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Children with autism spectrum disorders are less proficient in action identification and lacking a preference for upright point-light biological motion displays

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ABSTRACT

Recent studies demonstrated impaired biological motion perception in children with autism spectrum disorder (ASD), who are characterized by deficits in social interactions and communication. Using point-light displays, the present study intended to examine the looking preferences for human and non-human biological motion paired with non-biological scrambled motion (Exp. 1) and the performance on the action identification task (Exp. 2) in typically developing (TD) children and children with ASD. Forty-two participants (21 ASD and 21 TD children) aged 3–7 years were included in this study. In Exp. 1, we found that children with ASD did not preferentially attend to biological motion as TD children did. The ASD group also exhibited shorter overall fixation time for all the point-light displays than did the TD group. In the action identification task of Exp. 2, children with ASD made more errors in naming and needed more time to respond than did TD children. Nevertheless, the actions that were likely to be correctly identified by TD children were also likely to be correctly identified by children with ASD. In conclusion, children with ASD are lacking the preference TD children have for biological motion stimuli over the scrambled motion. Moreover, such impairment might be due to an overall deficit in processing biological motion information and may explain the poor performance on action recognition in the ASD group.

1. Introduction

Being inherently social creatures, human agents not only move in a uniquely non-rigid way but also excel in recognizing other people's movements (Blake & Shiffrar, 2007). A large body of studies have shown that, even with impoverished visual motion stimuli such as the point-light displays first introduced by Johansson (1973), one can still easily extract sufficient information to recognize an agent's action such as walking, dancing, or reaching (Johansson, 1973), and to identify the agent's gender (Pollick, Kay, Heim, & Stringer, 2005), identity (Loula, Prasad, Harber, & Shiffrar, 2005), and emotional state

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(Atkinson, Dittrich, Gemmell, & Young, 2004; Dittrich, Troscianko, Lea, & Morgan, 1996). The visual sensitivity to biological motion appears to have an early ontogeny and is well-conserved evolutionarily, as evidenced across various species. For example, dark-raised newborn chicks preferentially oriented to images of the heads and the necks of hens (Johnson & Horn, 1988) and to point-light displays depicting the biological motion of a hen (Regolin, Tommasi, & Vallortigara, 2000; Vallortigara, Regolin, & Marconato, 2005). Similarly, 2-day-old human newborns were able to discriminate between biological motion and random motion point-light displays; they preferred upright over inverted biological motion displays (i.e., a walking hen) (Simion, Regolin, & Bulf, 2008) and over a rigid, rotating object (Bardi, Regolin, & Simion, 2011). Moreover, human observers could selectively preserve biological motion perception even when other forms of motion perception are impaired (Jordan, Reiss, Hoffman, & Landau, 2002). These findings collectively suggest an early occurring mechanism and perhaps dedicated brain circuitry for perceiving and attending to biological motion.

Autism spectrum disorders (ASDs) are characterized by qualitative deficits in social interactions, communications, and having stereotypical or repetitive behaviors of restricted interests (American Psychiatric Association, 2006). Given the quintessential importance of biological motion perception to social interaction, studies have shown that individuals with ASD exhibited a disrupted perception of point-light biological motion displays and reduced brain activity in correlated areas. In adults, neuroimaging studies revealed that brain activity in the superior temporal sulcus (STSp), an area known to be associated with the perception of biological motions (Pyles, Garcia, Hoffman, & Grossman, 2007), was much reduced in individuals with ASD when they viewed point-light displays (Herrington et al., 2007; Kaiser, Hudac, et al., 2010). In children, recent studies suggested that children with ASD showed impaired biological motion perception as compared to typically developing (TD) children in several ways. For example, Blake, Turner, Smoski, Pozdol, and Stone (2003) tested 8–10-year-old children with ASD and age-matched TD children with two visual tasks. The first task involved grouping small, line elements into a global figure (i.e., the global-form task) and the second task involved the perception of human actions portrayed in point-light displays. The results showed that both groups performed equally well on the first global-form task, indicating a seemingly normal functioning of contour integration in the ASD group. However, children with ASD were significantly impaired in the biological motion task, which may be related to the observed impairments in social skills, characteristic of autism. In a recent study, Parron et al. (2008) tested 7–18-year-old TD children and adolescents as well as their counterparts with ASD on the ability to recognize a person's actions, "subjective states," the term they used to refer to non-emotionally charged states such as itching, or emotions portrayed in point-light displays. They found that the ASD group differed from the TD group only in their ability to name the emotional states depicted in the point-light displays. This suggests that older children with ASD can still extract meanings from bodily movements but may be less sensitive to higher-order emotional information conveyed by human movements.

When might such deficit in perceiving point-light biological motion displays in individuals with ASD emerge during childhood? In a recent single case study, Klin and Jones (2008) examined a 15-month-old autistic infant's preferential looking using point-light displays depicting upright biological motion, and their inverted versions played backwards (non-biological motion). The stimuli were presented side by side and accompanied with audios (e.g. peek-a-boo actions with speech sounds). In contrast to the control toddler group (matched on verbal and non-verbal mental age), the autistic infant did not preferentially look toward the biological motion display, whereas the typically developing toddlers did. Using eye-tracking techniques, Klin, Lin, Gorrindo, Ramsay, and Jones (2009) further examined preferential looking in a larger group of 2-year-old toddlers with ASD. The results demonstrated that toddlers with ASD failed to orient preferentially toward point-light displays of upright biological motion. Instead, they exhibited preferential attention to nonsocial audiovisual contingencies that were ignored by typically developing children and even developmentally delayed children without autism. Taken together, these two studies provided evidence for a lack of looking preference to biological motion in the ASD group as young as 2 years old.

Recently, Annaz, Campbell, Coleman, Milne, and Swettenham (2012) pointed out that because the biological motion stimuli in Klin et al.'s (2009) combined visual motions with sounds (p. 402), the ASD group may simply reflect a preference for the moments when the sound and the movement were contingent in the display, instead of a genuine preference for the nonsocial audiovisual motion displays. Thus, Annaz et al. (2012) adopted the preferential looking method with purely visual stimuli to examine whether children with ASD aged 3–7 years would preferentially attend to biological motion point-light displays. In their Exp. 1, TD children and children with ASD were presented with visual, with no sound, point-light displays depicting a person walking (i.e. not a social gesture) and their phase-scrambled versions of point-light displays as a comparison. The phase-scrambled PLDs served as good control stimuli in which the configural cues in the original biological motion displays were completely eliminated and that the other factors remained unchanged. In Exp.2, the stimuli were the point-light displays of a human walker paired with a point-light display of a non-biological motion, exemplified by a rotating spinning top. The results showed that TD children preferentially attended to the human biological motion in both experiments. In contrast, children with ASD did not preferentially attend to biological motion over scrambled motion, but they spent more time looking at the non-biological spinning top motion than the human walker. This lack of preference for biological motions suggested that children with ASD had a deficit in attending to biological motion.

Using point-light displays, the present study aims to further explore the nature of biological motion perception in 3–7-year-old children with ASD and aged-matched TD children with two specific tasks. Firstly, the *looking preference task* in Experiment 1 adopted Annaz et al.'s (2012) paradigm and examined children's looking preferences for human and non-human biological motion stimuli in point-light displays. In particular, inspired by Simion et al.'s (2008) demonstration that 2-day-old human infants exhibited a looking preference for an upright point-light display depicting a hen walking over its