Autistic Traits Modulate Gaze And Neural Activity In Constrained Versus Unconstrained Conditions

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BACKGROUND

- Resting paradigms are convenient research tools to examine brain activity across populations because they are easily tolerated, require no overt response, are non-invasive, and highly accessible.
- Distinctive patterns in brain activity during awake, resting states have successfully differentiated ASD populations from controls and correlate with autistic traits (Wang et al., 2013).
- Studies using electroencephalogram (EEG) during resting tasks reveal significant differences in neural activity in ASD populations (Cornew, Roberts, Blaskey & Edgar 2012).
- In particular, alpha power during eyes open resting conditions correlates with common traits associated with ASD (Mathewson et al., 2012).
- Atypical functioning of the autonomic nervous system (ANS) is believed to influence ASD symptoms (Anderson, Colombo and Unruh, 2013).
- Pupil diameter is a noninvasive measure of brain stem locus coeruleus (LC) activity and may reflect differences in arousal, alertness, and behavioral characteristics (Joshi, Li, Kalwani & Gold, 2015). Furthermore, differences in pupil change (Fan, Miles, Takahashi & Yao, 2009) and tonic pupil diameter differences are associated with ASD (Anderson and Colombo, 2009).
- Very few studies explore the relationship between neural activity, gaze patterns and states of arousal and alertness through resting paradigms (Wagner, Hirsch, Vogel-Farley, Redcay & Nelson, 2014). To date, no research study has applied concurrent EEG and eye-tracking (ET) measures to investigate function within these networks.

Current Study

- For the first time, we use concurrent EEG and ET measures within a typically developing (TD) population to explore how variations in gaze patterns and brain activity within unconstrained and constrained viewing conditions relate to autistic traits.
- We hypothesize that autistic traits, such as behavioral rigidity, will be reflected through: (1)Differing patterns of neural activity across visually unconstrained and constrained viewing conditions and (2) fluctuations in pupil diameter and fixation totals across unconstrained and constrained resting paradigms.

PARTICIPANTS AND METHODS

- Resting EEG data was recorded using a 128-channel sensor net.
- Resting ET data was acquired with an Eye-Link 1000 eye-tracking system.
- Using NetStation 5 software, EEG data was filtered and segmented with overlapping 2s epochs and hand edited for artifacts.
- Processed and cleaned data were averaged from electrodes across both hemispheres.
- Spectral power was estimated using a Multitaper Fast Fourier Transform.
- All bands of spectral power were examined for left and right hemispheres.
- Pupil size and fixation patterns were analyzed through Eye-Link DataViewer 2.5.0.
- Participants completed: (1) 2-minute unconstrained viewing task, in which they viewed a blank, gray colored screen (2) 2-minute constrained viewing task, in which they were prompted to maintain gaze within a dark square in the center of a light background. Self-report measures of autistic traits and sensory behavior were administered: Broad Autism Phenotype Questionnaire (BAPQ); Glasgow Sensory Questionnaire (GSQ); State Trait Anxiety Inventory (STAI); Autism Quotient (AQ); and Social Responsiveness Scale (SRS).

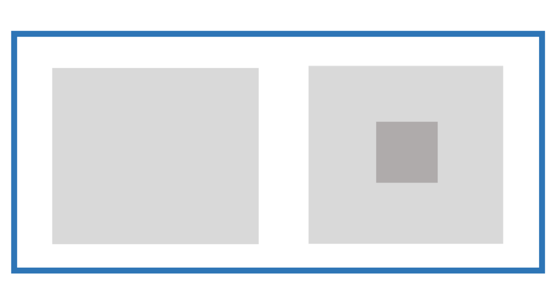

Fig. 1: Screenshots of unconstrained viewing task (left) and constrained viewing task (right)

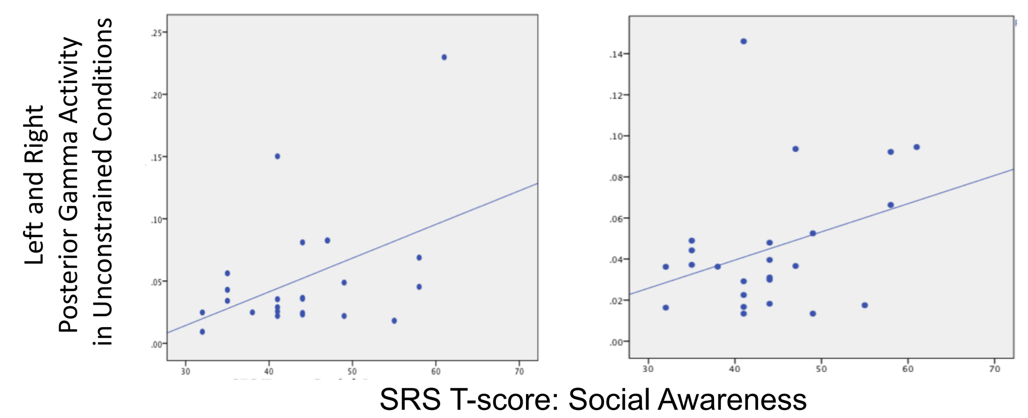

Fig. 2a & 2b: Positive correlations of lateralized posterior gamma activity within unconstrained viewing conditions and SRS Social Awareness T-score left= .441, *p < 0.05*, right= .449, *p < 0.05*. X-axis is SRS Social Awareness T-score. Y-axis is posterior gamma power.

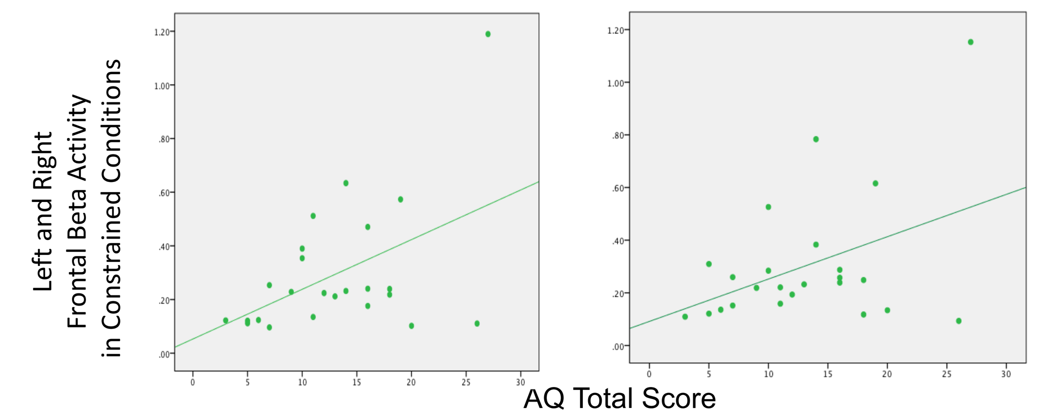

Fig. 3a & 3b: Positive correlations of lateralized frontal beta activity within constrained viewing conditions and AQ total score, left r= .477, *p < 0.05*, right r=.413, *p < 0.05*. X-axis is AQ total score. Y-axis is beta power.

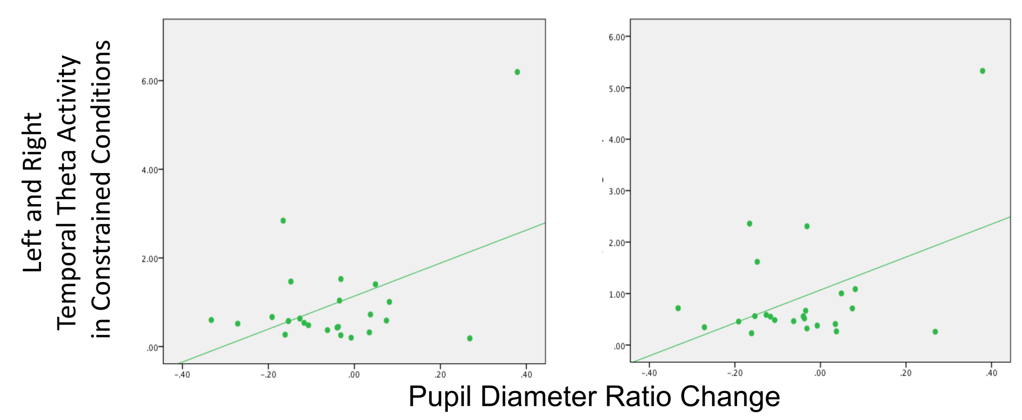

Fig. 4a & 4b: Difference in pupil diameter and power ratio between unconstrained and constrained viewing conditions right r=.459, *p < 0.05;* left r=.450, *p < 0.05*. X-axis is temporal theta power. Y-axis is the percentage of change.

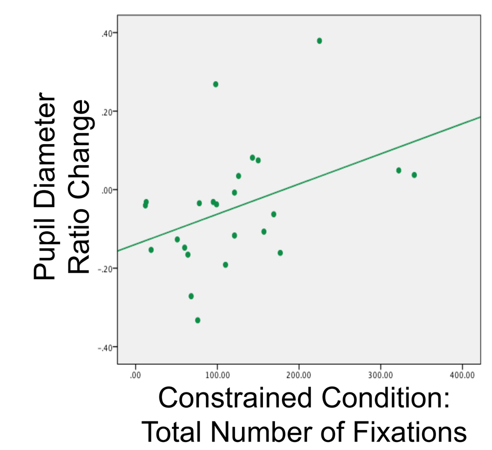

Fig. 5: Positive correlation between pupil diameter change and total number of fixations within constrained resting paradigms, r = .416, *p < 0.05*. X-axis is total number of fixations. Y-axis is ratio change in pupil diameter

Fig. 6: Positive correlation between theta band power ratio and self-report STAI scores, r = .424, *p < 0.05*. X-axis is STAI score. Y-axis is ratio of theta power difference

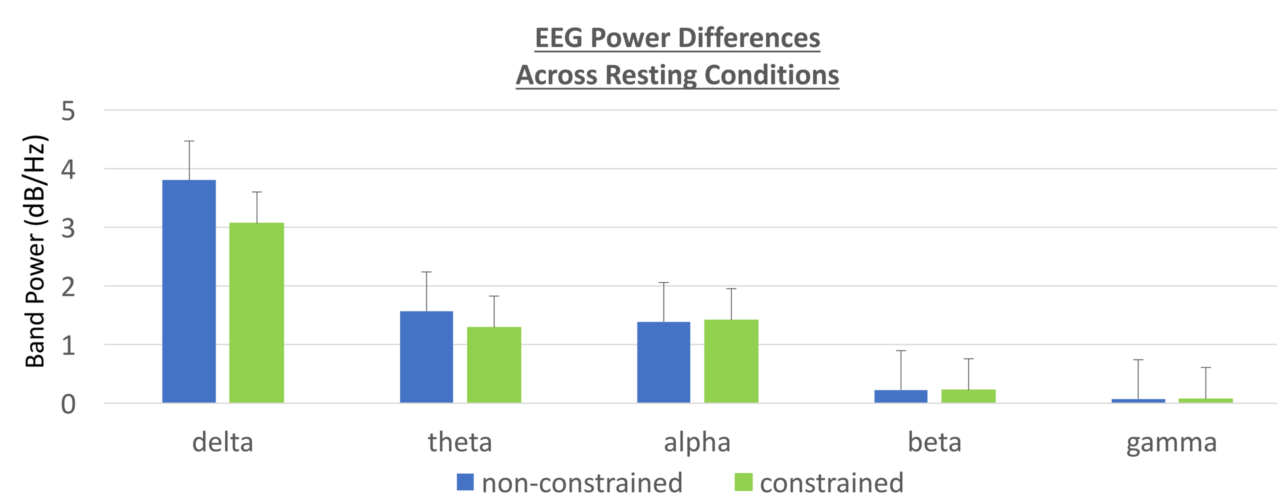

Fig. 7: Power ratios between resting paradigm condition. X-axis is power band. Y-axis is the bandwidth.

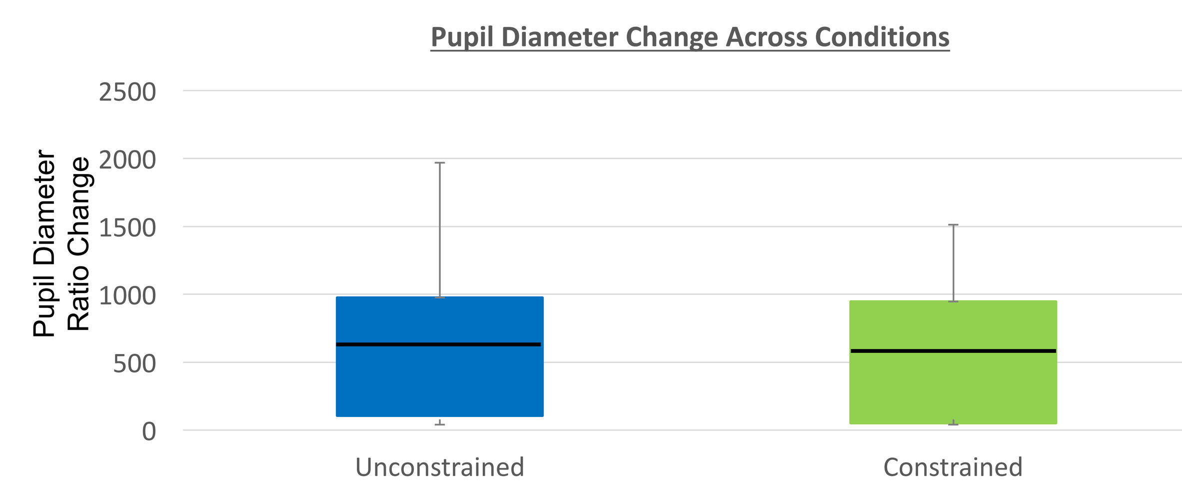

Fig 8: Relative pupil change across unconstrained and constrained resting paradigm.

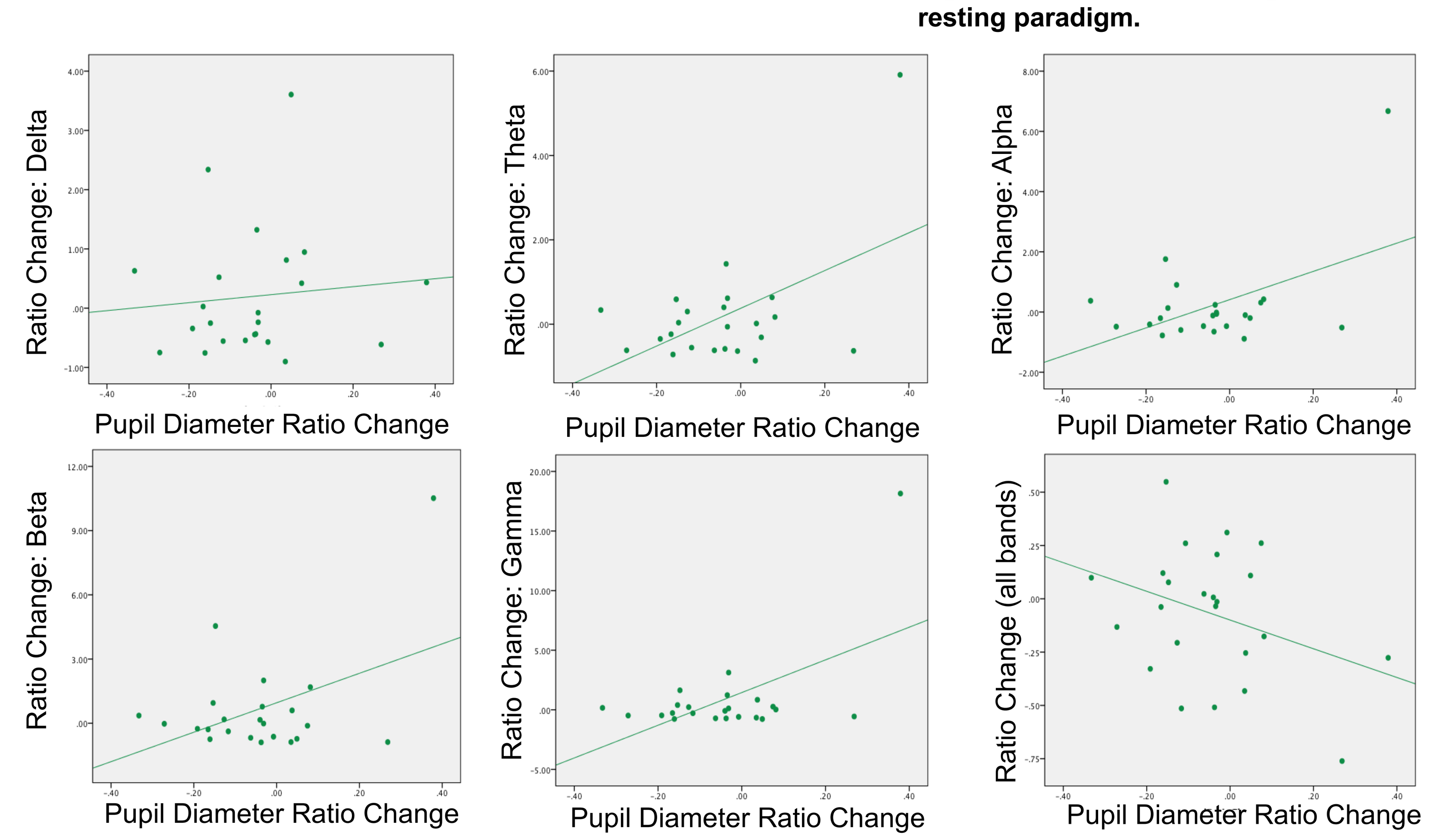

Fig. 9a, 9b, 9c, 9d, 9e, 9f: Pupil diameter and spectral power ratios of resting paradigm, (delta) r =.098, *p < 0.05;* (theta) r = .515, *p < 0.05,* (alpha) r = .486, *p < 0.05,* (beta) r = .440, *p < 0.05,* (gamma) r = .559, *p < 0.05,* (all bands), r = .434, *p < 0.05.* On the x-axis is all power bands. On the y-axis is the pupil diameter ratio. No significance when pupil diameter compared to delta or average spectral power

RESULTS

- Lateralized posterior gamma power positively correlated with social awareness scores on the SRS: left *r* = .441, *p < 0.05*; right *r* = .449, *p < 0.05*. As such, individuals reporting higher levels of social awareness on the SRS displayed higher levels of posterior gamma power (Figures 2a and 2b).
- Lateralized frontal beta activity positively correlated with total AQ score, left *r* = .477, *p < 0.05;* right *r* =.413, *p < 0.05*. Individuals with elevated total AQ scores demonstrated increases in left frontal beta activity during constrained conditions (Figures 3a and 3b).
- No significant differences were determined between total number of fixations and power change between viewing .
- Lateralized temporal theta power elicited during constrained conditions positively correlated with change in pupil diameter across conditions, right *r* =.459, *p < 0.05*; left r=.450, *p < 0.05*. Individuals with increased theta power, also show an increase in pupil diameter when transitioning to constrained viewing conditions (Figures 4a and 4b).
- Total number of fixations positively correlated with ratio of pupil change during resting paradigms, *r* = .416, *p* < 0.05. Results showed that individuals exhibiting fewer total number of fixations displayed decreased pupil size within constrained viewing (Figure 5).
- Changes in theta band power correlated positively with scores on the STAI, *r* = .424, *p < 0.05* (Figure 6). Individuals reporting fewer anxious traits displayed decreased spectral power in theta bands within constrained viewing conditions.
- A 19% decrease in delta band power and an 18% decrease in theta band power was observed in constrained viewing conditions (Figure 7).
- There was an average decrease of 5% in pupil diameter during constrained viewing conditions (Figure 8).
- Similarly, changes in delta band power within viewing conditions positively correlated with total and average scores of rigidity on the BAPQ, total *r* = .484, *p < 0.05*; average *r* = .484, *p < 0.05*. As such, individuals reporting lower levels of rigidity also displayed an overall decrease in delta power in constrained viewing conditions.

CONCLUSIONS

- Differences in neural activity during visually unconstrained and constrained resting EEG paradigms correlate with autistic traits and associated symptomology, such as anxiety.
- Changes to LC activity between conditions as indexed by pupil diameter correlate with measures of behavioral rigidity, suggesting that demands to maintain fixation during resting paradigms might differentially elicit brain activity in a manner that aligns with autistic traits.
- Both cortical and subcortical markers (pupil dilation) of brain activity express differentially with relationship to autistic traits and associated symptomology. This finding suggests that traditional resting paradigms that constrain eye-movements may bias findings in clinical populations.

FUTURE DIRECTIONS

- Our results suggest that the type of resting paradigm might impact brain activity in clinical populations. Future research will explore this mechanism in clinical populations.
- Examining states of alertness and arousal through concurrently applied measures have revealed spectral power and pupil diameter as potential biomarkers. Future research will explore the relationship in cortical and subcortical spontaneous activity to differentiate clinical populations and parse clinical heterogeneity among individuals with ASD.

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