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Brief Report

Biological motion perception links diverse facets of theory of mind during middle childhood

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ABSTRACT

Two cornerstones of social development—social perception and theory of mind—undergo brain and behavioral changes during middle childhood, but the link between these developing domains is unclear. One theoretical perspective argues that these skills represent domain-specific areas of social development, whereas other perspectives suggest that both skills may reflect a more integrated social system. Given recent evidence from adults that these superficially different domains may be related, the current study examined the developmental relation between these social processes in 52 children aged 7 to 12 years. Controlling for age and IQ, social perception (perception of biological motion in noise) was significantly correlated with two measures of theory of mind: one in which children made mental state inferences based on photographs of the eye region of the face and another in which children made mental state inferences based on stories. Social perception, however, was not correlated with children's ability to make physical inferences from stories about people. Furthermore, the mental state inference tasks were not correlated with each other, suggesting a role for social perception in linking various facets of theory of mind.

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Introduction

Preferential attention to biological motion—most often assessed via point-light displays in which dots are placed on the joints of a moving human figure (Johansson, 1973)—is an evolutionarily conserved and early emerging ability hypothesized to serve as an ontogenetic and phylogenetic foundation for humans' higher order social cognition (Frith & Frith, 1999; Klin, Lin, Gorrindo, Ramsay, & Jones, 2009; Pavlova, 2012). In evaluating this claim of a broader role for biological motion perception, determining the relation between this basic perceptual capacity and theory of mind (ToM) is of particular interest. ToM, or inferring and reasoning about the mental states of others, is a complex instantiation of social cognition hypothesized to rely on separate behavioral and neural systems than biological motion perception (Gweon & Saxe, 2013; but see Yang, Rosenblau, Keifer, & Pelphrey, 2015). Finding that variability in biological motion perception can explain variance in ToM would provide evidence that these two distinct tasks may rely on a common social processing system.

Two recent studies have found a relation between biological motion perception and ToM. Phillips et al. (2011) sampled a wide age range of adults and found that the ability to make social judgments (e.g., emotional inference) about a point-light display correlated with false belief reasoning. However, because the biological motion task required emotional inference, the relation may have been driven by common variance in higher order social abilities. In contrast, Miller and Saygin (2013) employed a biological motion task that presented a point-light figure walking in place and required no mental state inference. Adults who were better able to detect the direction that the walking point-light figure was facing (i.e., right or left) while the figure was embedded in increasing levels of noise were better able to infer mental states from a photograph of someone's eyes (i.e., face-based ToM). Interestingly, participants' ability to determine whether the biological figure was walking backward (i.e., "moonwalking") or forward (regardless of whether the figure was facing left or right) was not correlated with face-based ToM. The differential behavioral correlates of facing versus walking direction judgments may be explained by adult research indicating that these judgments differentially rely on form information (used to determine facing direction) versus motion information (used to determine walking direction) (Thompson, Clarke, Stewart, & Puce, 2005). These findings suggest that, at least during adulthood, face-based ToM is related to form-based biological motion perception.

In addition to research with typical adults, clinical evidence has suggested a possible link between biological motion perception and social cognition. For example, individuals with autism spectrum disorders have deficits in both biological motion perception (e.g., Blake, Turner, Smoski, Pozdol, & Stone, 2003; Klin et al., 2009) and ToM (reviewed in Tager-Flusberg, 2007), and these impairments correlate with symptomatology (Blake et al., 2003). Similar patterns have been found in schizophrenia, a disorder that includes deficits in both ToM (Bora, Yucel, & Pantelis, 2009) and biological motion perception (Kim, Park, & Blake, 2011). Furthermore, biological motion processing also tends to be less typical in disorders with larger social impairments (e.g., fragile X syndrome) versus disorders with more preserved social skills (e.g., Williams syndrome) (reviewed in Pavlova, 2012). Most clinical studies, however, have not examined higher order social cognition and biological motion processing in the same sample, leaving open the question of whether these domains are linked on an individual level.

Middle childhood (roughly 7–12 years of age) is an important time to examine the relation between biological motion and ToM. Children's ability to detect biological motion in visually noisy displays increases throughout middle childhood (Hadad, Maurer, & Lewis, 2011), and these behavioral changes coincide with increased neural specialization for processing biological motion (Carter & Pelphrey, 2006). During this same developmental window, children's ToM improves across a variety of different tasks (Apperly, Warren, Andrews, Grant, & Todd, 2011; Banerjee, Watling, & Caputi, 2011; Devine & Hughes, 2013; Dumontheil, Apperly, & Blakemore, 2010; Miller, 2012) and demonstrates increased neural specialization (Gweon, Dodell-Feder, Bedny, & Saxe, 2012). No existing studies, however, have examined the relation between these two domains during middle childhood.

Investigating the relation between ToM and biological motion processing during this time of specialization will provide clearer insight into whether both tasks rely on an integrated social processing system. A first possibility is that children will show the same pattern as adults (i.e., relation between ToM and judging the facing direction of a point-light display), providing evidence for a developmentally