Sensory Characteristics and Autistic Traits Influence Neural Responsivity to Predictable versus Unpredictable Visual Information

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Background

- Hypo- and hyper-sensory response and preference for predictability are common features of autism spectrum disorder (ASD).
- Prior research investigating sensory sensitivities using event-related potentials (ERPs) has demonstrated atypical early visual processing in individuals with ASD.
- However, most ERP paradigms are repetitive and temporally predictable. Because early visual brain response is influenced by expectancy, the temporal regularity of previous ERP experiments represents a potential confound, raising the possibility that differences attributed to abnormalities in low level visual processing might reflect atypical response to predictable stimuli rather than disruptions in the functional integrity of the visual pathway.
- This study investigates (a) the relationship between sensory processing, as indexed by visual evoked potentials (VEPs), and the predictability of visual stimulation and (b) the degree to which this relationship is modulated by autistic traits and sensory sensitivities.

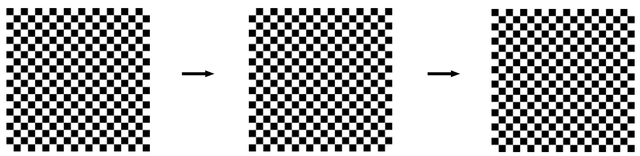
Method

Sample

N	Female	Min Age	Max Age	Mean Age (SD)
24	18	19	33	24.78 (3.59)

Experimental Paradigms:

- 24 typically developing adults were presented with black and white checkerboards that appeared on screen and reversed phase in two experimental paradigms (Figure 1).
- In the predictable condition (VEP), the phase reversal occurred every 500ms. In the unpredictable condition (VXP), reversal occurred randomly between 300 and 1000ms.
- ERPs were time-locked to each phase reversal; occipital P1 and N1 amplitude and latency were extracted for analyses.
- Self-report questionnaires captured sensory features (Glasgow Sensory Questionnaire; GSQ), autism characteristics (Social Responsiveness Scale; SRS), anxiety (State-Trait Anxiety Inventory; STAI), and resistance to change (Resistance to Change Scale; RTC).



1. Checkboard 2. Continual phase reversal after a) 500ms in predictable condition or b) 300-1000ms in unpredictable condition

Figure 1. *Checkerboards used in experimental paradigms.*

EEG and ET Data Acquisition and Collection:

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

ERP, ITC, and PD Preprocessing and Analysis:

- EEG data were filtered from 0.1-30 Hz, segmented from -100 to 300ms relative to timing of phase reversal, artifact detected, re-referenced to average reference and baseline corrected. P1 (60-90ms) and N1 (100-130ms) amplitude and latency were extracted from occipital electrodes (figure 2).
- Inter-trail phase coherence (ITC) was extracted from channels with the highest alpha synchronization.
- Pupillary dilations (PD) in response to fixations were extracted from ET data and averaged across trials within conditions.
- Condition was included as a within-subject variable in repeated measure ANOVAs, with correlations to clarify effects.

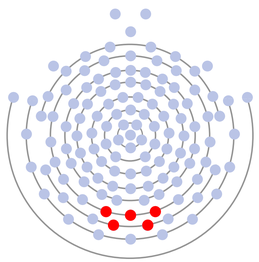


Figure 2. *Occipital (OZ) electrodes used for ERP analyses (70, 74, 75, 82, 83).*

Preliminary Results

Condition Differences in ERP, ITC, and PD Data:

- There were no statistically significant differences between the VEP and VXP conditions as measured by ERP amplitude or latency (Figure 3), inter-trial phase coherence (Figure 4), or pupil diameter (Figure 5).
- However, there were significant correlations between these dependent variables and self-reported autism symptomology, sensory sensitivity, resistance to change, and anxiety.

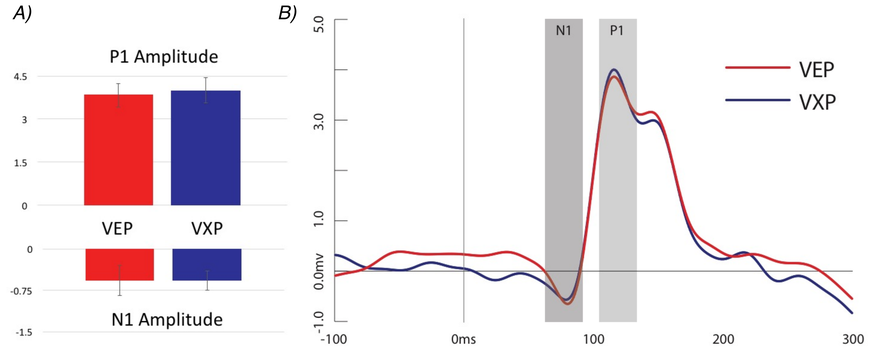


Figure 3. *A) Average P1 and N1 peak amplitudes and B) ERP waveforms extracted from OZ electrodes in response to VEP and VXP conditions.*

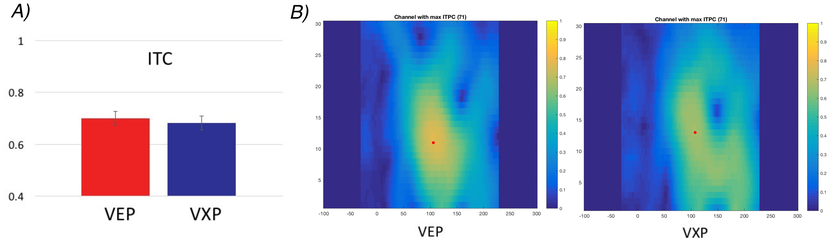


Figure 4. *A) Average ITC values across participants and B) images of ITC averages for one participant in response to VEP and VXP conditions.*

Correlations (Figure 6):

- **ERP**: Larger N1 peak amplitudes in VXP correlated with greater subthreshold autistic symptomatology (SRS Social Communication subscale, r=-0.52, p=.001). Earlier N1 responses in the VXP condition correlated with higher ratings of sensory sensitivity (GSQ Vestibular Modality, r=0.61, p<0.01). Additionally, difference scores for P1 peak amplitude demonstrate that larger P1 amplitudes in VXP compared to VEP were associated with increased cognitive rigidity (RTC Cognitive Rigidity subscale, r=-0.58, p<0.01).
- **ITC:** Difference scores for ITC demonstrate that greater alpha synchronization in response to VEP compared to VXP was associated with greater subthreshold autistic symptomatology (SRS Restricted Interest and Repetitive Behavior subscale, r=0.49, p=0.02) and sensory hypersensitivity (GSQ Visual Modality, r=0.48, p=0.02).
- **PD**: Difference scores for PD demonstrate that greater pupillary dilation in response to VXP compared to VEP was associated with greater sensory hyposensitivity (GSQ Visual Modality, r= -0.50, p=0.03) and ratings of anxiety (STAI Total Score, r=-0.56, p=0.01).

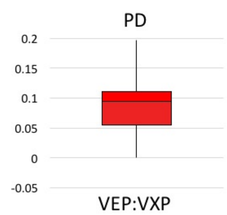


Figure 5. *Boxplot of PD response ratio to VEP and VXP conditions across participants.*

Preliminary Results

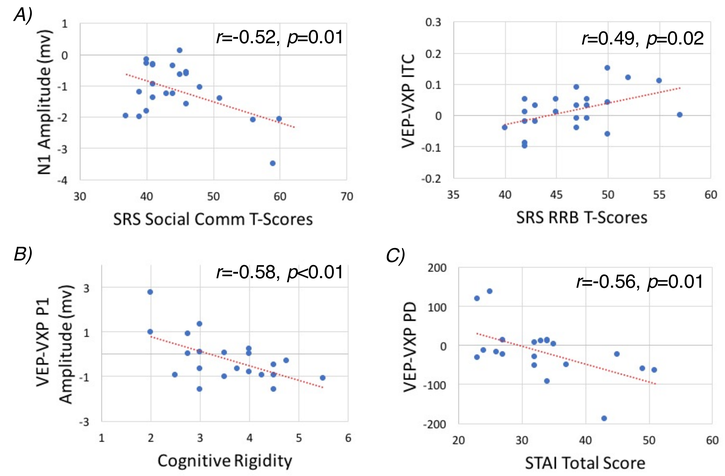


Figure 6. *Scatterplots of select correlations between neural markers and self-reported A) autistic traits, B) resistance to change, and C) anxiety.*

Conclusions

- The neural responses elicited by visual stimuli presented at predictable versus unpredictable rates were indistinct. However, variability associated with expectancy explained variance in autistic traits.
- Individuals who displayed enhanced or more rapid response to unpredictable stimuli reported higher levels of social-communication difficulties, increased vestibular sensory sensitivities, and increased cognitive rigidity.
- Those who exhibited greater alpha synchronization to the predictable condition compared to the unpredictable condition reported increased restricted interests and repetitive behaviors and visual hypersensitivity.
- Additionally, individuals who experienced greater pupillary dilation to the unpredictable condition compared to the predictable condition reported increased anxiety and visual hyposensitivity.
- These data show that symptom variability is associated with both early visual processing and top down expectancies and that these relationships are dissociable. By exploring the intersection of top-down and bottom-up sensory driven brain activity we are better poised to determine how these factors influence sensory and social symptomology and uncover sources of heterogeneity in ASD.
- Continuing data collection and analyses will allow further exploration of neural markers associated with the VEP and the relationship between brain activity, pupil dilation, and symptomatology.

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