Comparison of Visual Sensitivity to Human and Object Motion in Autism Spectrum Disorder

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Successful social behavior requires the accurate detection of other people’s movements. Consistent with this, typical observers demonstrate enhanced visual sensitivity to human movement relative to equally complex, nonhuman movement [e.g., Pinto & Shiffrar, 2009]. A psychophysical study investigated visual sensitivity to human motion relative to object motion in observers with autism spectrum disorder (ASD). Participants viewed point-light depictions of a moving person and, for comparison, a moving tractor and discriminated between coherent and scrambled versions of these stimuli in unmasked and masked displays. There were three groups of participants: young adults with ASD, typically developing young adults, and typically developing children. Across masking conditions, typical observers showed enhanced visual sensitivity to human movement while observers in the ASD group did not. Because the human body is an inherently social stimulus, this result is consistent with social brain theories [e.g., Pelphrey & Carter, 2008; Schultz, 2005] and suggests that the visual systems of individuals with ASD may not be tuned for the detection of socially relevant information such as the presence of another person. Reduced visual sensitivity to human movements could compromise important social behaviors including, for example, gesture comprehension.

Keywords: autism; motion perception; biological motion; motion coherence

Introduction

When people move, their actions convey extensive social information. Social brain theories [e.g., Schultz, 2005] suggest that the visual system is typically tuned for the analysis of socially relevant information. Consistent with this, typical adult observers demonstrate greater visual sensitivity to human movement than to complex, nonhuman movement [e.g., Pinto & Shiffrar, 2009]. Because individuals with Autism Spectrum Disorder (ASD) experience compromised social abilities [APA, 2006] and atypical neural activity in social brain areas [e.g., Pelphrey & Carter, 2008], we examined whether observers with ASD exhibit or lack enhanced visual sensitivity to human movement.

Studies of visual sensitivity to human motion commonly use point-light stimuli created by attaching markers to a person’s body and then recording that person’s movements so that only the markers are visible [Johansson, 1973]. While the resultant displays are sparse (Fig. 1), typical adults readily detect point-light actors [Blake & Shiffrar, 2007]. Typically developing infants readily orient toward point-light displays of biological motion [Simion, Regolin, & Bulf, 2008] while toddlers with ASD do not [Klin, Lin, Gorrindo, Ramsay, & Jones, 2009]. Reduced visual experience with human motion typically decreases visual sensitivity to it [Jacobs, Pinto, & Shiffrar, 2005].

Observers with ASD and control observers do not differ in their ability to verbally describe the actions performed by point-light actors [Hubert et al., 2007; Moore, Hobson, & Lee, 1997; Parron et al., 2008] but do differ in their ability to detect the presence of coherent human motion in point-light displays [Blake, Turner, Smoski, Pozdol, & Stone, 2003]. Observers with ASD also frequently demonstrate impairments in their sensitivity to coherent visual motion in general [for review see Kaiser & Shiffrar, 2009; Simmons et al., 2009]. This raises the question of whether observers with ASD are compromised in their visual sensitivity to coherent human motion, in specific, or in their visual sensitivity to coherent motion, in general.

structural and processing atypicalities in the STSp [e.g., Zilbovicius et al., 2006] that are evident during the perception of point-light walkers [Freitag et al., 2008; Herrington et al., 2007]. During development in typical children, but not in children with ASD, STSp activity becomes increasingly tuned for human motion and less responsive to object motion [Pelphrey & Carter, 2008]. To the extent that perceptual sensitivity to point-light displays of human movement depends upon STSp activity [e.g., Grossman et al., 2005; Saygin, 2007], observers with ASD may not experience enhanced sensitivity to human motion over other types of motion. To determine whether observers with ASD, like typical observers, demonstrate enhanced sensitivity to human movement relative to object movement, we conducted a motion coherence task with point-light displays of a moving person and a moving tractor. Tractor motion was selected because, like human motion, it is complex, globally nonrigid, and jointed.

Typical observers can use local (point-by-point) and global (spatiotemporally extended) analyses to detect coherence in unmasked point-light displays. Masking disrupts local analyses and, in typical observers, increases reliance on global analyses [Bertenthal & Pinto, 1994]. Because observers with ASD rely on local analyses [e.g., Behrmann, Thomas, & Humphreys, 2006; Dakin & Frith, 2005], masking should disrupt their visual sensitivity to human motion.

Methods

Participants

An ASD group (lowest reading level = 10.4 years) included 6 males (mean age = 19.7 years, SD = 10.4) with a diagnosis of High Functioning Autism (3), Asperger's Syndrome (2), or PDD-NOS (1) recruited from a school for people with ASD. They received monetary compensation for their participation. All ASD diagnoses were made by an independent clinician and confirmed by a school district child study team or another clinician. A typical group contained 32 Rutgers undergraduates (26 female) who received credit toward a course requirement (mean age = 21.3 years, SD = 3.5). Mean ages across groups did not significantly differ, t(5) = 0.326, P = 0.757. All participants were naive to the hypothesis under investigation, had normal or corrected to normal visual acuity, and provided written informed consent. The Rutgers University Institutional Review Board approved this study.

Apparatus

Stimuli appeared on a 14-inch Dell™ monitor (60 Hz, 1,024 × 768 pixel resolution) positioned 52 cm from the observer and controlled by a Dell™ Pentium computer. The experiment was programmed in E-Prime (Psychology Software Tools, Inc., Pittsburgh, PA). Movies were processed with Motion Builder 5.0 (Kaydara™, San Rafael, CA). A ReActor motion capture system (Ascension Technology) measured sensors attached to a person or tractor moving within a 3.6 by 4.8 m area (Fig. 1).

Stimuli

Nine sensors were attached to the actor (head, wrists (2), elbow, shoulder, feet (2), knee, waist) and nine were attached to a “John Deere Loader” (Peg Perego, 124.5 × 63.5 cm) toy tractor (wheels (4), front bucket (4), bucket pivot joint (1)). The tractor and actor each repeatedly performed three similar actions: (1) locomoting along a 3 m linear path (2) rotating the bucket (tractor) or reaching (human) downward to pick something up and (3) locomoting 1.5 m and then rotating the bucket/reaching down to pick something up.

Motion capture data were converted into eight point-light human movies and eight point-light tractor movies.
(5 sec each). Motion direction (leftward/rightward) was counterbalanced. The point-light walker (maximum extents: 6.6 × 3.3 degrees of visual angle (DVA)) and tractor (maximum extents: 4.4 × 7.7 DVA) had lateral displacement distances ranging from 8.8 to 16.1 DVA and speeds ranging from 1.76 to 3.22 DVA/sec. The points defining each stimulus were white, 0.33 DVA in diameter, and appeared against a black background. One scrambled point-light movie was constructed from each coherent human and tractor movie by scrambling the starting locations of the points (Fig. 1E).

Across conditions, each stimulus appeared unmasked and masked. Unmasked stimuli had nine points as described above. Masked stimuli contained an additional nine masking points. Mask construction is described in detail elsewhere [Chouchourelou, Matsuka, Harber, & Shiffrar, 2006]. Briefly, each point-light stimulus was duplicated and the starting locations of those duplicate points were scrambled. Each stimulus was then hidden within the scrambled mask that had been constructed from it (Fig. 1F). Thus, the points defining each mask and stimulus had identical velocities, sizes, and luminance. Under these conditions, coherent motion detection involves global analyses [Bertenthal & Pinto, 1994].

**Design and Procedure**

In a blocked, within subjects design, each participant saw coherent and scrambled point-light human motion and tractor motion in masked and unmasked conditions. Trials were blocked by stimulus (human or tractor) and condition (masked or unmasked). Participants completed the unmasked condition first. Each block contained 32 movies (8 coherent and 8 scrambled movies each shown twice in random order). Block order was counterbalanced across participants within each condition. In each masking condition, participants completed two human and two tractor blocks.

Participants responded by pressing a button labeled “yes” or another labeled “no”. In the human blocks, participants reported whether all (unmasked condition) or some (masked condition) of the dots were “stuck” to a person. In the tractor blocks, participants reported whether all (unmasked condition) or some (masked condition) of the dots were “stuck” to a tractor. Correct responses were “yes” to coherent and “no” to scrambled motion. No feedback was provided. Reaction time data were not analyzed because participants responded after watching each movie.

**Results**

Visual sensitivities to human motion and tractor motion were assessed with d-prime measures (normalized hit rate minus normalized false alarm rate) for each participant for each stimulus type in each condition [Macmillan & Creelman, 1991]. Both groups performed well above chance (d-prime = 0), in all unmasked (all P < 0.001) and masked (all P < 0.002) conditions (Fig. 2A and B).

Due to limited matching of participant groups, direct statistical comparison across groups was not performed. Instead, data were compared within each group. The ASD group demonstrated equivalent visual sensitivity to the presence of coherent human motion and coherent tractor motion in the unmasked, t(5) = 1.123, P = 0.312, and masked, t(5) = 0.135, P = 0.898, conditions. Conversely, the typical group demonstrated significantly greater visual sensitivity to the presence of coherent human motion than to the presence of coherent tractor motion in the unmasked, t(11) = 3.547, P < 0.001, and masked, t(11) = 4.725, P < 0.001, conditions. Performance by the six typical males, considered separately, still showed greater sensitivity to human motion (e.g., masked t(5) = 2.55, P < 0.05).

Repeated measures analysis of variances were conducted for both groups separately, with Masking and Stimulus as within subject factors. The ASD group showed no significant main effect of Masking, F(1) = 2.123, P = 0.205, or Stimulus, F(1) = 1.339, P = 0.2995, nor a significant interaction, F(1,5) = 0.536,
Discussion

This study examined whether observers with ASD, like typical observers, demonstrate greater visual sensitivity to human movement than to nonhuman movement. There are three main findings. First, typical observers demonstrated greater sensitivity to human motion than to tractor motion, consistent with the hypothesis that the human visual system is typically tuned for the detection and analysis of socially relevant information [e.g., Pinto & Shiffrar, 2009; Schultz, 2005]. Second, observers with ASD demonstrated equivalent levels of visual sensitivity to coherent human and tractor motions, suggesting that their visual systems may not be tuned for the detection of socially relevant motion. Because this study assessed visual sensitivity to human motion relative to object motion, these results cannot be attributed to global deficits in coherent motion perception [Koldewyn, Whitney, & Rivera, 2010]. Consistent with past studies, the current results indicate that observers with ASD can detect coherent human movement [e.g., Atkinson, 2009; Blake et al., 2003; Moore et al., 1997]. The novel finding here is that, unlike typical observers, observers with ASD do not show enhanced visual sensitivity to human movement relative to object movement. This finding is consistent with evidence that, during development, STSp activity increasingly differentiates human motion from object motion in typicals but not in children with ASD [Pelphrey & Carter, 2008].

Finally, all participants could detect coherent human and tractor motion in masked displays [Annaz et al., 2010; Murphy, Brady, Fitzgerald, & Troje, 2009] that reduced the effectiveness of local processes [Bertenthal & Pinto, 1994]. Masking may not engage global motion processes in observers with ASD since masking reduced performance in the typical but not the ASD group. Global processes are typically important for action perception [e.g., Blake & Shiffrar, 2007].

The current data are subject to interpretive caveats. The ASD group had only six participants. Yet, each completed 256 trials, yielding 1,536 total trials. This provided far more data than previously reported in related studies. Nonetheless, we are currently running more participants to address problems associated with small sample sizes. Importantly, the current results are consistent with a recent finding that typical observers with low AQ scores (few autistic traits) show greater visual sensitivity to human than to tractor motion while typical observers with high AQ scores do not [Kaiser & Shiffrar, 2010].

Given limited matching between groups, performance patterns were only compared within each group. To determine whether performance in the ASD group reflected the inclusion of observers with lower mental ages, a shortened (one block per condition) but otherwise identical version of the current task was administered to a significantly younger group of 83 (40 males) typically developing children (Mean Age = 8.8 years, SD = 1.4 years) at the University of Victoria. Like typical adults a decade older, these young typically developing children demonstrated greater visual sensitivity to the presence of coherent human than tractor motion under masked, \( t(82) = 4.90, P < 0.0001 \), and unmasked, \( t(82) = 5.14, P < 0.0001 \), conditions (Fig. 2C and D). Thus, mental age differences are unlikely to account for the group differences reported above.

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References


