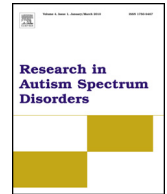




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Biological motion and the animate–inanimate distinction in children with high-functioning Autism Spectrum Disorder



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ABSTRACT

The current study examined whether children with high-functioning Autism Spectrum Disorder (HF-ASD) preferentially attend to point-light displays of biological, compared to mechanical motion. We hypothesized that children's attentional patterns toward the motion of living things would be reduced compared to typically developing (TD) children. Children also completed two categorization tasks measuring the animate–inanimate distinction. Children with HF-ASD were matched with TD children ($n = 18$ per group) on age, gender, and verbal ability. Overall, children with HF-ASD attended to biological and non-biological motion equally, whereas TD children demonstrated a preference for inanimate motion. Children with HF-ASD were also unimpaired in the formation of animate and inanimate concepts. Among children with HF-ASD, a link between attention to motion and categorization ability was observed, but only for inanimate objects. TD and HF-ASD groups differed in that visual exploration of the motion videos (e.g., saccades) was related to animate–inanimate categorization only among children with HF-ASD. These results are discussed as a low-level test of the social attention/orienting hypothesis.

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1. Introduction

Investigations of children's preference for social, compared to non-social, aspects of the environment have gained momentum, particularly as these investigations relate to the social motivation theory of ASD. Research has shown that one of the earliest behavioral markers associated with ASD is abnormal attentional preference for non-social aspects of the environment (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Swettenham et al., 1998; Webb et al., 2010). Specifically, this research has shown that infants with ASD as young as 20 months demonstrate social orienting deficits, whereby they are less likely to orient their gaze toward people, more likely to shift their gaze from object to object (Swettenham et al., 1998), show a lack of preference for social compared to geometric scenes (Pierce, Conant, Hazin, Stoner, & Desmond, 2011), and spend less time attending to faces during dynamic social interactions (Shic, Bradshaw, Klin, Scassellati, & Chawarska, 2011).

In addition to deficits in orienting toward realistic social stimuli, evidence for an early emerging disruption in attention to the biological motion of animate beings has also been consistently reported in toddlers with ASD (Klin & Jones, 2008). Specifically, whereas even TD newborns orient toward biological motion and prefer this motion compared to random or scrambled the motion (Bardi, Regolin, & Simion, 2010; Simion et al., 2008), toddlers and young children with ASD pay less attention to biological motion compared to non-social motion (Annaz, Campbell, Coleman, Milne, & Swettenham, 2012;

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Falck-Ytter et al., 2013; Klin, Lin, Gorrindo, Ramsay, & Jones, 2009). This disruption in visual preference for biological motion has been proposed as a hallmark of ASD (for a review see Kaiser & Pelphrey, 2012; Pavlova, 2011, 2013).

Another body of research challenges the notion that deficits in biological motion perception and social orienting are a universal feature of ASD, and instead supports the notion that these abilities are either compensated for, or have had the opportunity to develop, by adolescence or adulthood (Cleary, Looney, Brady, & Fitzgerald, 2013; Freitag et al., 2008; Hubert et al., 2007; Moore, Hobson, & Lee, 1997; Murphy, Brady, Fitzgerald, & Troje, 2009; Rutherford & Troje, 2012; Saygin, Cook, & Blakemore, 2010). Recently, Flanagan, Brodeur, and Burack (2015) expanded on these developmental findings by showing that that pre-adolescent children with ASD (CA = 10 years, NVMA = 8.5 years) were unimpaired in visually orienting toward social, compared to non-social, stimuli. Thus, one of the main goals of the present study was to test whether younger children with high-functioning ASD (HF-ASD) orient toward biological motion and/or show an attentional preference for biological motion when contrasted with both mechanical and random motion.

It is also possible that the observed deficits in biological motion perception are part of a broader pattern of deficits in animacy perception, which affect the perception of a host of animate motion cues. Previous research has identified deficits in the use of other animate motion cues (e.g., contingency, acceleration, deceleration, self-starting) when children with ASD make animacy attributions (Klin & Jones, 2006; Johnson & Rakison, 2006; Rutherford, Pennington, & Rogers, 2006). Additionally, although children with ASD have been shown to possess knowledge of the motion patterns of animates (e.g., having legs is correlated with walking), they were found to lack knowledge of the broader significance of possessing legs in relation to the animate concept (e.g., things with legs are living) (Johnson & Rakison, 2006). Children with HF-ASD have also been found to be more likely to describe the biological motion of a stimulus using inanimate descriptors (e.g., rectangles), while TD children, in contrast, used animate descriptors (e.g., caterpillars) (Congiu, Schlottmann, & Ray, 2010). In sum, research addressing animacy perception in children with ASD largely suggests deficits in the formation of an animacy concept based on motion cues. However, the ability to form animate and inanimate categories among children with ASD has yet to be investigated. Thus, a secondary goal of this research was to test whether children with HF-ASD were impaired on cognitive measures of the animacy concept, namely the ability to form explicit animate and inanimate categories.

In typical development, research investigating the development of an implicit form of animacy concept among infants supports the notion that attention to motion plays a key role in cognitive development (Gelman & Spelke, 1981). Theorists have identified motion as an organizational mechanism that directs infants' attention to socially relevant information, such as whether an entity is animate or inanimate, is goal directed, or is intentional (Gelman & Opfer, 2002; Mandler, 1992; Opfer & Gelman, 2010; Rakison & Poulin-Dubois, 2001). More recently, infants' ability to differentiate implicit animate and inanimate concepts was shown to be facilitated by animate, biological motion cues (Poulin-Dubois, Crivello, & Wright, 2015). However, the question of whether motion continues to be important to the development of children's explicit animate versus inanimate (A–I) categories remains to be explored. The development of A–I categories in TD children has primarily been investigated using tasks requiring categorical inferences based on biological properties (Gottfried & Gelman, 2005; Inagaki & Hatano, 1996; Jipson & Gelman, 2007; Margett & Witherington, 2011). This body of research has shown that knowledge of biological properties such as the ability to eat, grow, think, and feel, as well as the internal structure of animates, emerges between 4 and 6 years of age. In one of the few studies to examine the ability to form animate and inanimate taxonomic categories, Wright, Poulin-Dubois and Kelley (2015) showed that by 5 years of age A–I categorization was above chance, but was not as well developed as adults'.

Whether children with ASD form animate–inanimate level categories similar to their TD peers has not been thoroughly investigated. However, there is reason to hypothesize that the A–I categories would be particularly challenging for children with ASD given that such global categories possess few common observable features. Therefore, unlike lower level categories such as dogs, or vehicles, A–I categories cannot be easily formed using a rule-based strategy. It has been suggested that children with ASD rely on a rule-based approach to categorization (Klinger & Dawson, 2001). Furthermore, the detail-focused cognitive style characteristic of ASD (Happé & Frith, 2006) may make it difficult for children to identify broader categories such as animates and inanimates.

The current body of research has yielded inconsistent findings concerning whether deficits in categorization at less inclusive levels are present in ASD (e.g., Gastgeb, Strauss, & Minshew, 2006; Klinger & Dawson, 2001; Molesworth, Bowler, & Hampton, 2005; Soulières, Mottron, Giguère, & Laroche, 2011). For instance, Gastgeb et al. (2006) showed that while 10-year-old children with high-functioning ASD were unimpaired in categorizing superordinate (e.g., animal) and basic (e.g., dog) level categories, they responded more slowly when exemplars deviated from the most typical instances of a particular category. Other research using an object sorting procedure, however, showed that mental age matched individuals with ASD (mental age of 9 years) were impaired in categorizing representational objects from basic and superordinate level categories compared to individuals with intellectual disability and TD children (Shulman, Yirmiya, & Greenbaum, 1995). In the extant literature, there has yet to be an investigation of whether children with ASD form the A–I distinction by attending to the same information as TD children, or do so on the same developmental timetable. This area of inquiry is particularly relevant given the evidence that children with ASD attend to inanimate as opposed to animate aspects of their environment. Thus, it may be expected that children who attend to inanimate aspects of the environment (i.e., inanimate biological motion) may be better able to categorize inanimate, as opposed to animate stimuli, while the converse would be expected to be true for children who show an attentional preference toward animates.

The goals of the current investigation were thus threefold. The first goal was to test the assumption that deficits in attention to animate, biological motion stimuli are present in young school-aged children with HF-ASD. Secondly, this

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