

Neural response to direct and averted gaze in children with autism spectrum disorder during a gaze contingent social simulation

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Background

- Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by difficulties in social communication, such as maintaining reciprocal eye contact.
- Electroencephalography (EEG) can be used to study social perception, with the P100 event-related potential (ERP) indicating early visual processing and the N170 marking face-sensitive processing.
- Direct and averted gaze elicit atypical neural responses in ASD, yet electrophysiological markers of gaze during reciprocal social interactions are not well understood.
- Though executive function (EF) impairment is common in ASD and associated with social difficulties, the influence of EF-related symptoms on neural response to gaze in ASD has not been studied.
- This study utilized a gaze-contingent paradigm to explore relationships among neural response to gaze and EF in children with ASD and typical development (TD).

Method

Participants:

Group	n	Mean Age	Mean IQ
ASD	53	13.85	107.04
TD	51	13.06	108.06

EF Symptoms:

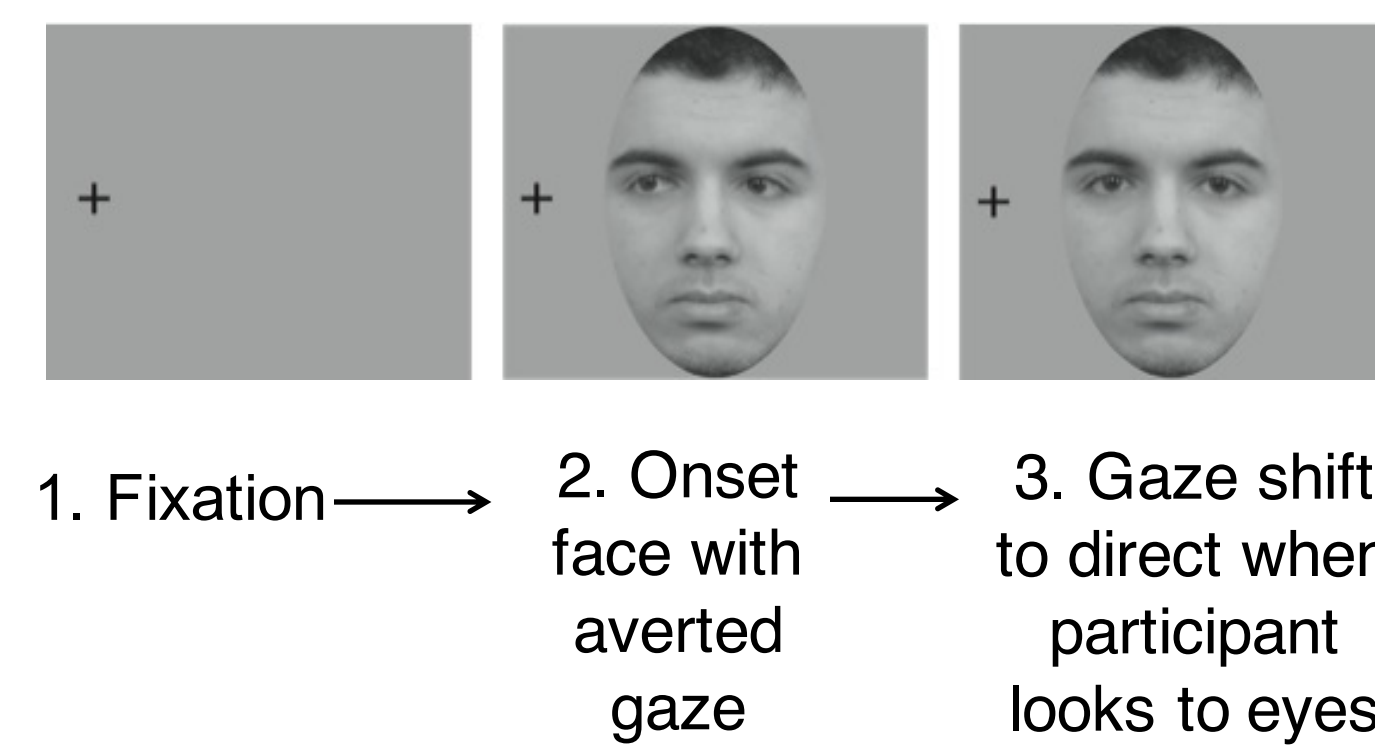
- EF problems were measured with the Child and Adolescent Symptom Inventory Attention Deficit/Hyperactivity Subscale.

Experimental Paradigm:

- Participants viewed 112 faces that shifted gaze (from direct to averted, or from averted to direct) in response to participant fixation on the eyes (see Fig. 1).

Figure 1. Trial Structure.

Participants first fixated on a crosshair for ~300ms (Panel 1). Then a face displaying either direct or averted gaze was presented (Panel 2). After the participant looked to the eyes of the face for 500ms, the gaze of the face shifted (Panel 3) for 600ms.



EEG and ET Data Acquisition and Collection:

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

ERP Analyses:

- P100 (60-160ms) and N170 (150-300ms) were extracted from electrodes over left and right occipitotemporal regions (electrodes 58, 64, 59, 66, 65, and electrodes 96, 95, 91, 84, 90 respectively, see Fig. 2). Data were filtered at 0.1 to 30Hz and segmented from -100 to 500ms relative to shift in stimulus gaze. Trials with eye movements greater than 1.5 degrees of visual angle were excluded.
- Peak amplitude and latency were analyzed for response to direct and averted gaze in repeated measures ANOVAs.
- The association between EF problems and ERPs was examined with Pearson correlations.

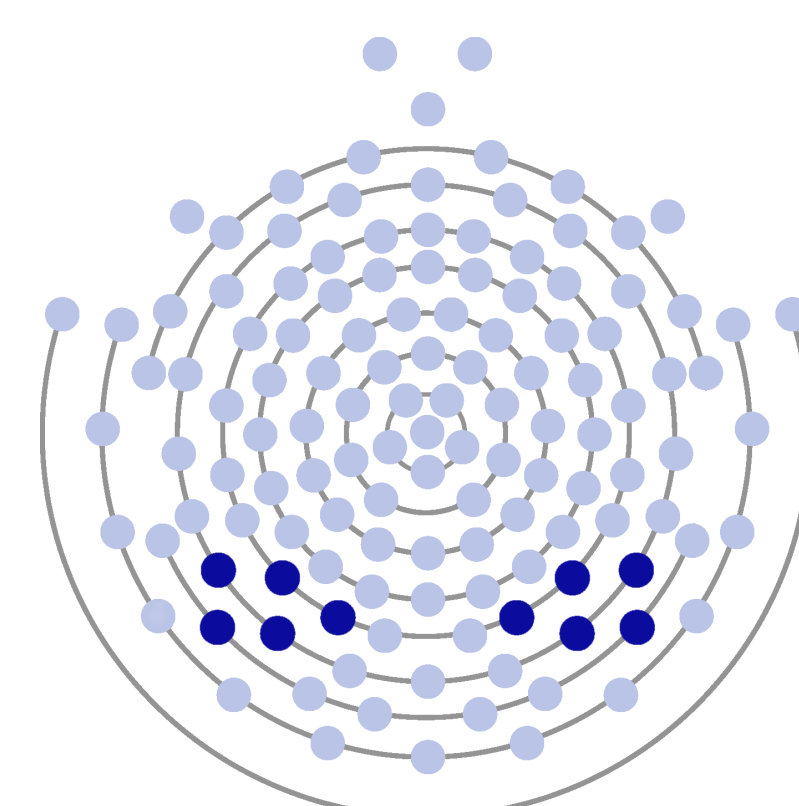


Figure 2. Selection of electrodes for analyses.

Results

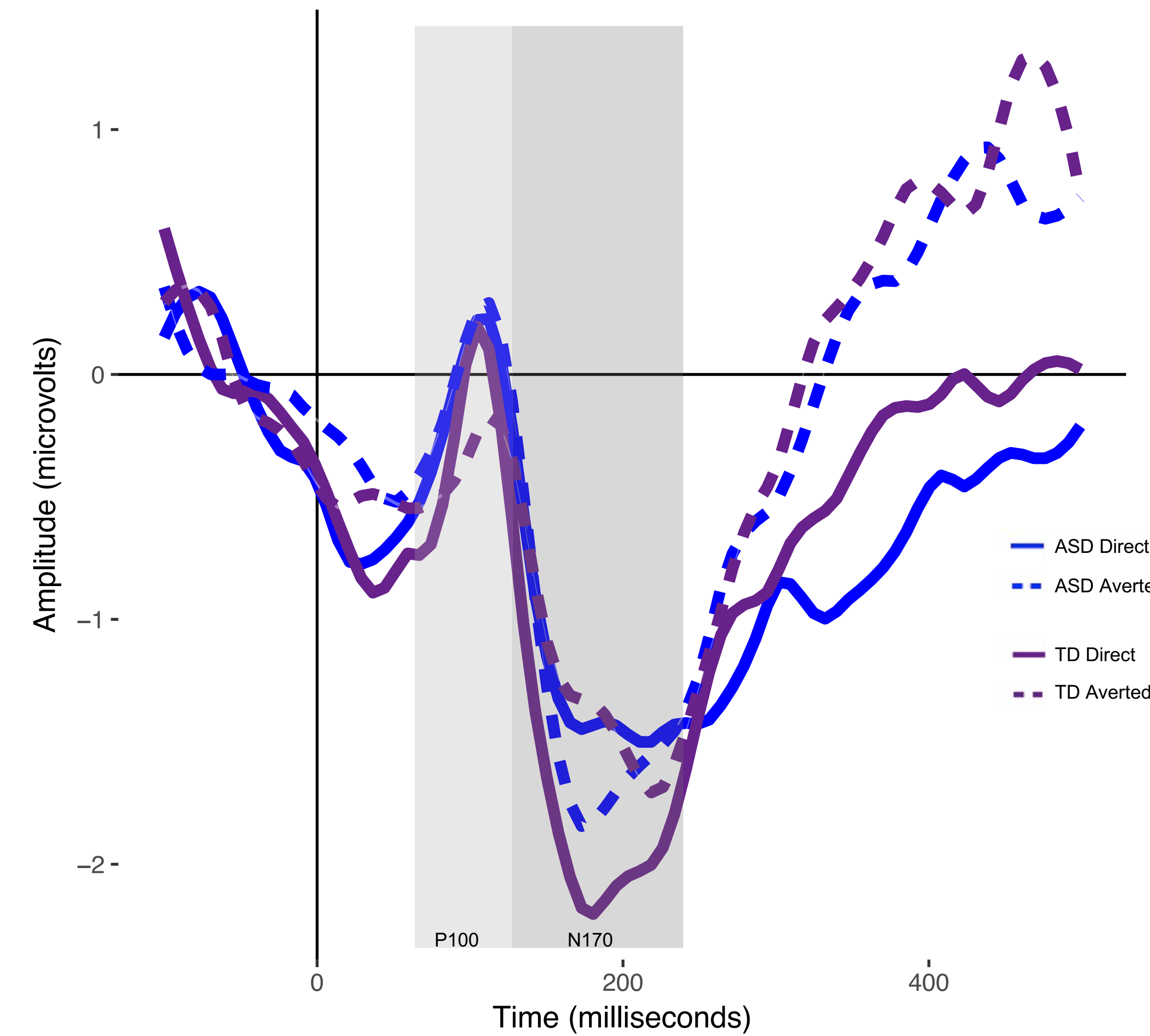


Figure 3. Grand average waveform for individuals with ASD and TD in response to direct and averted gaze.

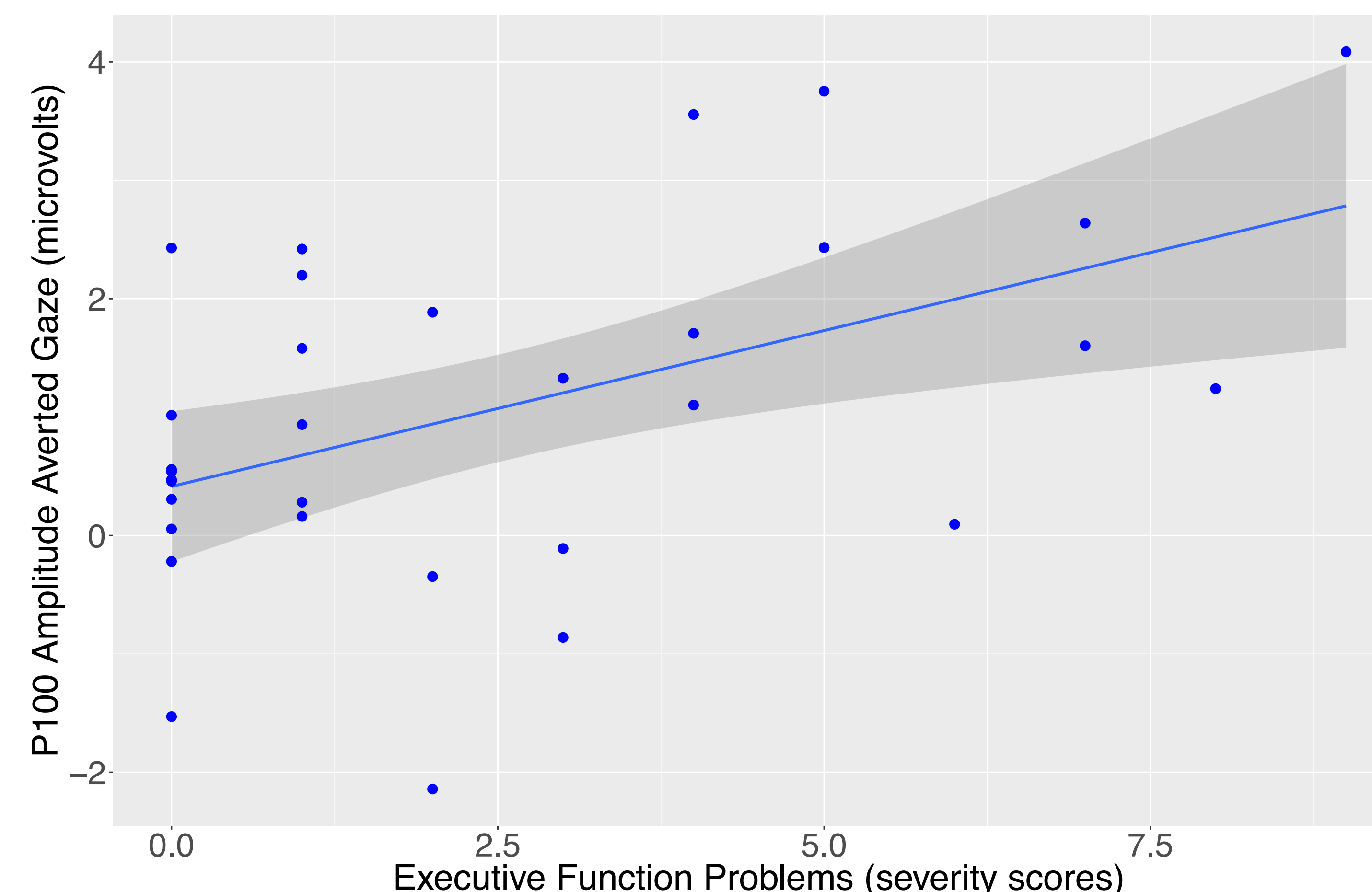


Figure 4. Positive association between EF problems and P100 amplitude to averted gaze in children with ASD.

Results

Group and Condition Differences:

- Across groups, N170 amplitude was greater over the RH compared to the LH, $F(1, 102)=18.40$, $p<.01$, and to direct gaze compared to averted gaze, $F(1, 102)=5.54$, $p<.05$ (see Fig. 3).

Lateralization of N170 Amplitude:

- There was a significant three-way interaction between hemisphere, condition, and diagnosis, $F(1, 102)=4.41$, $p<.05$.
- N170 amplitude to direct gaze was right lateralized in the ASD group, $F(1, 52)=14.04$, $p<.01$, and left lateralized in the TD group, $F(1, 50)=5.63$, $p<.05$ (see Fig. 3).

Association Between EF Problems and P100 Amplitude:

- Above and beyond age and IQ, children with ASD with greater EF impairment showed more positive LH P100 amplitudes to averted gaze, such that children with ASD with greater EF impairment had a significantly stronger P100 response, $p<.05$, $\beta=.44$ (see Fig. 4).
- There was no association between EF problems and neural response to gaze in children with TD.

Conclusions

- Results contribute to literature demonstrating modulation of face-related ERPs by direct versus averted gaze and reveal atypical lateralization of this neural response in ASD.
- In addition, a distinct neural marker of directed attention to a target was associated with EF-related symptoms in ASD but not TD.
- This pattern of findings suggests that EF difficulties may contribute to clinically observed difficulties with eye contact in ASD and may account, in part, for variability in neural response to faces in ASD.
- Future studies should account for EF as a factor in social neuroscience research in ASD.

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