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Schematic and realistic biological motion identification in children with high-functioning Autism Spectrum Disorder

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ABSTRACT

Research investigating biological motion perception in children with ASD has revealed conflicting findings concerning whether impairments in biological motion perception exist. The current study investigated how children with high-functioning ASD (HF-ASD) performed on two tasks of biological motion identification: a novel schematic motion identification task and a point-light biological motion identification task. Twenty-two HF-ASD children were matched with 21 TD children on gender, non-verbal mental, and chronological, age (*M* years = 6.72). On both tasks, HF-ASD children performed with similar accuracy as TD children. Across groups, children performed better on animate than on inanimate trials of both tasks. These findings suggest that *identification* of both realistic and schematic biological motion is unimpaired in children with HF-ASD.

1. Introduction

One of the most robust and replicable findings in psychology is that the visual system is exquisitely tuned to detect point-light biological motion (Blake & Shiffrar, 2007). In typical development, newborn infants and toddlers have been shown to prefer biological motion over non-biological motion (Simion, Regolin, & Bulf, 2008) or inverted motion (Klin, Lin, Gorrindo, Ramsay, & Jones, 2009). The predisposition to attend to biological motion has been shown in typical development using multiple methods including, point-light display (Klin et al., 2009; Morita et al., 2012; Simion et al., 2008), schematic motion such as the Michotte "caterpillar" stimulus (Michotte, 1963; Schlottmann & Ray, 2010), and the motion of a single animated dot (Rutherford, Pennington, & Rogers, 2006; Schultz & Bulthoff, 2013). This early sensitivity and preference for animate motion has been difficult to reconcile with some research suggesting that individuals with Autism Spectrum Disorder (ASD) have deficits in biological motion perception (Annaz et al., 2010; Annaz, Campbell, Coleman, Milne, & Swettenham, 2012; Blake, Turner, Smoski, Pozdol, & Stone, 2003; Centelles, Assaiante, Etchegoyhen, Bouvard, & Schmitz, 2013; Congiu, Schlottmann, & Ray, 2010; David et al., 2014; Herrington et al., 2007; Kaiser, Delmolino, Tanaka, & Shiffrar, 2010; Klin et al., 2009; Koldewyn, Whitney, & Rivera, 2010; Koldewyn, Whitney, & Rivera, 2011). However, a number of other studies do not support the contention that biological motion processing deficits are characteristic of ASD, particularly among high-functioning, older individuals with ASD (Cleary, Looney, Brady, & Fitzgerald, 2013; Freitag et al., 2008; Hubert et al., 2007; Moore, Hobson, & Lee, 1997; Murphy, Brady, Fitzgerald, & Troje, 2009; Parron et al., 2008; Rutherford & Troje, 2012; Saygin, Cook, & Blakemore, 2010).

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The processing of biological motion has been hypothesized to relate to the development of core cognitive abilities such as the ability to differentiate animate and inanimate categories (Gelman & Opfer, 2002; Mandler, 1992; Opfer & Gelman, 2010; Rakison & Poulin-Dubois, 2001), as well as social-cognitive abilities, commonly affected in individuals with ASD. The aims of the current research are to (a) investigate whether children with high-functioning ASD (HF-ASD) identify animate (biological) and inanimate (mechanical) motion and (b) explore whether children's performance on biological motion identification tasks relate to parental report of ASD symptoms.

Animate motion cues such as an entity's ability to cause the motion of another entity at a distance, change direction or speed, and engage in self-propulsion are important for the development of the concept of living and non-living things in infancy (Csibra, 2008; Csibra, Gergely, Biro, Koos, & Brockbank, 1999; Mandler, 1992; Premack, 1990; Rakison & Poulin-Dubois, 2001; Schlottmann, Surian, & Ray, 2009; Tremoulet & Feldman, 2000). Similarly, typically-developing (TD) preschool and school-aged children use motion information to guide their animacy judgements (Gelman & Coley, 1990; Mak & Vera, 1999). However, this research has not specifically evaluated whether biological motion, as a single animacy cue, is sufficient for typically-developing children and children with HF-ASD to accurately differentiate animate–inanimate categories. The current research aims to investigate this question using a novel schematic motion categorization task.

Research regarding the perception of biological motion has generally used point-light displays (Johansson, 1973), or schematic, non-rigid "caterpillar" motion (Michotte, 1963). Different aspects of biological motion are emphasized with each method and existing research has yet to compare performance across methodologies. Whereas point-light biological motion emphasizes the "gravity-defined trajectory" of the limbs of living organisms (Troje, 2013), schematic motion depicts non-rigid, expansion–contraction movement, which only animate beings are capable of. One advantage of using schematic biological motion over point-light displays is that schematic motion stimuli do not provide information about the general form of the organism (e.g. limbs), and therefore the attribution of animacy is based on the object's motion alone. While schematic biological motion is an advantageous method to study the perception of animacy, the majority of studies testing biological motion understanding in children with ASD have primarily used point-light display (PLD).

1.1. *Point-light biological motion*

Point-light displays depict the movement of an animate being by placing point-light dots on all the major joints of the body while rendering the rest of the body invisible. Although the resulting motion is considerably degraded, the point-light markers have been shown to convey important information about both the structure of the body and the dynamic movements of each of the parts (Chang & Troje, 2008; Troje, 2002). In one of the few studies to examine the development of children's ability to identify biological motion, Pavlova, Krägeloh-Mann, Sokolov, and Birbaumer (2001) found that 5-year-old children could accurately identify animate point-light displays of humans, dogs, and birds with the presentation of a single motion trial (Pavlova et al., 2001). However, children were not tested on their ability to identify non-biological, or mechanical motion, as a comparison. Other research has investigated how well human and mechanical motion is visually detected in typically-developing children, adults, and young adults with ASD. Kaiser et al. (2010) presented coherent and scrambled motion point-light displays of a human and a tractor, which were either masked (among noise) or unmasked. Scrambled motion displays contain the same dots as coherent motion, but are displaced to remove the form cues present in coherent motion displays. While both TD groups showed greater visual sensitivity to human motion (both masked and unmasked), compared to the motion of a tractor, young adults with ASD (*M* age = 20) showed equal sensitivity to the motion of a human or a tractor.

The large majority of investigations concerning how children with ASD perceive biological and mechanical motion have been confined to studies of visual preference and discrimination, while few studies provide a direct test of how children identify the form represented in point-light displays. Of the studies that have asked children with ASD to verbally identify biological motion displays, most have involved identifying complex physical actions (Swettenham et al., 2013), subjective states, or emotions (Hubert et al., 2007; Moore et al., 1997; Parron et al., 2008). While children's ability to identify an agent's emotions and internal states when presented using point-light display has been investigated, how accurately children with ASD identify animate vs. inanimate motion exemplars has yet to be examined. In the current study, we compare children with HF-ASD with typically-developing (TD) children on their ability to identify biological and mechanical motion point-light displays. Additionally, we wanted to explore whether children are equally able to identify schematic, compared to point-light, biological motion.

1.2. *Schematic biological motion*

Classic studies by Michotte (1963), Heider and Simmel (1944), Premack (1990), and Tremoulet and Feldman (2000) demonstrate how the motion of simple geometric forms is sufficient to give rise to the impression of animacy. This perception of animacy has been described as a rapid, automatic, and largely stimulus-driven process (Heider & Simmel, 1944; Schlottmann & Ray, 2010). Schematic presentations of biological motion such as the Michotte "caterpillar" depict a rectangular-shaped stimulus that moves by elongating from one side, then contracting on the opposite side. These stimuli have been shown to elicit the perception of goal-directedness in infants as young as 6 months of age (Schlottmann & Ray, 2010) and are judged as 'animal-like' by typically-developing children as young as 3 years of age (Schlottmann, Allen, Linderoth, & Hesketh, 2002).