Neural and Attentional Indices of Joint Attention in ASD

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Background

- Decreased joint attention is a commonly observed clinical symptom in ASD.
- However, experimental measures of brain and behavior have yielded inconsistent findings.
- We explored the effects of a brief interactive game on visual attention to faces and temporal dynamics of the neural response to shared gaze in individuals with ASD and typically developing (TD) controls.
- We explored group differences in brain and pupil response to changes in gaze in the context of social versus non-social reward.
- We hypothesized that individuals with ASD would show attenuated brain and pupil response to socially responsive stimuli.

Method

Sample

		N (male)	Age	IQ	SRS
TD	ET	30 (15)	14.31	110	25.04
ASD		31 (22)	14.81	108	83.31*
TD	EEG+ET	23 (11)	14.40	109	27.24
ASD		18 (13)	14.98	110	75.78*

* Indicates groups are significantly different p <.05

EEG and ET Data Acquisition and Collection:
- EEG recorded at 1000 Hz with a 128-channel Hydrocel Geodesic Sensor net.
- ET data collected using an Eyelink-1000 remote camera system at 500 Hz.

EEG Preprocessing:
- Data were cleaned utilizing PREP pipeline with line noise removal, a high-pass filter, and then re-referenced to average reference.
- Data were filtered from 0.1-100 Hz.
- Participants were included in the EEG sample if they had at least 15 good trials per condition. All participants contributed to eye-tracking data.

ERP Analysis:
- Data were segmented from -100 prior to 300 ms after gaze change (Direct, Averted) or reward receipt (Diamond, Smile), baseline corrected, and artifact detected.
- P100 and N170 were extracted from lateral occipital electrodes.

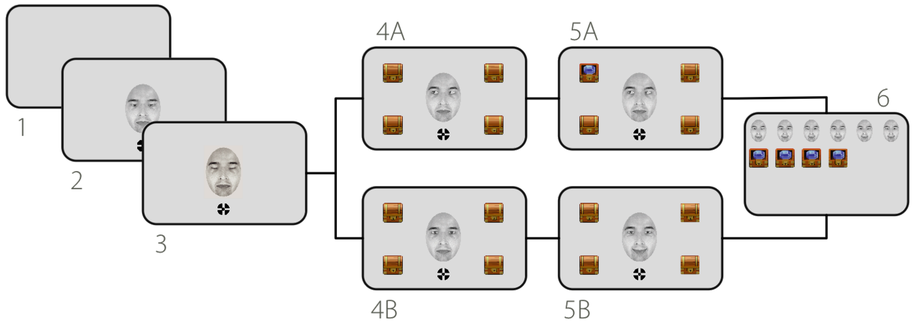
Pupil Analysis:
- Pupil dilation was measured in the 100ms before and after gaze change and reward.
- Pupil change was estimated as the correlation between pupil dilation and time.

Behavioral Data:
- Diagnosis was confirmed via the Autism Diagnostic Observation Schedule 2nd edition (ADOS), the Autism Diagnostic Interview (ADI), and clinician confirmation of DSM-5 criteria.
- Differential Ability Scales 2nd edition (DAS-II)
- Social Responsiveness Scale 2nd edition (SRS)

Experimental Design:

Trials began with presentation of a centrally presented fixation point, followed by a centrally presented neutral face looking down. Contingent upon participant gaze to the face, the face blinked and opened its eyes to display direct gaze or averted gaze (pointing to one of four treasure chests in the corners of the screen). In the direct gaze condition, participants were rewarded with a smile (social reward) after maintaining gaze with the onscreen face for 900ms. In the gaze-following condition, participants earned a jewel (non-social reward) by looking to the cued treasure chest for 600ms.

Method



(1) A blank screen is followed by a centrally presented fixation point.
(2) Following fixation to the point for 200ms a centrally presented face appears looking down.
(3) Following fixation to the eyes of the face, the face blinks for 500ms.
(4) The face opens it's eyes displaying either (4B) direct gaze or (4A) cued gaze.
(5) For 900 ms, the participant maintains eye contact to elicit a smile (5A) or follows gaze to reveal a jewel (5B)
(6) After each block of 32 trials a prize screen depicts points earned in the preceding block.

Figure 1. Experiment trial structure

Preliminary Results

Neural response to shared gaze and targets of joint attention

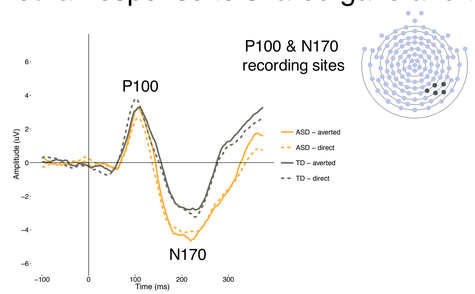


Figure 2. P100 and N170 waveform for gaze change

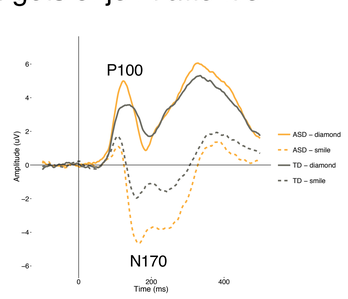


Figure 3. P100 and N170 waveform for reward

Pupillary dilation response in anticipation of reward

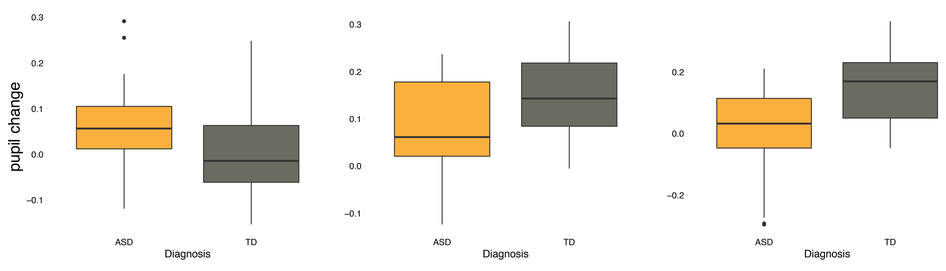


Figure 4. Pupil change before non-social reward (Diamond)

Figure 5. Pupil change before social reward (Smile)

Figure 6. Difference score for social vs non-social reward by group

Preliminary Results

Neural Response, Pupillary Dilation, and Clinical Characterization

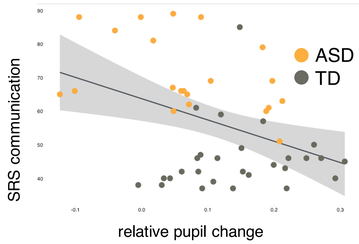


Figure 7. Relative pupil change for social vs non-social reward by SRS communication

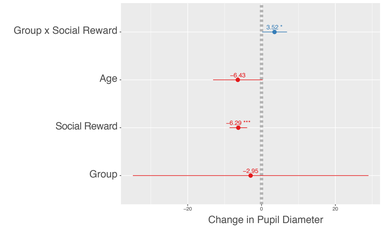


Figure 8. Regression coefficients for pupil diameter before and after social reward

- N170 amplitude for gaze-cueing trials (direct and gaze following) were compared across groups and did not reveal a significant group [F(1,34) = .004, p = .950] or group by condition interaction [F(1,34) = .209, p = .650] (Figure 2).
- P100 amplitude in response to social and nonsocial reward showed an effect of condition, such that non-social rewards elicited greater P100s [F(1,37) = 41.07, p < .001], and this interaction effect was larger in individuals with ASD [F(1,37) = 5.04, p = .031] (Figure 3).
- Individuals with ASD exhibited reduced dilation in pupil size before social reward compared to individuals with TD [t(56.54) = -3.16, p = 0.003] whereas the opposite pattern was seen in the anticipation of non-social reward [t(56.65) = 2.62, p = 0.011] (Figures 4 & 5).
- To estimate individual differences in reward prioritization, we calculated the difference between anticipatory pupil-change before social reward and before non-social reward for each individual. These results showed that TD individuals prioritize social reward significantly more than individuals with ASD [t(53.12) = -4.005, p < .001] (Figure 6).
- Across groups, social reward prioritization predicted continuous measures of social function as measured by the SRS Social Communication subscale [r(47) = -365, p = .010] (Figure 7).
- Mixed effects models of pupil size before and after social feedback revealed that, in response to smiling faces, individuals with ASD showed reduced pupil size [β = -6.138, p < .001] compared to larger pupil dilation in individuals with TD [β = 5.828, p < .001] (Figure 8-interaction indicated in blue).

Conclusions

- This study to investigated the neural correlates of an interactive joint attention paradigm in individuals with ASD and identified differences in social reward anticipation that distinguished groups.
- Preliminary results reveal that individuals with ASD exhibit greater neural upregulation of non-social reward compared to TD individuals but no difference in social reward.
- Results from pupillary dilation show that individuals with ASD do not prioritize the anticipation of social reward to the same extent as TD individuals, and the extent of this difference predicts variability in the clinical phenotype.
- Deficits in anticipation of social feedback may reflect difficulties in accurately predicting the outcome of actions in social situations thus leading to a failure to adaptively guide behavior during interactions.
- Future work will examine the diagnostic specificity of these joint attention differences and explore more advanced analytic techniques for dissociating brain response associated with visual processing from reward processing and social function.

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