

Gaze preference and underlying brain responses to dynamic eye movement in individuals with ASD across development

Day, T. C., Naples, A., Lewis, B., McNaughton, K. A., Chang, S. A. A., Rolison, M. J., Ellison, K., Jarzabek, E., Wolf, J., Malak, S. M., Trapani, J. A., Stinson, K., Foss-Feig, J. H., and McPartland, J.

mcp-lab.org | McPartland Lab | mcp.lab@yale.edu

Background

- Impairments in eye contact are among the earliest deficits in individuals with autism spectrum disorder (ASD).¹ Past research has shown individuals with ASD demonstrate atypical gaze response to social stimuli,² and atypical brain response to faces during passive electroencephalography (EEG) paradigms.³ Emerging evidence suggests individuals with typical development (TD) demonstrate left gaze bias (LGB) when viewing faces and that LGB may shape asymmetrical brain responses.⁴
- Examining these brain-behavior relationships during dynamic social paradigms is essential to understanding individuals with ASD in more ecologically valid contexts. Additionally, exploring these relationships in the context of child development is critical for the identification of social-communicative biomarkers.
- We explored brain-behavior relationships in individuals with ASD and TD during an interactive social neuroscience paradigm.⁵ Specifically we sought to:
 - a) Determine whether gaze behavior differed between groups,
 - b) Evaluate brain responses via the early stage face perception evoked-related potential (ERP), the N170, and its relationship to behavior, and
 - c) Examine the relationship between brain-behavior response and age.

Methods

Table 1. Characteristics of the sample population.

Group	<i>n</i> (Male <i>n</i>)	Age	Min Age	Max Age	IQ
ASD	122 (90)	16.0	5.5	33.6	104
TD	77 (43)	17.5	8.6	35.7	109

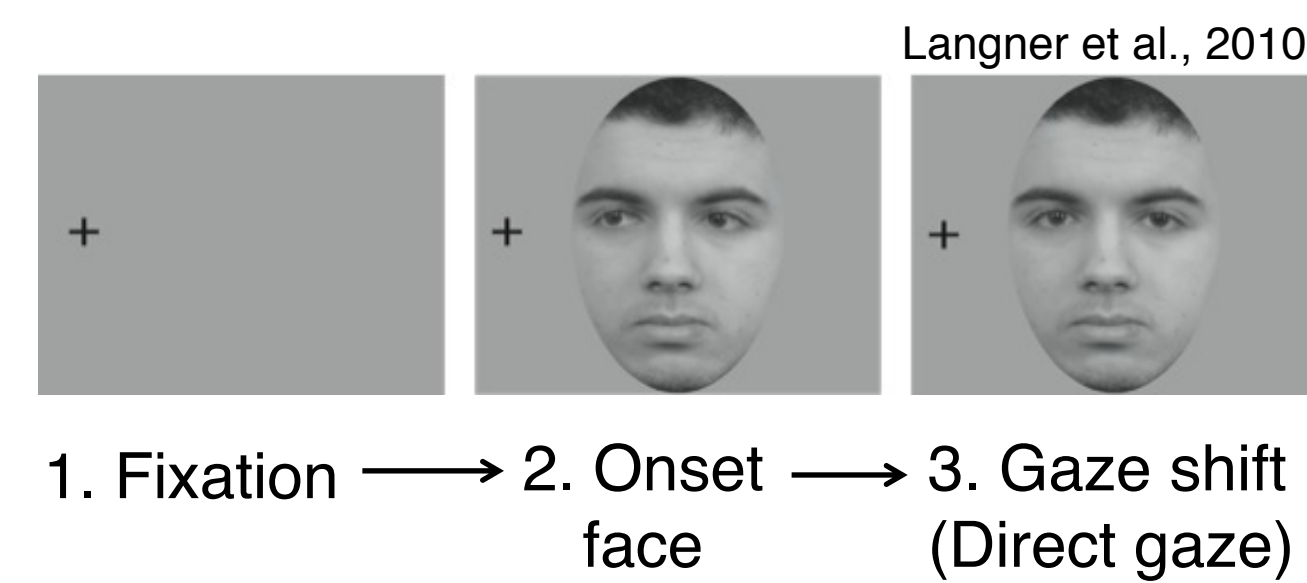
Notes. All participants contributed eye-tracking data and a subset contributed EEG data. For EEG data, the ASD group (*n*=59) and TD group (*n*=54) matched on age and IQ.

Experimental Paradigm:

Eye-tracking (ET) and EEG were co-recorded while the participant underwent a gaze-contingent viewing paradigm. Participants viewed 112 faces that were matched on low-level visual features. The faces responded to the participant's gaze by looking at (direct gaze) or away from (averted gaze) the participant.

Figure 1. Trial Structure.

A crosshair appears (1). When the participant fixates on the crosshair for ~300 ms, a face appears (2). After looking at the eyes for ≥500 ms, the gaze shifts and remains onscreen for 600 ms (3).



ET and EEG Data Acquisition:

- ET was recorded with an EyeLink-1000 remote camera system.
- EEG was recorded with a 128-channel Geodesic Sensor Net at 1000 Hz.

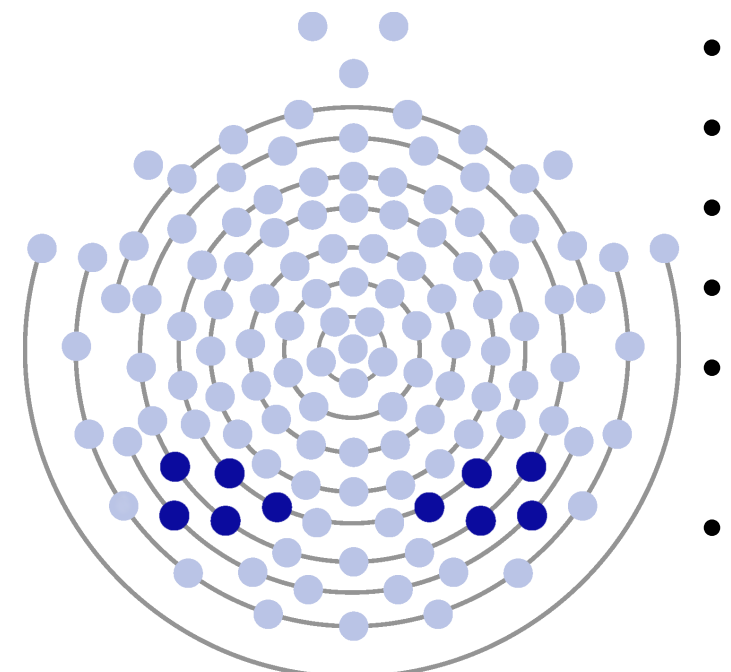
ERP Preprocessing:

- Data were filtered from .1 to 30 Hz.
- Re-referenced to average reference.
- Segmented from -100 to 500 ms relative to gaze shift.
- Baseline corrected and artifact detected.
- Trials were excluded if eye movement exceeded 1.5° of visual angle.
- N170 (150–300 ms post gaze shift) response was collected from occipitotemporal electrodes (Figure 2).

Figure 2. Occipitotemporal electrodes.

ET and ERP Analysis:

ET data were analyzed with independent *t*-tests. ERP data were analyzed with a repeated measures ANOVA and included a between-subject factor of diagnosis, and within-subject factors of condition (direct or averted) and hemisphere (right or left). Brain-behavior relationships were analyzed with Pearson product-moment correlations.



Results

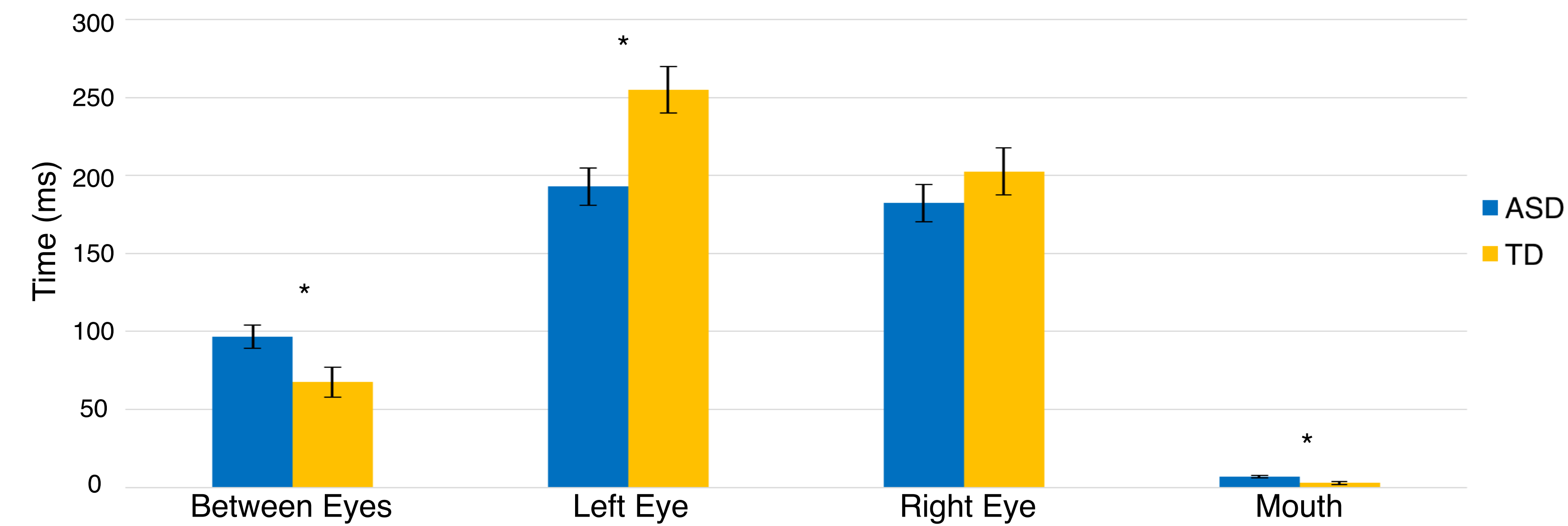


Figure 3. Time spent look at regions of the face after gaze shift.

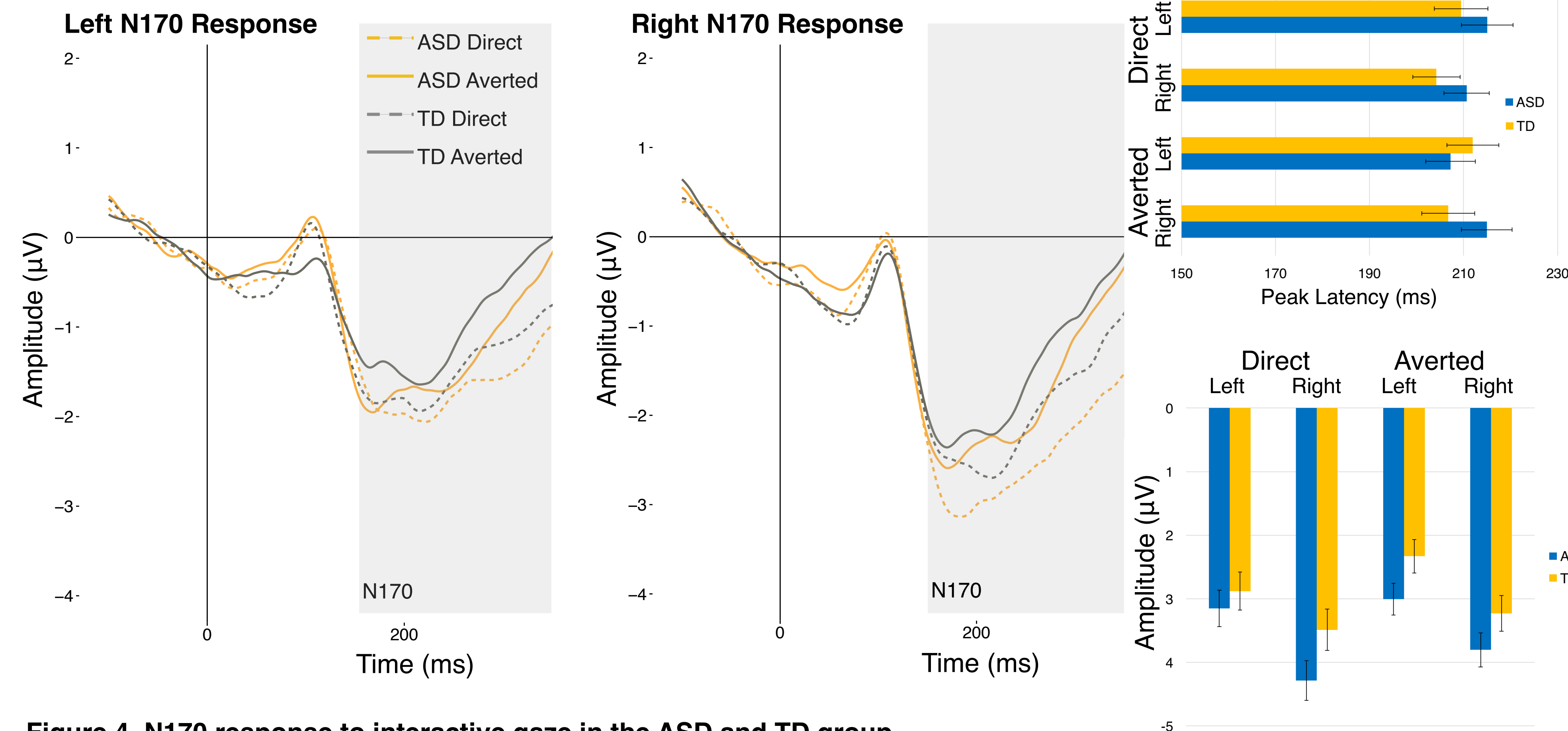


Figure 4. N170 response to interactive gaze in the ASD and TD group.

ET Findings: (Figure 3)

- Consistent with the expected LGB, the TD group looked more to the left eye than the ASD group [$t(127.60)=-3.02, p<.01$].
- The ASD group looked between the eyes [$t(196)=2.40, p<.05$] and at the mouth [$t(186.03)=3.71, p<.01$] more than the TD group.

ERP Findings: (Figure 4)

- A main effect of hemisphere emerged [$F(1,111)=27.96, p<.01$] with a more negative N170 amplitude in the right hemisphere.
- A main effect of condition emerged [$F(1,111)=4.72, p<.05$] with a more negative N170 amplitude to direct gaze.
- Differences in N170 amplitude between diagnostic groups approached significance [$F(1,111)=3.55, p<.10$].

References:

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- 5 Naples, A. J., Wu, J., Mayes, L. C., & McPartland, J. C. (2017). Event-Related Potentials Index Neural Response to Eye Contact. *Biological Psychology*.
- Langner, O., Dotsch, R., Bijlstra, G., Wigboldus, D.H.J., Hawk, S.T., & van Knippenberg, A. (2010). Presentation and validation of the Radboud Faces Database. *Cognition & Emotion*, 24(8), 1377–1388.

Results

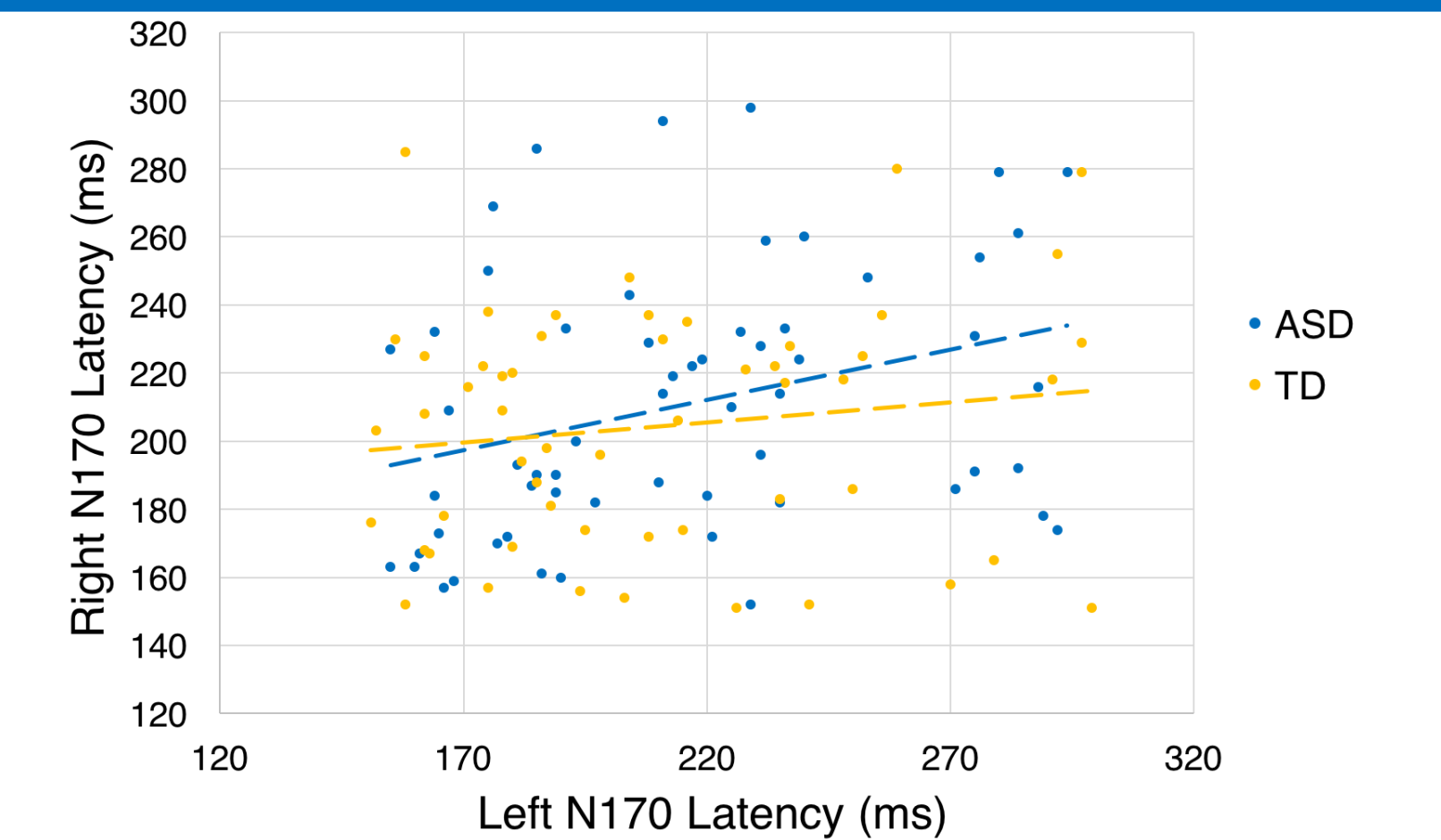


Figure 5. Relationship between left (x) and right (y) N170 peak latency in the direct condition.

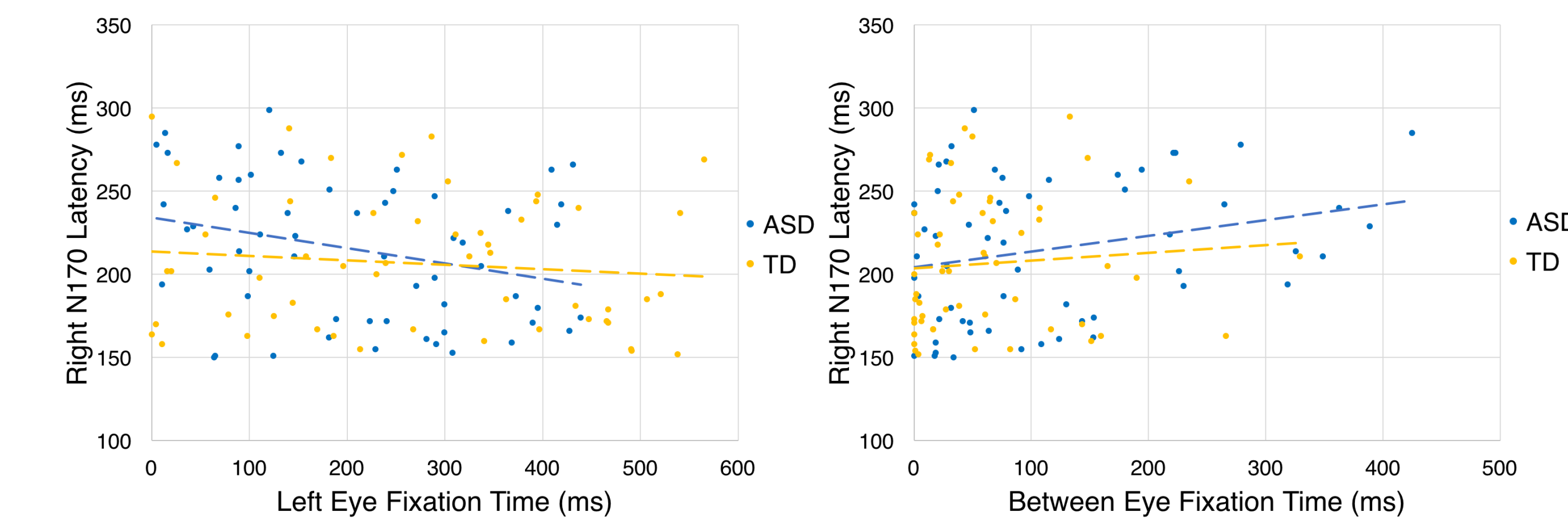


Figure 6. Relationship between behavior (ET) and brain response (right N170 peak latency) in the averted condition.

Relationships between ERP, ET, and age:

- A relationship between left and right N170 latency was present in the ASD ($r=.31, p<.05$), but not the TD group ($r=.14, p=.30$) in the direct condition (Figure 5).
- Decreased right N170 latency was related to increased time spent looking at the left eye ($r=-.21, p<.05$) across groups in the averted condition (Figure 6).
- Increased right N170 latency was related to increased time spent looking between the eyes ($r=.21, p<.05$) across groups in the averted condition (Figure 6).
- The relationship between age and N170 latency approached significance in the TD group ($r=-.23, p<.10$) but not in the ASD group ($r=-.11, p=.40$).

Conclusions

- Differences in gaze behavior revealed atypical viewing patterns in ASD. The patterns suggest individuals with ASD may be missing out on key social cues, such as eye contact and joint attention.
- Response to faces was right lateralized. Brain response to gaze cues indicated that processing differs when presented with direct versus averted gaze. Diagnostic group differences approached significance suggesting atypical processing of gaze cues in ASD. Differences in cross-hemisphere connectivity was evident between groups. Across groups, the relationship between brain and behavior linked LGB and asymmetrical brain response; furthermore, increased time looking between the eyes was related to less efficient processing. This may have implications for behavior-based therapies; specifically, teaching an individual to look to a specific eye rather than to the eye region may change neural response.
- The relationship between efficiency of processing and age approached significance in the TD but not the ASD group. This highlights the importance of considering development in research to identify social-communicative biomarkers.

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