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Cortical Sources of Categorization of Other-Species Faces for 6- & 12-Month-Old Infants

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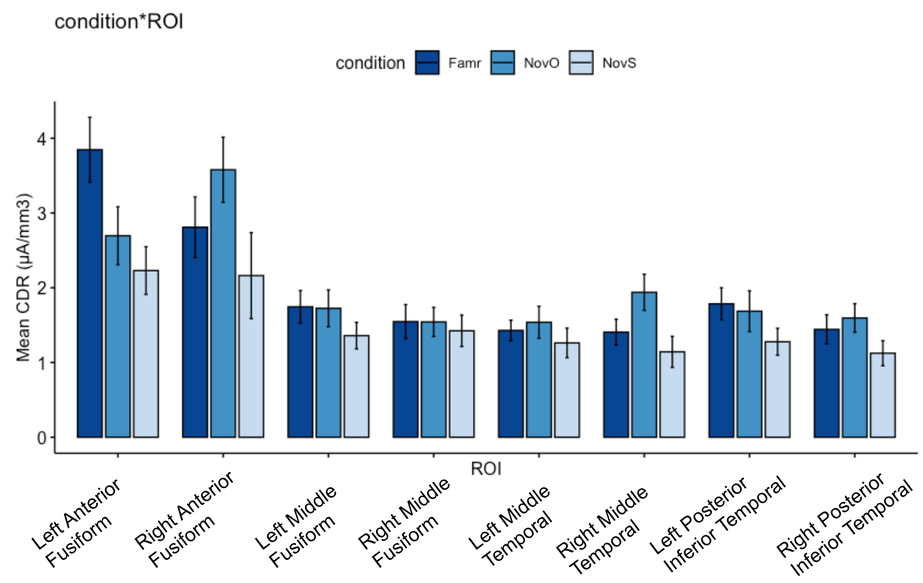
Introduction

- Perceptual narrowing is characterized by a narrowing of sensitivity from a broad range of stimuli in early development to a narrower range of stimuli commonly encountered in the native environment in later development (Maurer & Werker, 2014).
- Six-month-old infants can discriminate between novel and “familiar” monkey faces but no longer demonstrate this ability at 9 months (Pascalis, deHaan,& Nelson, 2002), possibly due to categorizing non-native stimuli rather than processing at the individual level (Nelson, 2001). However, exposure to multiple exemplars during initial learning has been shown to facilitate subordinate categorization of other-species faces (Dixon et al. ,2019).
- Mature category learning is proposed to be selection-based, characterized by a narrow focus of attention to relevant features (Deng & Sloutsky, 2015). However, infant category learning may be compression-based, driven by a bottom-up process detecting redundancies in visual input. Selection-based category learning may be associated with areas of prefrontal cortex, and compression-based category learning may be associated with inferotemporal cortex and basal ganglia (Ashby et al. ,1998; Best et al.,2013).
- Studies utilizing event-related potentials (ERPs) have implicated the P400 may be involved in novelty detection in face perception (Scott et al., 2006). Cortical source analysis of infant P400 response have noted increased activation in inferotemporal areas in response to novel faces and toys (Guy et al., 2016) .
- **The current study utilized cortical source analysis to identify the neural generator(s) of the P400 component for 6 - and 12-month-old infants during multiple or single exemplar learning conditions of monkey faces.**

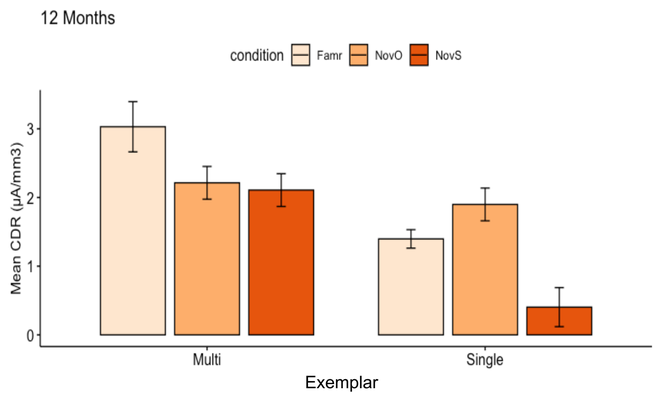
Results

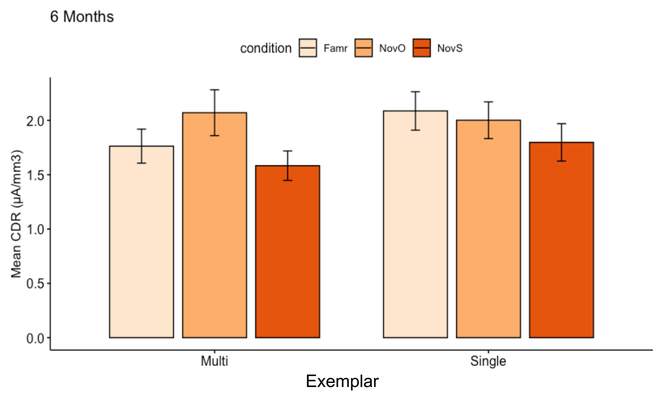
- **Main Effect of ROI**
  - $F(7, 1242) = 18.881$, $p < .001$
  - Left Anterior Fusiform Gyrus: $M = 2.96$ (μA/mm3), $SE = .193$
  - Right Anterior Fusiform Gyrus: $M = 2.78$ (μA/mm3), $SE = .193$
- **Interaction of Condition and ROI**
  - $F(2, 1242) = 7.609$, $p < .001$
- **Interaction of Age, Exemplar and Condition**
  - $F(2, 1242) = 7.609$, $p < .001$



12mo
- Single Famr > Single NovS $t(1341) = 3.576$, $p = .02$
- Single NovO > Single NovS $t(1341) = 5.384$, $p < .001$

6mo
- NS





Method

Participants
- 46 infants tested at 6 (n=24) or 12 months of age (n=22)

EEG Recording
- 124 channel EEG recording system
- Average reference
- 1000 Hz sampling rate
- Band-pass filters 0.1- 30 Hz

Cortical Source Analysis
- Head measurements used to generate realistic head models and assign each participant a structural MRI from the Neurodevelopmental MRI Database
- A finite element method head model was then generated with source dipoles restricted to gray matter in ROIs
- Current density amplitude in source locations was estimated with the CDR technique and exact-LORETA (Pascual-Marqui et al., 2011).
- ERP data surrounding P400 (300-400ms) time window was used to estimate CDR values for each ROI.

Selected ROIs
- Inferotemporal: middle fusiform gyrus, anterior fusiform gyrus, posterior inferior temporal gyrus, and middle temporal gyrus

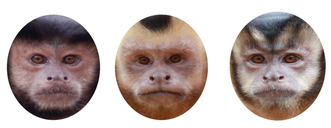
Statistical Analysis
- Mixed effects model with fixed effects of age, condition (Novel-Other, Novel-Same, Familiar), learning exemplar (Multiple, Single) and ROI and a random effect of participant.

Phase 1: Familiarization (Learning)

Single Exemplar (n=26)

1 face, shown 20x

Multiple Exemplars (n=19)



10 faces, shown 2x each

Phase 2: ERP Testing

Familiar | Novel-Same | Novel-Other

Discussion

- Our analysis of the cortical sources of the **P400** indicate that there may be differential recruitment of inferotemporal areas during categorization of monkey faces. Infants showed greater CDR amplitude in the **anterior fusiform gyrus** regardless of age or initial learning condition. The lack of significant CDR within ROI differences in response to different learning conditions may suggest that infants recruit brain areas similarly for other-species face processing regardless of how many exemplars are presented. There is however, an interaction of ROI and familiarity condition with the right anterior fusiform gyrus having higher CDR values during presentation of novel other-species faces.
- Exploring the interaction of age, exemplar and condition we found a significant effect of initial learning conditions on 12-month-old perception of novel monkey faces not found in 6-month-olds. The significant differences in CDR amplitude shown in the older infants between familiar and novel monkeys from the same species in the single exemplar group indicates that 12-month-old infants are capable of individuation within other-species faces. This is consistent with a learned attention model of face processing (Simpson et al., 2011) and is inconsistent with a perceptual narrowing model (Mauer & Werker, 2014).

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