Background

- Restricted and repetitive behaviors are a core symptom of autism spectrum disorder (ASD), including motor stereotypes, cognitive rigidity, and problems with attentional processing.
- Several studies have noted differences in oculomotor movements such as blinks and saccades between individuals with ASD and their typically developing (TD) peers.
- Characteristics of these oculomotor movements have also been linked to behaviors and biological systems that may underlie the stereotypes and cognitive rigidities often seen in ASD; however, scant research has examined relationships between variability in spontaneous eye-movement and clinically meaningful differences.
- Spontaneous eye movements may provide a unique means of examining low-level neurotransmitter dynamics influencing autistic traits.
- Based on prior literature, we predicted differences in both blink rate and characteristics of spontaneous saccadic eye movements between children with ASD and TD children, such that spontaneous eye movements and blinks would be more frequent in children with ASD.
- We specifically expected to see differences in the 4-10 Hz frequency characteristics of eye movements, which have been associated with neural mechanisms of attentional control and cognitive flexibility, such that children with less cognitive flexibility would show a greater degree of regularity in eye movements.

Methods

- **Participants**: Clinical and eye-tracking data were collected from 51 participants (see Table 1) recruited from the New Haven, CT, Boston, MA, Los Angeles, CA, Durham, NC, and Seattle, WA metropolitan areas as a part of the Autism Biomarkers Consortium for Clinical Trials (ABC-CT) feasibility study.

**Behavioral Assessment:**
- Stereotypy and rigidity were assessed using:
  - Aberrant Behavior Checklist (ABC) stereotypy standard score
  - Autism Impact Measure (AIM) frequency of restricted behavior subscale
  - Behavioral Assessment System for Children (BASC-3) adaptability and attentional control subscales

**Rigid and Stereotyped Behaviors**
- Summary statistics are presented for measures of rigid and stereotyped behaviors for each group (Table 2).

**Data Acquisition, Pre-processing, and Analysis**
- Remote eye-tracking data were collected at 500 Hz using an SR EyeLink 1000+ while participants freely viewed static images of naturalistic social scenes (such as that depicted in Figure 1a).1-3

**Blink Rate**
- Blinks were identified using the SR’s built-in blink detection algorithm, excluding blinks that were flagged as having a duration longer than 400 ms or shorter than 50 ms.
- Blink rate was calculated as the average number of blinks per second across all stimuli.

**Saccadic Rhythmicity**
- Distance between gaze loci at each timepoint was examined in the frequency domain in order to assess rhythmicity of spontaneous saccadic eye movement. Schematic process used to calculate saccadic rhythmicity is presented below in Figure 1.
- Power spectra were generated from 250 ms segments of data. Amplitude was extracted for frequencies from 4 to 10 Hz (see Figure 3); prior studies have identified attentional sampling and voluntary eye movements clustered around the 4-10 Hz frequency range and have linked eye movements to neural activity in this frequency band.

Conclusions

- These data suggest that the blink rate and frequency dynamics of spontaneous eye movements in children with ASD differ from that of their TD peers.
- Among children with ASD, eye movement rhythmicity exhibited a stronger frequency component from 4-10 Hz, which was further modulated by the degree of restrictive behavior displayed.
- That this frequency band has been implicated in attentional processing and cognitive control suggests that further examination of spontaneous oculomotor dynamics in this range may have potential as a biomarker of processes relevant to RRBs.
- Future research should examine relationships between the frequency dynamics of oculomotor movements and stereotypy and rigidity in ASD in both spontaneous and more structured eye-tracking paradigms.
- Frequency-spectrum-wide group differences in power suggest a possible confounding influence of noise in data; future research should aim to reduce noise in data collection and to further characterize any systemic differences in data quality between groups.