Developmental Brain Bases of Face Perception in Autism as Revealed by ERPs

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BACKGROUND

FACE PERCEPTION is an essential social ability that emerges early in life and is characterized by specialized processing mechanisms honed through continual developmental refinement.

- •Spatially, fMRI indicates that face-sensitive brain regions include the fusiform gyrus (FG) and superior temporal sulcus (STS).
- •Temporally, EEG indicates neural responses differ for faces compared to other objects.
  - •The N170 is a negative, face-sensitive event-related potential (ERP) measured over occipitotemporal scalp approximately 170 ms after viewing a face.
  - •The N170 displays enhanced amplitude and decreased latency to faces.

THROUGHOUT DEVELOPMENT brain processes underlying face perception change.

- •fMRI shows that older children, but not younger children, display significantly more activation in bilateral FG for faces than for houses; FG activation correlates significantly with age and a behavioral measure of configural face processing.
- •EEG studies indicate that the N170 first appears as a slower component with distinct morphology in young children and evolves into its mature form in adolescence.

INDIVIDUALS WITH AUTISM SPECTRUM DISORDER (ASD) show deficits in face perception and abnormalities in face processing.

- •These deficits may arise secondary to deviant developmental exposure to faces or from primary brain abnormalities.
- •FG activation is reduced during face viewing in individuals with ASD.
- •N170 latencies are delayed and insensitive to disruption in configural information via inversion in individuals with ASD.

Figure 1: Geodesic Photogrammetry System (GPS). *The Geodesic dome is a dodecahedron with the bottom excised. Attached to the remaining 11 vertices are cameras that capture images surrounding the subject's head.*

EEG SOURCE LOCALIZATION estimates brain sources from ERPs using inverse techniques. Source localization adds spatial information while preserving the temporal resolution of EEG. It typically entails use of generic head models.

IN THE PRESENT STUDY we employed subject-specific head models created with the Geodesic Photogrammetry System (GPS) to control for variation in head size associated with developmental and individual differences.

- •Previous analyses of scalp ERPs on this sample of children with ASD and typically developing children found differences in N170 latency to faces between groups.
- •We hypothesized that compared to controls, children with ASD would show:
  - •Distinct patterns of activation for faces
  - •Different developmental changes in patterns of activation for faces

METHOD

Participants

- •28 children with ASD based on ADOS, ADI-R, and DSM-IV-TR clinical diagnosis
- •23 typical controls matched for Full Scale IQ, age, sex, and handedness

Table 1: Participants

Group	IQ	Age	Sex	Handedness
ASD (n=28)	Mean: 108 Range: 84 – 141	Mean: 11 Range: 8 – 16	Male: 92.9% Female: 7.1%	Right: 89.3% Left: 10.7%
Typical (n=23)	Mean: 114 Range: 92 – 140	Mean: 12 Range: 8 – 16	Male: 95.7% Female: 4.3%	Right: 91.3% Left: 8.7%

Behavioral Measures

- •Benton Facial Recognition Test

ERP Procedure

- •92 stimuli from each category (upright/ inverted faces) in pseudorandom sequence in two blocks
- •Trial: Crosshair (250–750 ms)→ Stimulus (500 ms)→ Blank screen (500 ms)
- •One-back task with attention monitored by closed-circuit video

ERP Data Acquisition and Processing

- •ERP recorded continuously at 250 Hz using EGI 256-channel sensor net
- •Sources computed in three windows:
  - •P1: 90-140 ms
  - •N170: 140-190 ms
  - •N250: 230-280 ms

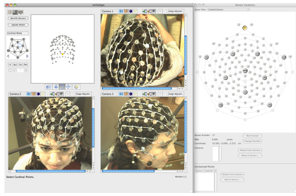


Figure 2: Creating head-specific models with GPS. *3-camera view showing customized head model (upper left) and 128 HydroCel electrode map highlighting cardinal points (upper right).*

Geodesic Photogrammetry System (GPS)

- •Image acquisition
  - •11 images from different angles record precise locations of EEG electrodes
- •Sensor registration
  - •Reconstructs 3D coordinates from 2D images using triangulation
  - •Mark individual electrodes and fiducial points to enable integration of data generated by different image modalities; then export solved head model for GeoSource analysis

Source Localization and Statistical Analysis

- •Broadmann Areas (BAs)
  - •11: Ventral frontal & orbitofrontal cortex
  - •19: V3 & associative visual cortex
  - •21: Lateral & medial temporal gyri
  - •22: Wernicke's Area, STS, STG
  - •37: FG
  - •17 and 18: V1 & V2
- •2 x 2 x 2 design; age as a covariate
  - •Group: ASD versus typical
  - •Stimuli: faces versus inverted faces
  - •Hemisphere: left versus right

RESULTS: FG AND OTHER REGIONS

Activation in the FG

P1 & N250

- •Activation decreases as age increases for both groups across conditions

N170

- •Activation decreases as age increases for both groups across conditions
- •Inverted faces elicit greater activation than faces for both groups in both hemispheres

Activation in Other Regions (BAs 11, 19 & 21)

P1, N170 & N250

- •Activation decreases as age increases for both groups across conditions
- •Inverted faces elicit greater activation than faces for both groups
- •Activation is greater in right than left hemisphere for both groups

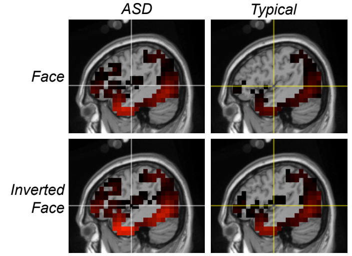


Figure 4: Source activation in STS at N170 for inverted – upright face contrast. *The ASD group shows reduced differential source activation between conditions relative to the typical group.*

RESULTS: STS AND VISUAL CORTICES

Activation in the STS

P1

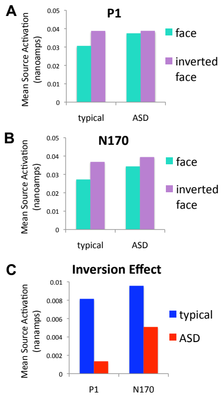
- •Activation decreases as age increases for both groups across conditions
- •Significant group x stimulus x hemisphere interaction
  - •Face marginally different from inverted face in right hemisphere in typical but not ASD group (marginal hemisphere x stimulus)

N170

- •Activation decreases as age increases for both groups across conditions
- •Inverted faces elicit greater activation than faces for both groups in both hemispheres
- •Marginal group x stimulus x hemisphere interaction
  - •Face marginally different from inverted face in right hemisphere in typical but not ASD group (marginal hemisphere x stimulus)

N250

- •Activation decreases as age increases for both groups across conditions



Activation in the Visual Cortices

P1

- •Activation decreases as age increases for both groups across conditions
- •Significant group x stimulus x hemisphere interaction
  - •Face marginally different from inverted face in right hemisphere in typical but not ASD group (marginal hemisphere x stimulus)

N170 & N250

- •Activation decreases as age increases for both groups across conditions
- •Activation greater in right than left hemisphere for both groups across conditions

Figure 3: Right lateralized inversion effect in STS in typical but not ASD group.
A) P1
B) N170
C) Difference between inverted face and face source activations in P1 and N170

CONCLUSION

Consistent with previous findings, our results show:

- •FG, STS, and visual cortex associated with face processing
- •Right-lateralized inversion effect in typical but not ASD group

Brain activation decreases as age increases across all conditions.

- •May reflect increased neural processing efficiency with development

The STS, not the FG, distinguished the ASD from the typical group.

- •STS showed right-lateralized inversion effect in typical but not ASD group
- •Itier & Taylor (2004) showed larger STS activations to faces relative to objects, attributing neural bases of inversion effect to increased activation of STS for inverted faces

A right-lateralized inversion effect in the STS was more robust at P1 than at N170 for the typical group.

- •May suggest that STS plays more focal role in face perception in developmental populations
  - •N170 to eyes emerges developmentally before N170 to faces, suggesting contribution of distinct brain regions
  - •STS involved in biological motion; eyes (and mouth) provide most salient social information through biological motion
  - •STS likely contributes to N170 and may account for differences in developmental and clinical populations

Work in Progress Investigates…

- •Correlations between source activations to faces and behavioral measures of face recognition
- •Contrasting N170 sources for individual facial features (e.g., eyes)

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