Infant Behavior & Development 38 (2015) 97–106

Contents lists available at ScienceDirect

Infant Behavior and Development

The development of gaze behaviors in response to biological motion displays

Naoki Furuhata [a,*], Nobu Shirai [b]

[a] Department of Psychology, Graduate School of Letters, Kyoto University, Yoshida-Honmachi, Sakyo-ku, Kyoto 606-8501, Japan
[b] Department of Psychology, Faculty of Humanities, Niigata University, 2-8050 Ikarashi, Nishi-Ku, Niigata 950-2181, Japan

ARTICLE INFO

Article history:
Received 6 July 2014
Received in revised form 3 November 2014
Accepted 18 December 2014

Keywords:
Biological motion
Attention direction
9-month-old infants
12-month-old infants

ABSTRACT

Although the relationship between biological motion perception as depicted by point-light displays and social cognition has been investigated in recent decades, the developmental course of the integration of social cognition and the perception of biological motion is not well understood. To better understand this development, we investigated the ability of 9- and 12-month-old infants to shift their gaze toward a point-light upright human figure using a paradigm similar to that used by Yoon and Johnson (2009). We found that 12-month-old, but not 9-month-old, infants were able to follow the direction of attention of the upright point-light figure (Experiments 1 and 2). However, both the younger and older infants were able to follow the attentional shift of others under the full-view condition (Experimental 3). These results suggest that the ability to process the higher-level information provided by biological motion patterns, such as the attentional direction of others, develops by 12 months, but not by 9 months, of age. The relationship between the development of social cognition and that of biological motion perception is discussed.

1. Introduction

Social cognition plays an important role in social interaction and communication, and a significant amount of social information is extracted from others' body movements. The perception of biological motion is an example of the importance of body movement for social cognition. Biological motion as depicted in a point-light display conveys the motion of animate agents by showing only the motion of light dots on major joints of body (Johansson, 1973). Biological motion has two notable characteristics. First, biological motion contains characteristics of social stimuli despite its lack of key features (e.g., eye, face, hair, skin, and so on). In addition to body movement, we are able to perceive sex (Kozlowski & Cutting, 1977; Mather & Murdoch, 1994), emotion (Dittrich, Troscianko, Lea, & Morgan, 1996; Pollick, Paterson, Bruderlin, & Sanford, 2001), and individual identity (Cutting & Kozlowski, 1977; Troje, Westhoff, & Lavrov, 2005) from biological motion. Second, there is an inversion effect for biological motion perception; that is, human adults experience difficulty perceiving actions in point-light displays that are presented upside down (Pavlova & Sokolov, 2000; Sumi, 1984), suggesting that biological motion is related to global form processing. Furthermore, neuroimaging studies have shown that the superior temporal sulcus (STS) region is involved in social perception, including biological motion perception (Allison, Puce, & McCarthy, 2000). This region plays a pivotal role in processing biological motion (e.g., Grossman et al., 2000; Grossman & Blake, 2001, 2002).

* Corresponding author. Tel.: +81 8016168414.
E-mail address: n.furuhata.28@gmail.com (N. Furuhata).

http://dx.doi.org/10.1016/j.infbeh.2014.12.014
0163-6383/

Previous developmental studies have shown that the ability to detect biological motion develops within the first year of life (e.g., Bertenthal, Proffitt, & Cutting, 1984; Fox & McDaniel, 1982). However, the findings related to the developmental onset of biological motion perception are controversial. Although several investigators have reported that the ability to discriminate between biological and non-biological (scrambled or inverted) motion patterns develops around 3–5 months of age (Bertenthal et al., 1984; Fox & McDaniel, 1982), Simion, Regolin, and Bulf (2008) recently reported that 2-day-old infants were able to discrimination between biological and non-biological motion. Thus, the developmental origin of biological motion perception is an open question (cf. review by Hirai, Watanabe, Honda, & Kakigi, 2009). Moreover, the ability to perceive biological motion develops throughout childhood. For instance, Pavlova, Krägeloh-Mann, Sokolov, and Birbaumer (2001) demonstrated that 3-year-old children can discriminate between the point-light biological motion of humans and that of other animals and that 5-years-olds can do so at the same level reached by adults. Research conducted by Freire, Lewis, Maurer, and Blake (2006) also showed that 9-year-olds (but not 6-year-olds) can distinguish biological motion from masking noise as well as adults can.

The findings of previous developmental studies indicate that the perception of biological motion emerges in early infancy and changes throughout the course of childhood. Most previous developmental studies focused on the ability of infants and children to perceive biological motion and thus examined the processing of relatively low-level information from point-light displays of biological motion, including the detection of biological motion, identification of the direction of the motion, and the perception of animacy (e.g., Bertenthal et al., 1984; Kuhlmeier, Troje, & Lee, 2010). In contrast, little is known about the ability of infants and children to process higher-level social information from biological motion, which is required to interpret point-light individual states such as emotion and sex (Kuhlmeier et al., 2010). The developmental origin of higher-level processing in biological motion perception has significant implications for the development of social cognition. Biological motion may provide a compelling cue for the cognition of others' social states. Thus, biological motion perception likely plays a critical role in various social abilities early in development. However, the development of the social aspects of biological motion perception has been largely neglected by investigators, whereas the early development of other social abilities (such as facial processing) has attracted much research attention. It is important to shed light on the social aspects of biological motion perception in infancy to understand the gross or overall development of social cognition.

Yoon and Johnson (2009) conducted an empirical investigation of the social aspects of biological motion perception in infancy. Working with 12-month-old infants, they presented upright or inverted point-light displays showing an actor turned to the left or the right to look at a target and found that infants followed the attentional orientation of the point-light figure in the upright, but not the inverted, condition. This finding suggests that the perception of biological motion can elicit following behavior to in response others' attention in 12-month-old infants and that 12-month-old infants were able to construe "action" from the biological motion presented in a point-light display that had minimal information about social features (Kuhlmeier et al., 2010).

The findings of Yoon and Johnson (2009) suggest that 12-month-old infants are able to process higher-level information from a point-light display of biological motion. However, the authors did not examine the developmental onset of the ability to follow the attentional orientation of point-light figures. The behavior observed by Yoon and Johnson (2009) is similar to gaze following and joint attention, which emerges around 9 months of age (Tomasello, 1995; Corkum & Moore, 1995). Additionally, other studies have reported that 3- and 6-month-old infants were able to follow the direction of an adult's gaze (D'Entremont, 2000). Thus, it is likely that infants younger than 12 months of age would be able to follow the direction of a point-light figure's actions under an experimental setting similar to that of Yoon and Johnson (2009).

In the present study, we aimed to replicate and expand the findings of Yoon and Johnson (2009) by examining 9- and 12-month-old infants using an experimental paradigm similar to that employed by Yoon and Johnson (2009). We conducted three experiments to investigate the development of the ability to process higher-level information from point-light displays of biological motion. In Experiment 1, we used a paradigm nearly identical to that of Yoon and Johnson to replicate their findings in 12-month-old infants. In Experiment 2, we tested 9-month old infants to explore the developmental onset of shifting attention to the action of point-light-figures. The results of Experiments 1 and 2 indicated that 12-month-old, but not 9-month-old, infants were able to follow the attentional orientation of the point-light figure. In Experiment 3, we used full-light displays of biological motion to test whether the difference between 9- and 12-month-olds observed in Experiments 1 and 2 was related to the infants' ability to shift their gaze toward the actions of others.

2. Experiment 1

The aim of Experiment 1 was to replicate the findings of Yoon and Johnson (2009); thus, we tested 12-month-old infants using a protocol similar to that used in their study.

2.1. Method

2.1.1. Participants

Fourteen 12-month-old infants participated in Experiment 1 (mean age = 354.36 days; range = 331–397 days; $SD \pm 21.99$; six males and eight females). All infants were healthy full-term babies who weighed >2500 g at birth. Four additional infants were tested but were excluded from the analyses for fussiness, defined as being inattentive to the visual stimuli in three