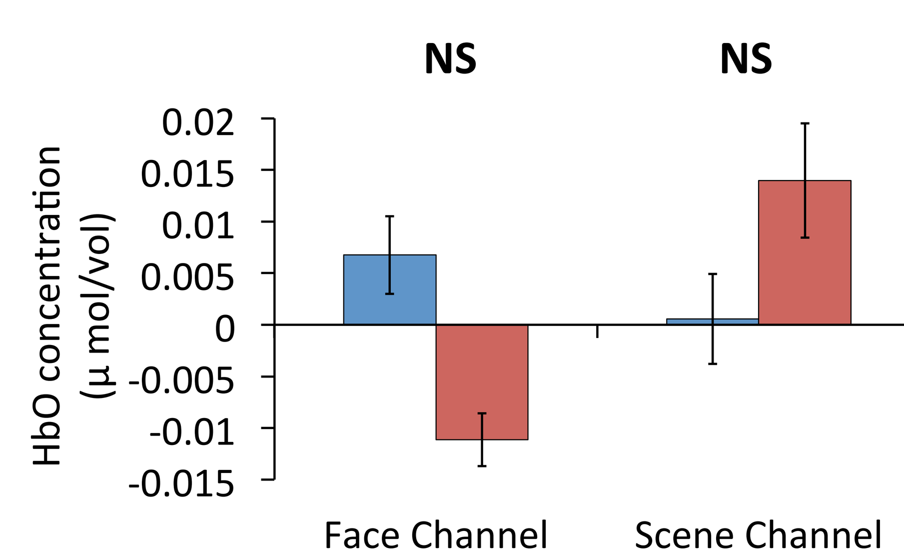


(Most significant channels -- Face: $t(19) = 3.04$, $P = 0.007$; Scene: $t(19) = 2.66$, $P = 0.016$)

NS $P > 0.003$
* $P < 0.003$
(correction for multiple comparisons)

Infant Data



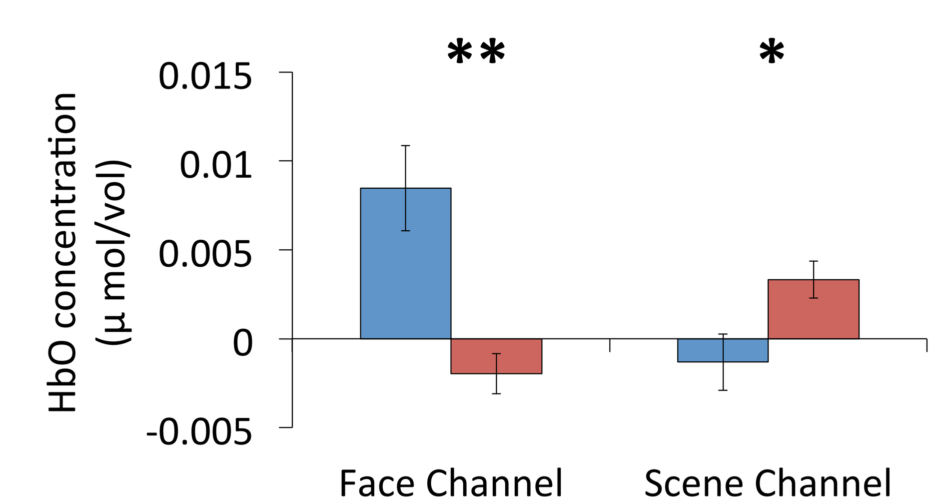


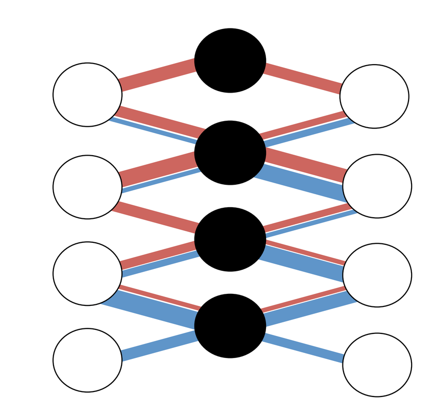
(Most significant channels -- Face: $t(12) = 3.45$, $P = 0.005$; Scene: $t(12) = 2.54$, $P = 0.026$)

face responses
scene responses

Individual fROI Approach

Adult Data

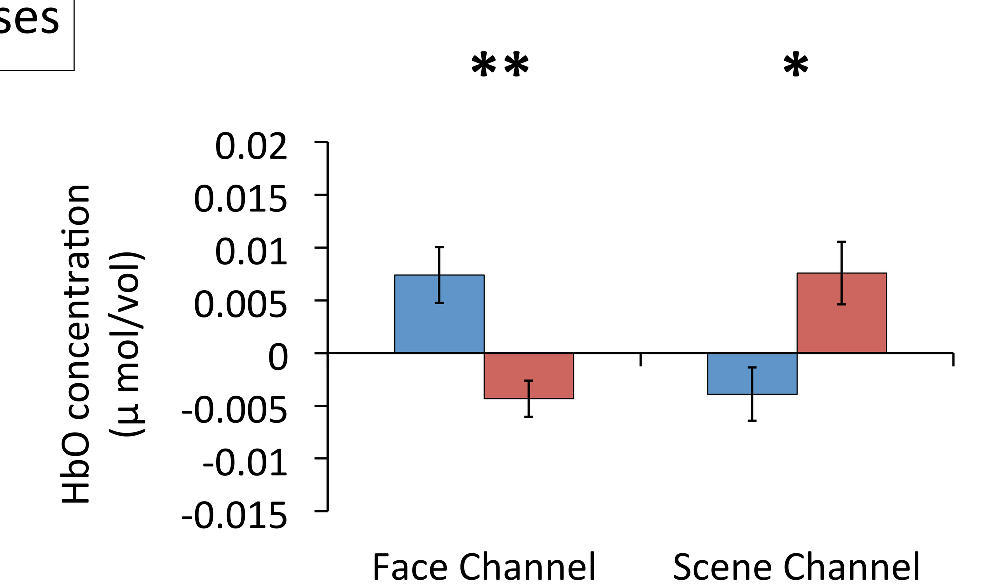


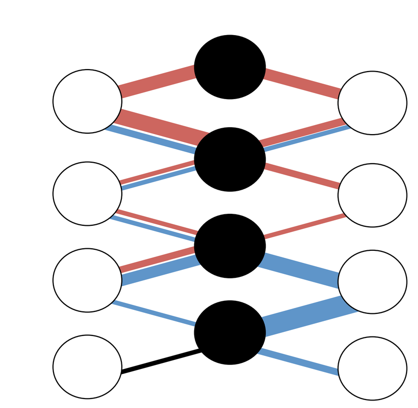


(Face: $t(19) = 3.06$, $P = 0.006$; Scene: $t(19) = 2.80$, $P = 0.011$)

* $P < 0.05$
** $P < 0.01$
(no multiple comparisons issue)

Infant Data





(Face: $t(12) = 3.42$, $P = 0.005$; Scene: $t(11) = 2.59$, $P = 0.025$)

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

Gervain, J., et al. (2011). *Dev Cogn Neurosci, 1*, 22-46.
Kabdebon, C., et al. (2014). *Neuroimage, 99*, 342-56.
Kanwisher, N. (2010). *P Natl Acad Sci USA, 107*, 11163-70.
Lloyd-Fox, S., et al. (2009). *Child Dev, 80*, 986-99.
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Acknowledgements

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