Attention and Neural Response to Simulated Social Interactions in ASD

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Background

- Atypical gaze, including difficulties with eye-contact and joint attention, is a common symptom of autism spectrum disorder (ASD).
- Research measuring event-related potentials (ERPs) reveals atypical face processing in ASD.
- Behaviorally, social differences in ASD are most pronounced during interactions, yet most existing experimental investigations of gaze processing use paradigms in which participants passively observe faces.
- Previous research investigating neural responses to static faces reveals a characteristic right-lateralized N170 in adults and children, but research exploring lateralization of neural responses to interactive faces is limited.
- Using gaze contingent ERP, this study aimed to (a) investigate attention to dynamic faces as measured by eye movements and neural response to eye-contact in children with ASD and typically developing children (TD) and (b) explore relationships among attentional and neural markers and clinical characteristics.

Method

Sample (matched on age and IQ):

Group	N	Min Age	Max Age	Age	IQ
TD	40	9.00	18.33	13.97 (2.63)	103 (14.78)
ASD	61	8.42	18.50	14.08 (2.72)	105 (18.64)

Experimental Paradigm:

- 101 participants (32 female) were presented with 112 faces matched for low-level visual features and modified such that only the eyes on the face moved in response to gaze.
- Contingent upon participants' fixating on the eyes of the onscreen face, the face responded by shifting eye gaze (from direct to **averted** or averted to **direct**).

1. Fixation   2. Onset face with averted gaze   3. Gaze shift to **direct** when participant looks to eyes

Figure 1. Trial Structure of Direct Gaze. After participants fixated on a crosshair for ~300ms (Panel 1), a face with averted gaze was presented (Panel 2). After the participant looked to the eyes of the face for ≥500ms, a second face with gaze shifted to direct gaze (Panel 3) was presented for 600ms. Inter-trial interval ranged from 200-1200ms.

EEG and ET Data Acquisition and Collection:

- EEG recorded at 1000 Hz with a 128-channel Hydrocel Geodesic Sensor net.
- Eye-Tracking (ET) data collected using an Eyelink-1000 remote camera system.

ERP Preprocessing and Analysis:

- Data were filtered from 0.1-100 Hz. Data were then re-referenced to average reference, segmented from -100-275ms relative to shift in stimulus gaze, baseline corrected, and artifact detected. Trials were excluded from EEG analyses if they contained eye movement exceeding .75° of visual angle.
- P100 (80-130ms) and N170 (130-250ms) were extracted from occipitotemporal electrodes (see figure 4). Condition and hemisphere were included as within-subject variables in repeated measures ANOVAs (with group as the between-subject factor) and again in ANCOVAs with age as a covariate, with correlations and t-tests to clarify effects.

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Autism Science Foundation (Foss-Feig)

Preliminary Results

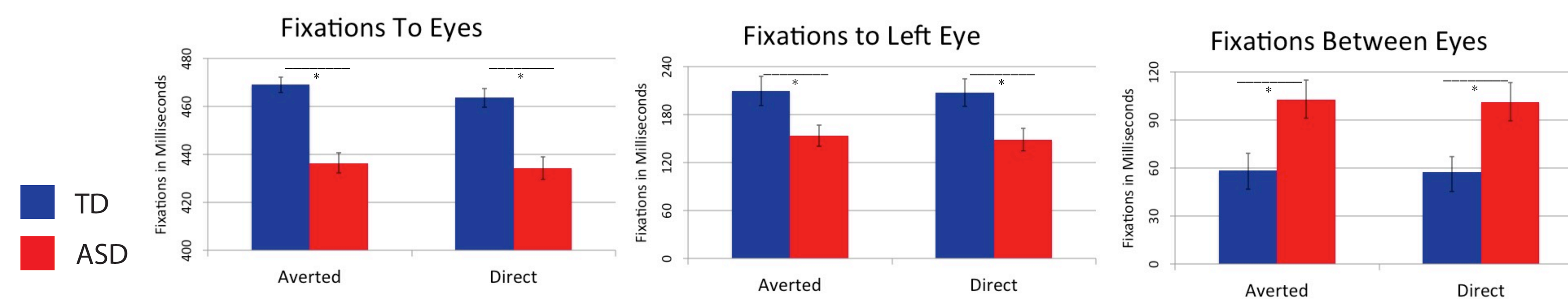
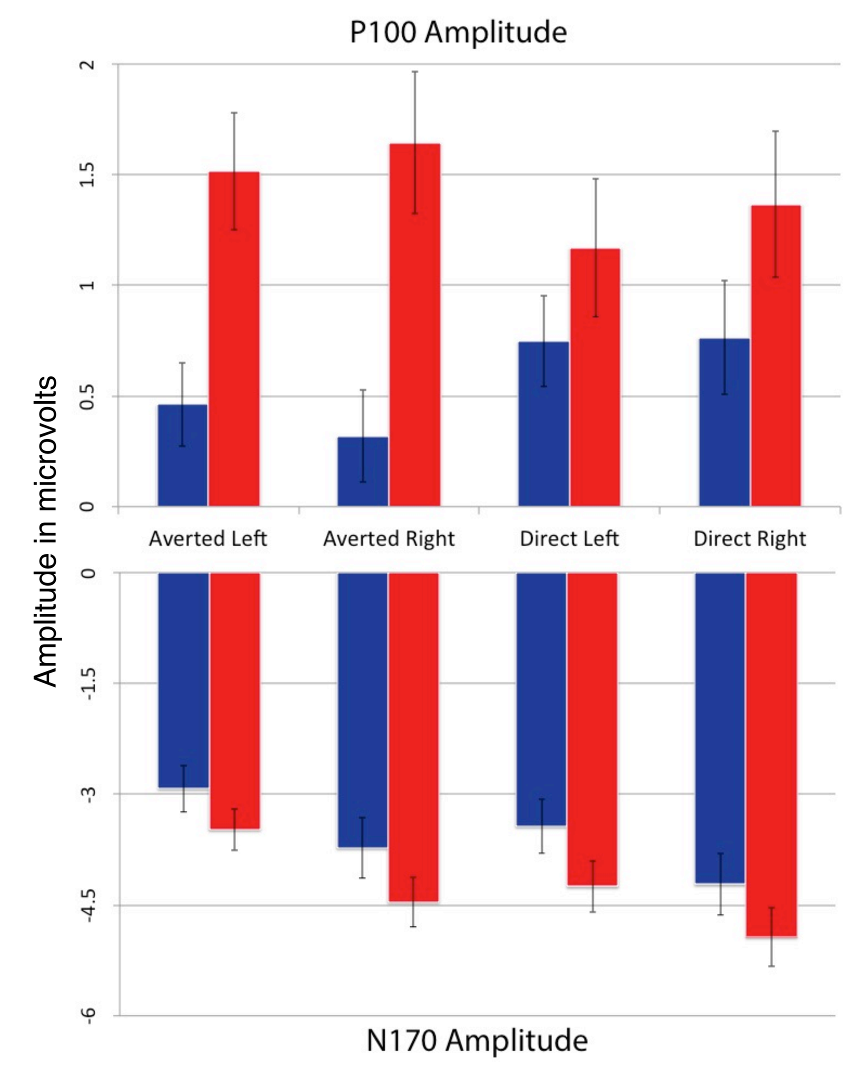


Figure 2: Fixation (dwell) time to regions of the face by group and condition.

Eye-Tracking:

- A main effect of Group indicated that individuals with ASD:
  - looked less to the eyes of the face following gaze change [$F(1,99) = 27.95$, $p < .001$].
  - looked less to the left eye of the face following gaze change [$F(1,99) = 7.45$, $p = .008$].
  - looked more to the area between eyes following gaze change [$F(1,99) = 6.871$, $p = .01$].



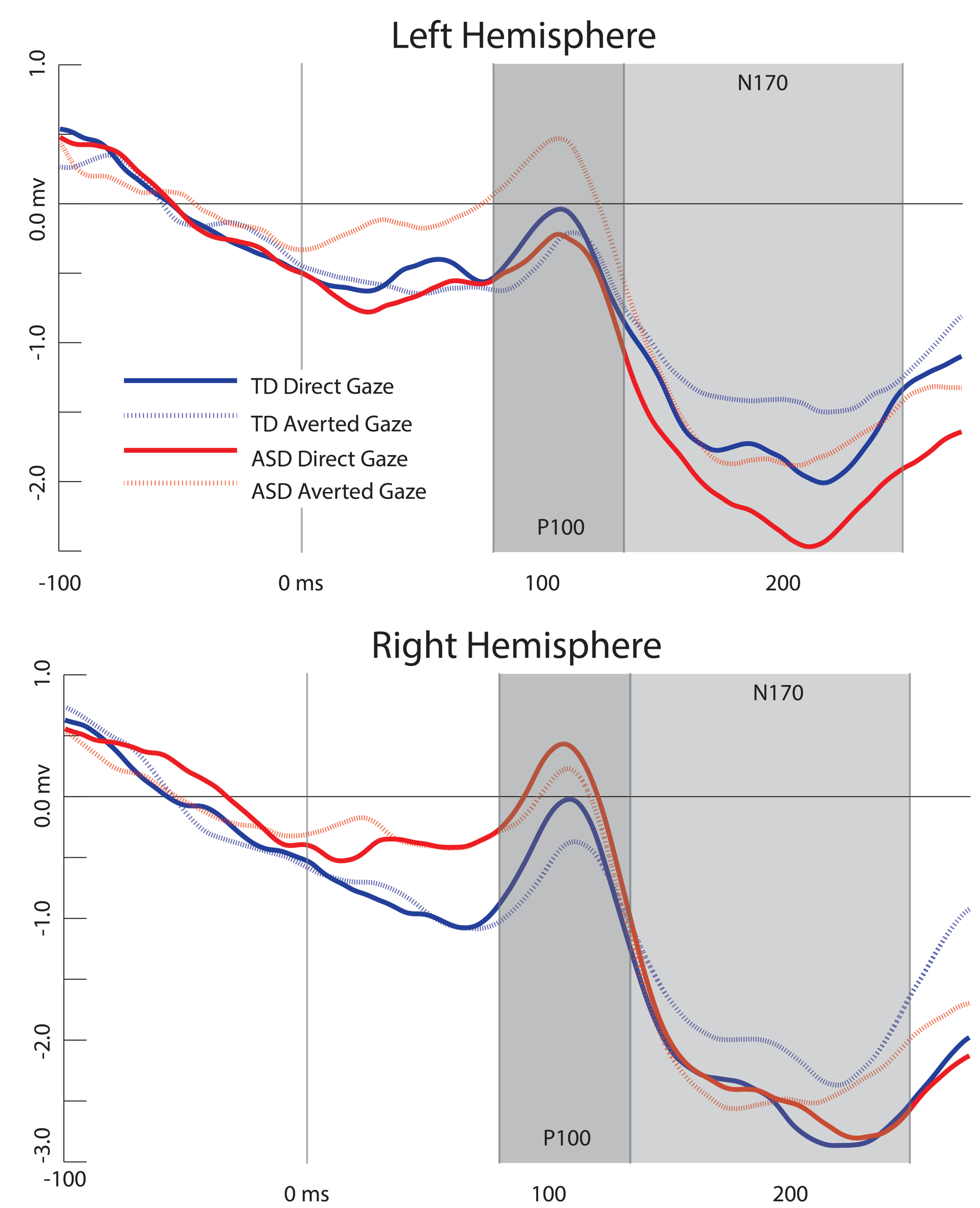


Figure 3: P100 and N170 response to interactive gaze in children with ASD and TD controls. Both groups show increased N170s to direct gaze. Individuals with ASD show greater P100 to averted gaze, while TD individuals show greater activity to direct gaze.

P100 Amplitude:

- An interaction between Condition and Group indicated that individuals with ASD had larger P100s to averted gaze while TD individuals had larger P100s to direct gaze [$F(1,79) = 4.68$, $p = .03$].
- Across conditions, individuals with ASD had larger P100s to gaze [$F(1,79) = 7.79$, $p = .007$].
- A Hemisphere by Age interaction trending significance revealed that younger individuals (aged 8-13) had greater P100s in the right hemisphere, while older individuals (aged 14-17) had greater P100s in the left [$F(1, 79) = 2.99$, $p = .088$].

N170 Amplitude:

- A main effect of Condition indicated that N170s to direct gaze were more negative than to averted gaze across groups [$F(1,79) = 4.98$, $p = .028$].
- A main effect of Hemisphere revealed larger amplitude N170s in the right hemisphere [$F(1,79) = 10.62$, $p = .002$].

Preliminary Results

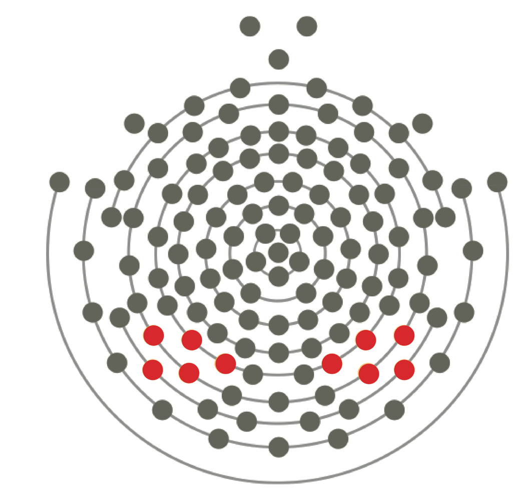


Figure 4: Electrode recording sites.

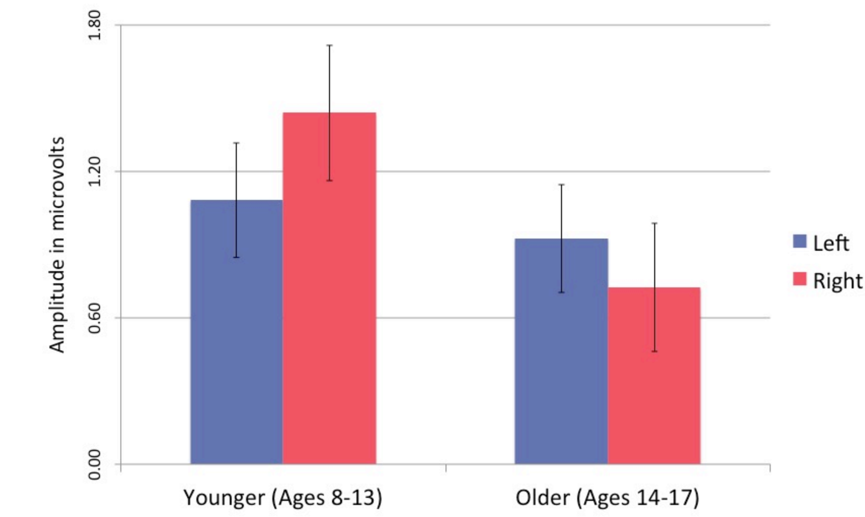


Figure 5: P100 amplitude across hemisphere and age groups.

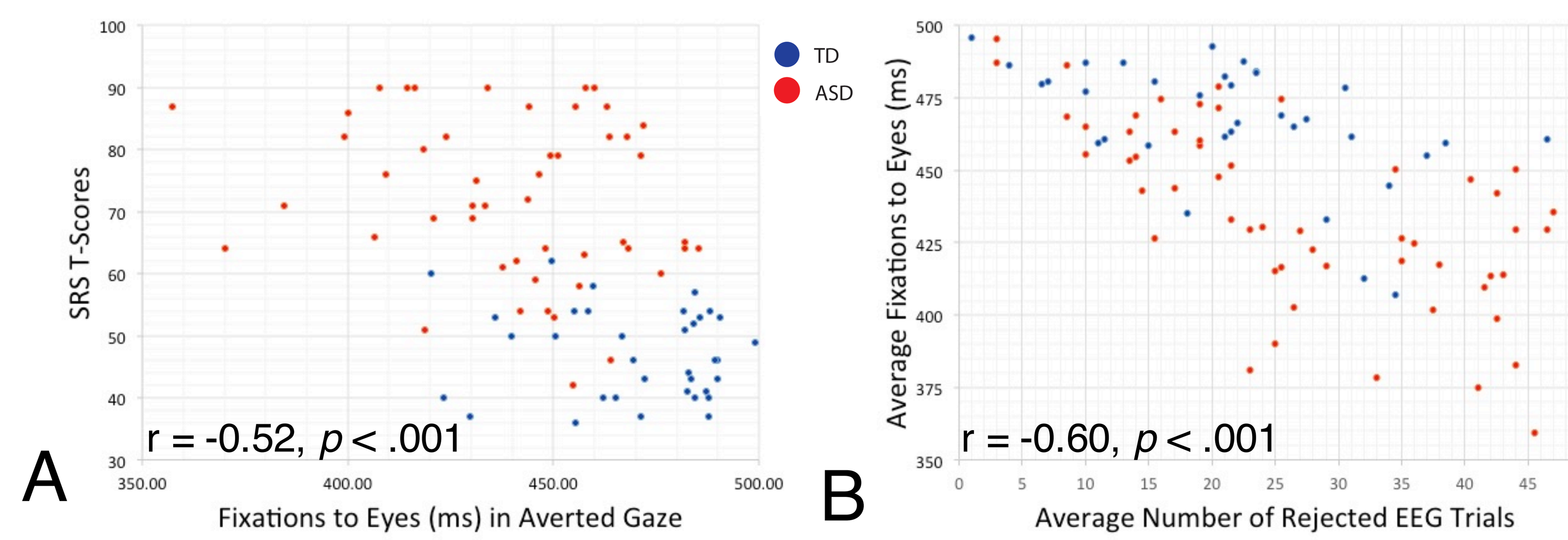


Figure 6: (A) Continuous relationships between attentional measure and social function and (B) average number of rejected EEG trials and attention to eyes.

Conclusions

- In this gaze contingent paradigm, group differences in attention revealed TD participants looked primarily to the eyes of the face while ASD participants looked more between eyes, indicating that looking patterns are more atypical for the ASD group even when instructed to look to the eyes.
- Increased attention to the eyes correlated with better ratings of social functioning, suggesting that the ability to engage in direct gaze is correlated with social symptom presentation.
- The direct condition elicited greater N170 amplitude than the averted condition for both ASD and TD groups, suggesting face-specific brain activity is greater in response to reciprocal eye-contact than gaze aversion.
- The average number of rejected EEG trials (due to eye-movement) negatively correlated with fixations to the eyes. Children with ASD who engage in eye contact (with fewer rejected trials) have similar brain activity to their typically developing peers, as evidenced by the lack of group differences in N170 amplitude.
- Larger N170 amplitudes were extracted from the right hemisphere across groups, but P1 amplitude decreased in the right hemisphere as participant age increased. This is incongruent with previous findings showing increased lateralization in the right hemisphere as individuals age, suggesting that the dynamic nature of this interactive paradigm elicits differences in neural effects compared to static face paradigms.
- Larger P1 amplitudes were produced by ASD participants for the averted condition, whereas larger P1 amplitudes were produced by TD participants for the direct condition. These findings suggest that TD participants have greater response to social engagement (reciprocal eye contact), while individuals with ASD produce greater responses to practical functions of gaze, such as directing attention.