Exploring the Relationship Between Visual Evoked Potentials and Visual Search in ASD: Results from the ABC-CT Interim Analysis

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Background

- Electrophysiology studies suggest atypical visual processing in individuals with ASD, as indexed by Visual Evoked Potentials (VEP) with **lower P100 amplitudes in individuals with ASD as compared to TD** (Kovarski et al., 2016)

- Eye-tracking studies suggest individuals with ASD exhibit **more circumscribed and preservative visual attention** as compared to TD individuals in Visual Search (VS) paradigms (Sasson et al., 2008, 2011)

Our question is: **Are visual processing differences associated with differences in higher-order behaviors of visual sampling?**

Objective

To explore the relationship between low level perceptual visual processing as measured by VEP and potentially higher-level visual search behavior as measured by the proportion of time spent in fixations and saccades in a VS paradigm in children with and without ASD.

Methods

The **Autism Biomarkers Consortium for Clinical Trials** (ABC-CT; McPartland) is a multi-site evaluation of candidate ASD biomarkers.

Sample Characteristics	ASD	TD
Participants	161	64
Participants with valid VS & VEP data	126	55
Males with valid VS & VEP data	101	35
Age (years)	8.8 (1.6)	8.8 (1.8)
Full Scale IQ***	99.0 (18.0)	115.5 (12.9)
Verbal IQ***	97.8 (19.3)	116.5 (13.0)
Nonverbal IQ***	99.9 (17.9)	112.8 (14.2)
Vineland Adaptive Behavior Composite***	7.7 (1.9)	1.4 (0.7)
ADOS Calibrated Severity Score***	7.7 (1.9)	1.4 (0.7)
ADOS SA Severity Score***	7.4 (1.9)	1.8 (1.2)
ADOS RRB Severity Score***	7.8 (2.1)	2.4 (2.1)

Table 1. Characterization means and standard deviations. Asterisks indicate significant group differences (*** = $p < .001$)

Experimental Paradigms
VEP Stimuli
- Black & white checkerboards that reverse their phase (i.e., black to white and white to black) every 500ms (Figure 1)
- 4 blocks x 52 trials for 204 trials
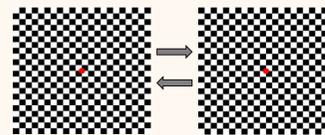- Mean luminance of 80cd/m2 & contrast of 99%

Figure 1. VEP stimuli. Modified by Jeste & Naples

VS Stimuli
- One face, five distractors placed at an equal distance from center of screen (Figure 2)
- 4 blocks x 3 trials (20s/trial) for 12 trials (interleaved with other paradigms and split across two days)

Figure 2. VS stimuli examples. Adapted from Gliga, Elsabbagh, Andravizou & Johnson, 2009

Methods Continued

Data Acquisition and Processing

- EEG data: 1000Hz with 128-channel Hydrocel Geodesic Sensor net
- P1 % N1 amplitude and latency extracted from 60-90ms and 100-130ms, respectively, from Occipital Midline (Figure 3)
- Secondary dependent variables: N1-P1 amplitude and latency
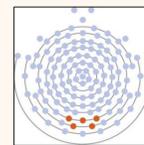- Removal of 60Hz line-noise, re-referenced to average reference, bandpass filtered at .1 to 30Hz, segmented from -100ms-300ms (unattended trials excluded), baseline corrected, artifact detected (150mV threshold)

- ET data: SR Eyelink 1000 Plus & processed at 500Hz
- Fixations: 1° spatial threshold and 100ms min. fixation time
- Fixation ratios: fixation duration/valid looking time (Fixation%) & fixation duration/fixation count
- Secondary dependent variables: Saccade duration/valid looking time (Saccade%)
- Static Regions of Interest (ROI) images used (Figure 4)
- Trials validity: > 50% on-screen looking & < 2.5° calibration error

Figure 3. ERP Regions of Interest: Occipital Midline (70/O1, 74, 75/Oz, 82, 83/O2)

Figure 4. ET Regions of Interest: Face (dark green & dark blue), Car (green), Bird (blue), Phone (red), Scrambled Face (pink), Background (grey)

Results

Exploring the effect of dx in visual processing and visual search

- No effect of age, IQ, sex or group (ASD vs. TD) in P1 amplitude (Figures 5 & 6)
- No between-group differences in any of the other dependent variables (e.g. N1 amplitude/latency, P1-N1 amplitude/latency)
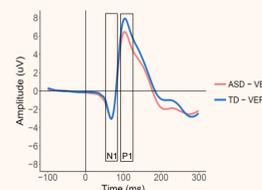

Figure 5. ERP waveforms by group

- Controlling for IQ, group differences (ASD vs. TD):
- On Screen looking% [TD > ASD; $F(1,178)=9.64, p=.002, \eta_p^2=.051$]
- Percentage time spent in fixations overall and on Phone (Figures 7 & 8) [TD > ASD; $F(1,178)=6.24, p=.013, \eta_p^2=.034$ & $F(1,178)=10.52, p=.001, \eta_p^2=.056$, respectively]
- Average fixation duration per fixation overall [TD > ASD; $F(1,178)=5.59, p=.019, \eta_p^2=.03$] and on certain ROIs (Phone, Bird & Background) ($p<.05$)
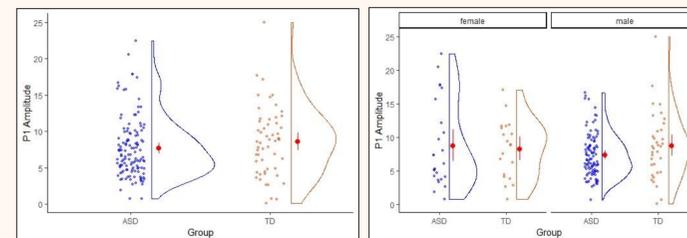
Results Continued

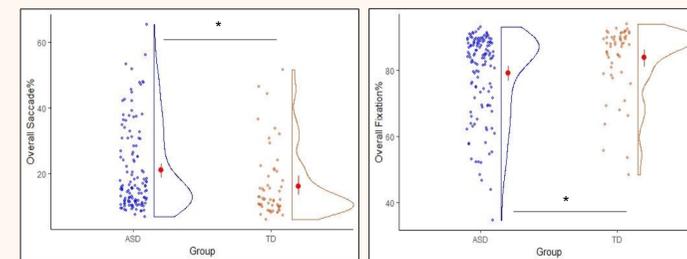*Figure 6.* (left) P1 distribution by group, (right) P1 distribution by group and sex. No group differences were found.

Figure 7. (top) Overall Fixation% by group, (bottom) Overall Saccade% by group. Asterisks indicate significant group differences (* = $p < .05$)
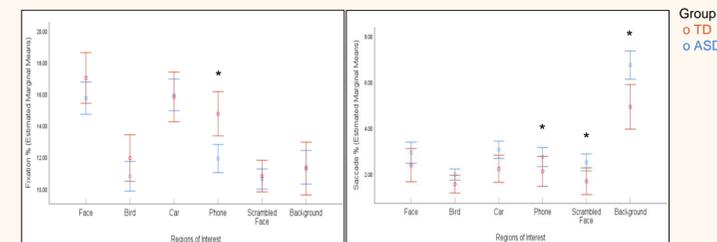

Figure 8. (left) ET Regions of Interest Fixation% by group, (right) ET Regions of Interest Saccade% by group. Asterisks indicate significant group differences

Exploring the relationships between visual processing & search
No significant relationships between VEP variables and ET variables with or without outliers. Outliers detected via outlier labeling rule using a multiplier of 2.2 (Hoaglin & Iglewicz, 1987).

Exploring the relationships between ERP/ET and sample characteristics
Correlations were significant with or without outliers (Figure 9).

In TD
- N1 Amplitude & Full Scale IQ [$r(55)=.343, p=.01$]
- N1 Amplitude & Vineland Adaptive Behavior Composite [$r(55)=.262, p=.054$]

In ASD
- Fixation% & ADOS SA Severity [$r(126)=-.186, p=.037$]
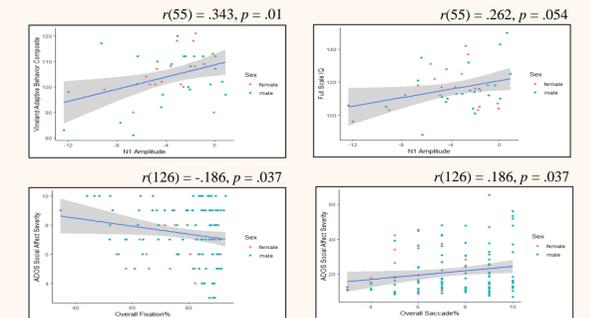- Saccade% & ADOS SA Severity [$r(126)=.186, p=.036$]

Results Continued

Figure 9. (top row) Significant relationships between N1 Amplitude and sample characteristics within the TD group, (bottom row) Significant relationships between ET Fixation% & Saccade% and sample characteristics within ASD

Discussion

- Contrary to prior findings on Visual Search, children on the spectrum spend less percentage of time perseverating or fixating as compared to TD and spend a higher percentage of time scanning or sampling the scene. This effect does not seem to be specific to social vs. nonsocial stimuli and this trend of reduced visual sampling is associated with more autism symptomatology.
- Modest correlations with sample characteristics suggest that N1 amplitude values are indexing some aspect of the continuum of functioning level and adaptive behavior across the TD group.
- P1/N1 amplitude and latency values and eye tracking fixation measures were not found to be related in this study.
  - Might be due to task differences between the EEG and ET paradigms.
  - Could signal a mechanistic disconnect between lower-level visual processing and higher-order visual search behavior.

References

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