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Walking direction triggers visuo-spatial orienting in 6-month-old infants and adults: An eye tracking study

Lara Bardi [a,b,*], Elisa Di Giorgio [c,d], Marco Lunghi [c], Nikolaus F. Troje [e], Francesca Simion [c,f]

[a] Department of Experimental Psychology, Ghent University, Belgium
[b] Department of General Psychology, University of Padova, Italy
[c] Department of Developmental and Social Psychology, University of Padova, Italy
[d] CIMeC, University of Trento, Italy
[e] Queen's University, Canada
[f] Center of Cognitive Neuroscience of Padova, Italy

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ABSTRACT

The present study investigates whether the walking direction of a biological motion point-light display can trigger visuo-spatial attention in 6-month-old infants. A cueing paradigm and the recording of eye movements in a free viewing condition were employed. A control group of adults took part in the experiment. Participants were presented with a central point-light display depicting a walking human, followed by a single peripheral target. In experiment 1, the central biological motion stimulus depicting a walking human could be upright or upside-down and was facing either left or right. Results revealed that the latency of saccades toward the peripheral target was modulated by the congruency between the facing direction of the cue and the position of the target. In infants, as well as in adults, saccade latencies were shorter when the target appeared in the position signalled by the facing direction of the point-light walker (congruent trials) than when the target appeared in the contralateral position (incongruent trials). This cueing effect was present only when the biological motion cue was presented in the upright condition and not when the display was inverted. In experiment 2, a rolling point-light circle with unambiguous direction was adopted. Here, adults were influenced by the direction of the central cue. However no effect of congruency was found in infants. This result suggests that biological motion has a priority as a cue for spatial attention during development.

1. Introduction

Humans are intensely social creatures. Our ability to efficiently interact with others strongly depends on our capacity to recognize and respond to biological signals, such as for example eye gaze and body motion, which are among the most important source of socially relevant information.

Previous studies demonstrated that social cues can trigger visuo-spatial orienting of attention in adults: averted gaze of another person can automatically induce the observer to shift attention toward the location signalled by the averted gaze (e.g., Driver et al., 1999; Friesen & Kingstone, 1998). The capacity to identify the direction of another person's attention and to orient our own attention accordingly is particularly relevant because it allows humans to draw inferences about the intentions and future

* Corresponding author at: Department of Experimental Psychology, Ghent University, Henri Dunantlaan 2, 9000 Gent, Belgium. Tel.: +32 264 94 27; fax: +32 264 64 96.
E-mail address: lara.bardi@ugent.be (L. Bardi).

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behavior of others. Evidence for the idea that social cues can effectively affect orienting comes from studies adopting variants of Posner's cueing paradigm. According to the Posner's theory of costs and benefits, when attention moves to a particular location (such as for example the direction of an arrow), the visual processing of targets present in the cued location is facilitated (Posner, 1978). Consequently, reaction times are faster if the target appears in the cued position (congruent trials) and slower if the target appears in the uncued position (incongruent trials). Spatial cueing studies usually make a distinction between exogenous orienting, which typically occurs when a non symbolic cue, such as a brief flash of light, appears on one side of a computer screen and endogenous orienting, which occurs in response to symbolic cues (such as the words "right" or "left") presented in the center of the screen. Adapting the spatial cueing paradigms, a series of studies has shown that the gaze direction of a centrally presented face can trigger automatic visuo-spatial orienting, even if gaze direction does not predict where a target item may appear and/or the observer is explicitly asked to ignore the cue (e.g., Driver et al., 1999; Friesen & Kingstone, 1998; Langdon & Bruce, 1999). A typical task involves the presentation of a central stimulus depicting a face with averted gaze and the subsequent presentation of a peripheral target. The congruency between the direction of non-predictive gaze cues and target position has been shown to modulate target discrimination (e.g., Driver et al., 1999; Friesen & Kingstone, 1998) saccade's reaction times (e.g., Deaner & Platt, 2003) and latency accuracy of gaze shifts (e.g., Ricciardelli, Bricolo, Aglioti, & Chelazzi, 2002). These findings suggest that averted gaze is a socially and biologically relevant signal able to trigger automatic shifts of attention.

Although the special nature of orienting effects induced by social stimuli as compared to orienting attention by non social cues is still under debate, a number of studies suggests that visuo-spatial orienting due to social cues and non-social cues (such as arrows) determines different behavioral effects and relies on different processes (Friesen, Ristic, & Kingstone, 2004; Langdon & Smith, 2005) and distinct neural system (Calleias, Shuman, & Corbetta, 2014; Hietanen, Nummenmaa, Nyman, Parkkola, & Hämäläinen, 2006; Kingstone, Tipper, Ristic, & Ngan, 2004; Lockhofen, Gruppe, Ruprecht, Gallhofer, & Sammer, 2014; but see Greene, Mooshagian, Kaplan, Zaidel, & Iacoboni, 2009). For instance, Friesen et al. (2004) used a counter-predictive spatial cueing task that induces a bias to expect the target to appear at the opposite to gazed-at location in the observer. In this task, nevertheless, the gaze cues resulted in attention shifts to the gazed-at locations. Importantly, this kind of counter-predictive cuing was not observed with arrow cues. Kingstone et al. (2004) investigated brain activation during an attentional orienting task by using an ambiguous figure that could be perceived as a gaze cue (a hat pulled down to the eyes) or as a nonsocial directional cue (a car with eccentric wheels). The standard behavioral cuing effect was observed in both cases. When contrasting orienting by (perceived) gaze and car cues, the results revealed that activity in the area of superior temporal sulcus (STS), an area known to be involved in face and gaze processing, was increased when the stimulus was perceived as eyes as compared to condition in which it was perceived as a car.

Recently, a similar effect to that obtained for gaze has been discovered for another socially relevant stimulus, namely the motion of the human body. Several studies have demonstrated that the visual system is remarkably adept at recognize the motion of a human body even when it is portrayed by just a few dots moving as placed on the main joints of a person (Johansson, 1973). From such point-light biological motion display, observers can retrieve ample information, such as actions (Dittrich, 1993), emotions (Dittrich, Troscianko, Lea, & Morgan, 1996), and walking direction (Hirai, Saunders & Troje, 2011; Troje & Westhoff, 2006). This is true as long as the display is presented upright. Performance in almost all the tasks drops when the display is presented upside-down, thus revealing a strong inversion effect (e.g., Chang & Troje, 2009; Hirai, Chang, Saunders, & Troje, 2011; Sumi, 1984; Troje & Westhoff, 2006), a phenomenon already known for face perception (Yin, 1969).

Walking direction is an important attribute of biological motion, which provides critical information about another living creature's disposition and intention. By adopting a central cueing paradigm, Shi, Weng, He, & Jiang (2010) demonstrated that the walking direction of an upright point-light biological motion display induced an automatic shift of visuo-spatial attention in the observers. In this study, participants were asked to discriminate the orientation of a laterally presented gabor patch. The target was preceded by a point-light sequence depicting a human walker, an animal walker, a static human point-light figure or a rolling point-light circle. Results revealed that, although participants were explicitly told that the direction of the cue was not predictive of the position of the target, accuracy in a discrimination task was significantly better when the position of the target was congruent with the facing direction of an upright walking human or animal cue than when it did not. This result revealed that automatic orienting of attention can be elicited by upright biological motion. In the study of Hirai, Saunders et al. (2011), the latency to make a saccade to a peripheral target was measured under condition in which the location of the target was congruent or incongruent with the facing direction of a centrally presented point-light walker (upright or inverted). Participants were asked to orient their eyes either toward the right or the left according to the color of the cue. Results revealed that saccade latency and accuracy were affected by the facing direction of the central walker and this was true only when the target was presented upright.

Finally, using a Simon effect task, Bosbach, Prinz, & Kerzel (2004), observed a stimulus–response compatibility effect with point-light walkers. In this task, participants were asked to respond to the color of the dots representing the walker. Although the walking direction of the point-light display was irrelevant for the task, responses were faster and less error prone when the facing direction of the walker and the response position corresponded than when they do not.