Psychon Bull Rev (2017) 24:447–452
DOI 10.3758/s13423-016-1083-9

BRIEF REPORT

Backward-walking biological motion orients attention to moving away instead of moving toward

Xiaowei Ding[1] · **Jun Yin**[1,2] · **Rende Shui**[1] · **Jifan Zhou**[1] · **Mowei Shen**[1]

Published online: 1 July 2016

Abstract Walking direction is an important attribute of biological motion because it carries key information, such as the specific intention of the walker. Although it is known that spatial attention is guided by walking direction, it remains unclear whether this attentional shift is reflexive (i.e., constantly shifts to the walking direction) or not. A richer interpretation of this effect is that attention is guided to seek the information that is necessary to understand the motion. To investigate this issue, we examined how backward-walking biological motion orients attention because the intention of walking backward is usually to avoid something that walking forward would encounter. The results showed that attention was oriented to the walking-away direction of biological motion instead of the walking-toward direction (Experiment 1), and this effect was not due to the gaze direction of biological motion (Experiment 2). Our findings suggest that the attentional shift triggered by walking direction is not reflexive, thus providing support for the rich interpretation of these attentional effects.

Keywords Biological motion · Backward walking · Spatial attention · Lean interpretation · Rich interpretation

Xiaowei Ding and Jun Yin contributed equally to this work.

Electronic supplementary material The online version of this article (doi:10.3758/s13423-016-1083-9) contains supplementary material, which is available to authorized users.

✉ Jifan Zhou
jifanzhou@zju.edu.cn

✉ Mowei Shen
mwshen@zju.edu.cn

[1] Department of Psychology and Behavioral Sciences, Zhejiang University, Xixi Campus, Hangzhou 310028, People's Republic of China

[2] Department of Psychology, Ningbo University, Ningbo, People's Republic of China

Humans are very sophisticated in their ability to detect biological motion signals and use them as cues to influence their own actions (for a review, see Blake & Shiffrar, 2007; Thompson & Parasuraman, 2012). Walking is an important motion signal that conveys action and intent to observers. Humans can easily and sensibly detect walking direction (Sweeny, Wurnitsch, Gopnik, & Whitney, 2013; Thompson, Hansen, Hess, & Troje, 2007; Thornton & Vuong, 2004). Perhaps more important, walking direction can reflexively and robustly orient our spatial attention to the direction of motion. This phenomenon was first documented by Shi, Weng, He, and Jiang (2010) and further confirmed by follow-up studies in both neuroscience (Wang, Yang, Shi, & Jiang, 2014) and development domains (Bardi, Di Giorgio, Lunghi, Troje, & Simion, 2015; Zhao et al., 2014). It was suggested that such effects ensure a fast attentional shift to the future path of observed persons, thus making our social interactions more effective (Bardi et al., 2015).

However, it is still unknown what aspects of walking behavior drive attentional shifts and therefore where attention is focused when viewing walking motion. It is possible that we simply attend to the location the walker is approaching. This interpretation implies that spatial attention constantly shifts to the walking direction regardless of the potential intent underlying the motion, similar to the mechanisms that drive attentional shifts caused by nonbiological motion, such as a moving ball (for adult evidence, see Bardi et al., 2015; for infant evidence, see Wronski & Daum, 2014). Another possible interpretation is arguably more subtle: Biological motion might not trigger reflexively attentional shifts to the direction of motion; rather, the motion may direct attention to seek more information so as to understand the current event. In particular, to understand the motion, the attentional system could be evoked to seek cues to the cause of the motion. These may be internal (what does the agent *want* to do?) and external (what drives the agent to do this?). Given that the internal cause, or mental state, of the agent is not observable, inferring the internal cause also relies on external cues. Thus, it is important for individuals to attend to the location where the potential cues to the cause of the biological motion are likely found. This interpretation may be difficult to immediately appreciate, but it is intuitive if one imagines biological motion in a real-life scene. For example, when a man walks toward a drinking fountain, we understand that he wants a drink of water, and we will naturally attend to the fountain. However, we will not attend to the direction of motion of a man running away from a smoking car. Instead, we will focus our attention on the car in order to make sense of the man's behavior. In this case, the attentional orienting triggered by biological motion reflects a more complicated mechanism, and a deep analysis of the motion is required to deploy attention. As a result, objects or events that are important for understanding the structure of the environment, including the physical, social, and causal relationships among objects, might receive a greater share of processing resources. This interpretation suggests that the attentional system does much more than simply follow walking direction.

These two kinds of interpretation are also found in other social attention studies. For example, in gaze-cue studies, researchers have found that other person's gaze direction automatically guides spatial attention (Driver et al., 1999; Friesen & Kingstone, 1998). Such a gaze-cue effect could be interpreted as attention shifting reflexively to the gaze direction (Friesen & Kingstone, 1998; Friesen, Moore, & Kingstone, 2005; Friesen, Ristic, & Kingstone, 2004; Langton & Bruce, 1999). In contrast, other researchers suggest that the visual system infers others' attentional focus from gaze cues and shifts attention to joint it, so that gaze cues function as a mechanism that aligns our attention with others (as reviewed by Teufel, Fletcher, & Davis, 2010). As evidence, such joint attention can be elicited by a gaze cue from an agent wearing sunglasses, but if the agent wears occluders (Nuku & Bekkering, 2008), indicating that the inferred attentional focus of others determines where we attend. A similar debate also occurred in developmental psychology with respect to interpreting the gaze-following behavior of infants: Either the gaze-following behavior is an innate reflex to follow the gaze of others, or infants align their attention to what another is looking at based on attributions about the intentions of other people. Carey (2009) terms these *lean* and *rich* interpretations, respectively. That is, the lean interpretation regards gaze-following behavior as a reflexive response to the gaze direction, while the rich interpretation assumes a "smart" mechanism that is capable of making agentive attributions in support of gaze-following behavior. Although the lean interpretation is plausible on the basis of the early occurrence of gaze-following behavior (Hood, Willen, & Driver, 1998), Carey (2009) argued that the rich interpretation is also possible because a wealth of evidence shows that the representation of eye gaze is integrated with representations of an agent's goals (e.g., Luo & Baillargeon, 2005; Johnson, Shimizu, & Ok, 2007; Shimizu & Johnson, 2004). However, with respect to the attentional effects induced by biological motion, no empirical evidence has provided a distinction between lean and rich interpretations, even for adults who already have a mature cognitive system.

The first step in testing the lean and rich interpretations for the attention orienting induced by biological motion is to investigate whether the attentional system reflexively responds to the movement orientation of the biological motion. The present study examined the reflexive hypothesis through the use of novel stimuli—*backward-walking* biological motion. All previous studies used forward-walking stimuli that predict the same results for both the lean and rich interpretations. The intention for forward-walking is usually to approach something; thus, the rich interpretation predicts an attention shift toward the moving direction, and that is identical to the lean interpretation. The intention underlying walking backwards is usually to avoid something while maintaining attention on it; thus, the rich interpretation might predict that attention would be to where the cause of the walking-away action is likely to be found (this is not an exclusive prediction: The rich interpretation could make other predictions, but this is one possibility). Thus, in the case of backward walking, if observers still shift their attention to the direction of motion, which is the back direction of the walker, the reflexive hypothesis is likely correct. Otherwise, if attention shifts to the walking-away direction, although we cannot conclude that the rich interpretation is correct, at least this would demonstrate that the attentional shift does not stick to the direction of motion, thus the attentional orienting induced by biological motion is likely to have a richer interpretation.

Experiment 1a

Method

Participants

Twenty students from Zhejiang University (11 women and 9 men, 19–25 years old) were paid 20 RMB each to participate in the current study and signed consent forms. All participants had normal or corrected-to-normal visual acuity and were naïve to the purpose of the study. The sample size was decided based on our pilot study where we tested 20 participants and replicated the findings of previous studies (Shi et al., 2010;

Wang et al., 2014). The study was approved by the Institutional Review Board (IRB) at the Department of Psychology and Behavioral Sciences, Zhejiang University.

Stimuli

Point-light displays (PLDs) were used to display walking. They were selected from the Motion Capture Database (http://mocap.cs.cmu.edu) built by the Graphics Lab at Carnegie Mellon University. This database has many types of PLDs, consisting of 13 points of light with 60 frames/s. The distribution of these 13 points were located in the following locations on the body: one on the head, two on the shoulders, two on the elbows, two on the wrists, two on the hips, two on the knees, and two on the ankles. We chose a sequence with backward-walking motion from the database (see Video S1 in the Supplementary Material for demonstrations of the stimuli) as our experimental stimulus. In a pilot experiment, we successfully replicated the result of a previous study (Shi et al., 2010) using the forward-walking version of these PLD stimuli. The backward-walking PLDs were displayed on a 19-inch CRT screen (resolution: 1024 × 768; refresh rate: 60 Hz) using MATLAB (Mathworks, Inc.) with Psychophysics Toolbox extensions (Brainard, 1997; Pelli, 1997). When presenting the PLDs to participants, we presented a continuous epoch of 30 frames (i.e., 0.5 s). The initial frame was randomized for each trial to avoid participants predicting the motion.

Procedure and design

The experiment was conducted in a dark and sound-attenuated room. Stimuli were presented in white on a gray background that was ~57 cm away from participants. Each trial began with a central cross (0.8° × 0.8°) within a white frame (24.5° × 24.5°) that extended beyond the outer border of the stimuli. Participants were instructed to fixate on the central cross. During an entire trial, the central cross and the frame were always displayed in the center of the screen. After 1,000 ms from the beginning of each trial, a backward-walking PLD (4.0° × 6.8°) was presented at the center of the screen. The walking direction of the PLD was either toward the left or the right of fixation, but without translational motion. The backward-walking PLD was displayed for 500 ms. Afterward, there was a 100-ms interstimulus interval (ISI) where only the fixation point and the frame were displayed. Immediately following the ISI, a Gabor patch (2.5° × 2.5°, 4.8 cpd) was presented as a probe on either the left or right side of the fixation point. The center of the Gabor patch and the fixation point were offset by 5.0°. The Gabor patch was slightly tilted clockwise or counterclockwise (2°), and participants were required to quickly press a button to indicate their perceived orientation of the Gabor patch regardless of the side of presentation. Two conditions were employed: (1) a walking-toward condition, in which the backward-walking PLD moved toward the Gabor patch (i.e., the head of PLD faced away from the Gabor patch), and (2) a walking-away condition, in which the backward-walking PLD moved away from the Gabor patch (i.e., the head of PLD faced the Gabor patch). After participants responded, the Gabor patch disappeared and the next trial began. If participants did not make a response within 2,000 ms, the Gabor patch disappeared and the next trial started automatically. At the beginning of the experiment, participants were explicitly told that the walking direction was not predictive of target location, and they were required to fixate on the central cross throughout the experiment (Fig. 1 shows the experimental procedure).

In addition, the orientation of the PLD (inverted or upright) served as another variable. The inverted PLD was used to examine the physical-level factors contributing to the

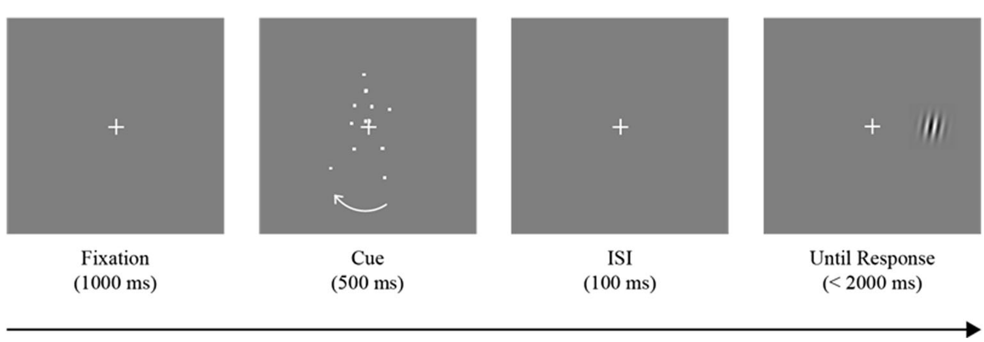

Fig. 1 Schematic procedure for Experiment 1. Each trial began with a fixation cross presented at the center of the frame. After 1,000 ms, a backward-walking PLD appeared, and the walking direction of the walker could be toward the left or right of fixation. In the trial shown in Fig. 1, the walker was moving toward the left of fixation while he faced to the right. The backward-walking PLD was presented for 500 ms. After a 100-ms interstimulus interval (ISI) during which only the fixation and the frame were displayed, a Gabor patch appeared as a probe on the left or right side of the fixation. The Gabor patch was slightly tilted clockwise or counterclockwise, and participants were required to press a button to indicate their perceived orientation of the Gabor patch regardless of the side of presentation. At the beginning of each experiment, participants were explicitly told that the walker was not predictive of probe location

attentional orienting effect. Each condition for the orientation of PLDs was displayed in a different block, resulting in two blocks. Each block consisted of 80 trials with 40 walking-toward trials and 40 walking-away trials. Trials were presented in random order for each observer. The order of the blocks (upright and inverted blocks) was counterbalanced across observers. Participants were required to respond as quickly as possible. Here, reaction times (RT) were more informative than accuracy for exploring participants' cognitive processing. Thus, we primarily focused on analyzing RTs.

Results

Figure 2a shows RTs for correct trials for all conditions (see the Supplementary Material for the analysis of accuracy data for all the experiments in this study). Reaction time data were entered into a 2 × 2 repeated-measures analysis of variance (ANOVA) with two within-subjects factors of PLD orientation (upright vs. inverted) and walking direction (walking toward vs. walking away). The main effect of PLD orientation was not significant, $F(1, 19) = 0.03$, $p = .86$, $\eta_p^2 = 0.002$. The main effect of walking direction (walking toward vs. walking away) was significant, $F(1, 19) = 10.02$, $p = .005$, $\eta_p^2 = .35$. Discrimination of the Gabor patch orientation was faster in the walking-away condition than in the walking-toward condition when stimuli depicted upright biological motion (652 ms vs. 694 ms), $t(19) = -3.39$, $p = .003$, Cohen's $d = 0.76$, 95 % CI [−67, −16], indicating that attention shifted in the opposite direction to the motion. This attention-orienting effect disappeared in the inverted condition (670 ms vs. 671 ms), $t(19) = -0.12$, $p = .91$, Cohen's $d = 0.03$, 95 % CI [−20, 18]. There was also a significant interaction between PLD orientation and walking direction, $F(1, 19) = 5.78$, $p = .027$, $\eta_p^2 = .23$. These results demonstrate that observers' spatial attention was oriented away from the walking direction.

Experiment 1b

To verify our findings, we conducted Experiment 1b, which was a direct replication of Experiment 1a. Thus, all experimental details were identical to Experiment 1a, except that a new set of student participants were recruited (10 women and 10 men, 20–23 years old). As shown in Fig. 2b, although the overall responses were faster for this group of participants, a similar pattern of data as in Experiment 1a was obtained. The ANOVA, which was identical to that used in Experiment 1a, showed a significant interaction between PLD orientation and walking direction, $F(1, 19) = 7.43$, $p = .013$, $\eta_p^2 = .28$. Again, discrimination of the Gabor patch orientation was faster in the walking-away condition than in the walking-toward condition for upright biological motion (570 ms vs. 599 ms), $t(19) = -2.88$, $p = .01$, Cohen's $d = 0.64$, 95 % CI [−50, −8], indicating that attention again shifted away from the direction of motion. This attention-orienting effect did not occur in the inverted condition (586 ms vs. 579 ms), $t(19) = 0.76$, $p = .46$, Cohen's $d = 0.17$, 95 % CI [−13, 27].

Experiment 2

A potential confound in Experiment 1 was that attention was oriented to the gaze direction of the biological motion because the gaze direction was in opposition to the direction of motion in the backward-walking condition. Additionally, gaze direction is aligned with the direction of motion in the forward-walking conditions used in previous studies (Bardi et al., 2015; Shi et al., 2010; Wang et al., 2014; Zhao et al., 2014). To address this confound, we designed Experiment 2, in which stepping biological motion was used (see Video S2 in the Supplementary Material for demonstrations of the stimuli). We chose this stimulus because it does not move as a whole and has a clear gaze direction. If gaze direction plays a

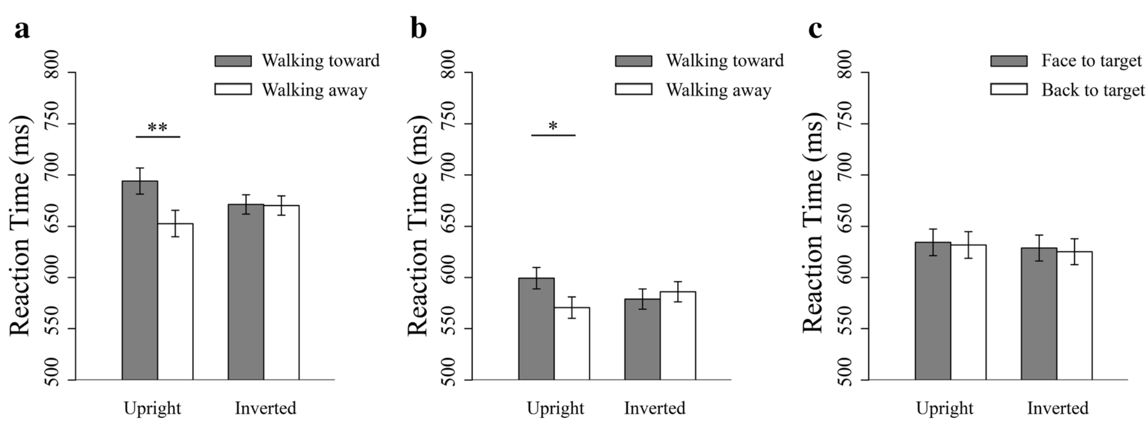

Fig. 2 RT results from (**a**) Experiment 1a, (**b**) Experiment 1b, and (**c**) Experiment 2. In Experiment 1a and 1b, observers' RT were faster in the walking-away condition than in the walking-toward condition in upright blocks. This effect was not observed in inverted blocks. In Experiment 2, no attentional orienting effect was found. Error bars indicate 95 % within-subjects confidence intervals of the mean RT. * $p < .05$. ** $p < .01$

key role, attention would be directed toward the stepping direction, and we would observe the same results as in Experiment 1. Otherwise, we would expect no attention-orienting effect.

Method

Twenty new students from Zhejiang University (8 women and 12 men, 18–24 years old) participated in this experiment. The walking-direction condition was replaced with the stepping-direction condition. All other procedures were identical to those of Experiment 1, except that conditions were as follows: (1) a face-to-target condition, in which the PLD was stepping while facing the Gabor patch, and (2) a back-to-target condition, in which the PLD was stepping while turned away from the Gabor patch. All the other aspects were the same as Experiment 1.

Results

Figure 2c shows RTs for correct trials in all conditions. Reaction time data were entered into a 2 × 2 repeated-measures analysis of variance (ANOVA) with two within-subjects factors of PLD orientation (upright vs. inverted) and stepping direction (face-to-target vs. back-to-target). No significant effect of PLD orientation was found, $F(1, 19) = 0.17$, $p = .68$, $\eta_p^2 = 0.009$, nor of stepping direction, $F(1, 19) = 0.14$, $p = .72$, $\eta_p^2 = 0.007$. There was also no significant interaction between the two factors, $F(1, 19) = 0.003$, $p = .96$, $\eta_p^2 < 0.01$. To further quantify the evidence against the null effect of the stepping direction, we performed a Bayesian *t* test (Rouder, Speckman, Sun, Morey, & Iverson, 2009) to compare the reaction times in the face-to-target and back-to-target conditions for each PLD orientation (upright: 634 ms vs. 632 ms; inverted: 629 ms vs. 625 ms). The results showed that the null hypothesis was 3.18 and 3.13 times as likely to be true as the alternative hypothesis in the upright and inverted condition, respectively, providing strong evidence for the null effect (Jeffreys, 1998). These results are inconsistent with the prediction that biological motion draws attention to its gaze direction.

Discussion

Through two experiments, we found that backward walking oriented attention away from the person walking, and this effect was *not* due to the gaze direction of the biological motion stimuli. Thus, the attentional-orienting effect associated with walking is not always in the walking direction. These findings support the aforementioned rich interpretation.

However, one might argue that Experiment 2 could not rule out the influence of gaze direction completely. It is possible that participants were unable to determine the gaze direction of the walker, which would contribute to the null result. However, this possibility is unlikely based on intuitive observation and empirical evidence. As may be seen in the demonstrations (in the Supplementary Materials), the leg movement of the stepping PLD is very clear, and it provides a reliable cue about the direction the walker's is facing. In addition, post-experiment interviews with the participants indicated that all participants in Experiment 2 could easily and accurately detect where the biological motion faced. Hence, the stimuli of Experiment 2 were fit for purpose.

The flexible attentional-orienting effect induced by social signals is not only found with respect to walking direction but is also supported in research on gaze cues. For example, the strength of the gaze cue effect (i.e., orienting the observer's attention to where the gaze is directed) is weakened or removed if the actor wears goggles (Nuku & Bekkering, 2008) or has their eyes occluded (Teufel, Alexis, Clayton, & Davis, 2010). Furthermore, the gaze-cue effect is modulated by the interactive or communicative context (Böckler, Knoblich, & Sebanz, 2011; Myllyneva & Hietanen, 2015; Senju & Csibra, 2008), showing that when the observed eyes have a communicative intent, attention is more strongly directed toward the gaze direction than when no such intent is present. In summary, these studies show that the gaze-cue effect is not always associated with gaze direction or the current walking direction. Instead, an interpretation of gaze cues is that attention is deployed according to the inferred mental state of others.

Inspired by research into gaze cues, we speculate that the human visual system makes implicit inferences concerning the walker's mental state automatically, to support the deployment of social attention. As Dennett (1987) suggested, humans often use the intentional stance to understand actions. That is, we see behavior not only as the behavior itself but also as the perceived intention underlying it. Such inferences provide answers as to why a walker walks backward, and downstream outputs modulate the visual system to shift attention to seek important information that helps in understanding the motion. This mechanism has adaptive value: Teufel, Fletcher, et al. (2010) argued that such a mechanism could help us choose the most important information and avoid the interference of other perceptual information. However, as noted earlier, the current study cannot provide sufficient evidence to support a strong claim about implicit inferences regarding the walker's mental state, or the cause of the motion. Further studies need to be conducted using richer stimuli, for which the cause of walking is manipulated systematically, to investigate whether implicit inferences guide attention to seek the cause of the motion and how attention-orienting facilitates understanding of social events. In addition, the rich interpretation predicts an attentional shift supported by complicated mechanisms that require analysis of the mental state of the moving agent; further evidence for such input analyzers should be sought.

In conclusion, our findings suggest that the attentional orienting induced by biological motion is not a reflexive attentional shift that constantly aligns the attentional focus with the direction of motion, but rather is controlled by a more complicated mechanism. This implies that a richer interpretation is required, such as considering the attentional orienting system as part of the social cognition system that serves to understanding other's behavior.

Acknowledgments This research was supported by the National Natural Science Foundation of China (No. 31571119, 31170975), and the Fundamental Research Funds for the Central Universities (No. 2015QNA3021). We thank the Graphics Lab in Carnegie Mellon University for kindly providing us the point-light biological motion stimuli.

Author Contributions X. Ding, J. Yin, and M. Shen conceived and designed the experiments. X. Ding, J. Yin, R. Shui, and J. Zhou performed the experiments and analyzed the data. X. Ding, J. Yin, J. Zhou, and M. Shen wrote the manuscript.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflicts of interest.

References

Bardi, L., Di Giorgio, E., Lunghi, M., Troje, N. F., & Simion, F. (2015). Walking direction triggers visuo-spatial orienting in 6-month-old infants and adults: An eye tracking study. *Cognition, 141,* 112–120.

Blake, R., & Shiffrar, M. (2007). Perception of human motion. *Annual Review of Psychology, 58,* 47–73.

Böckler, A., Knoblich, G., & Sebanz, N. (2011). Observing shared attention modulates gaze following. *Cognition, 120,* 292–298.

Brainard, D. H. (1997). The Psychophysics Toolbox. *Spatial Vision, 10,* 433–436.

Carey, S. (2009). *The origin of concepts* (pp. 175–186). New York, NY: Oxford University Press.

Dennett, D. C. (1987). *The intentional stance*. Cambridge, MA: MIT Press.

Driver, J., IV, Davis, G., Ricciardelli, P., Kidd, P., Maxwell, E., & Baron-Cohen, S. (1999). Gaze perception triggers reflexive visuospatial orienting. *Visual Cognition, 6,* 509–540.

Friesen, C. K., & Kingstone, A. (1998). The eyes have it! Reflexive orienting is triggered by nonpredictive gaze. *Psychonomic Bulletin & Review, 5,* 490–495.

Friesen, C. K., Moore, C., & Kingstone, A. (2005). Does gaze direction really trigger a reflexive shift of spatial attention? *Brain and Cognition, 57*(1), 66–69.

Friesen, C. K., Ristic, J., & Kingstone, A. (2004). Attentional effects of counterpredictive gaze and arrow cues. *Journal of Experimental Psychology: Human Perception and Performance, 30*(2), 319–329.

Hood, B. M., Willen, J. D., & Driver, J. (1998). Adult's eyes trigger shifts of visual attention in human infants. *Psychological Science, 9*(2), 131–134.

Jeffreys, H. (1998). *The theory of probability*. Oxford, UK: Oxford University Press.

Johnson, S. C., Shimizu, Y. A., & Ok, S. J. (2007). Actors and actions: The role of agent behavior in infants' attribution of goals. *Cognitive Development, 22*(3), 310–322.

Langton, S. R., & Bruce, V. (1999). Reflexive visual orienting in response to the social attention of others. *Visual Cognition, 6*(5), 541–567.

Luo, Y., & Baillargeon, R. (2005). Can a self-propelled box have a goal? Psychological reasoning in 5-month-old infants. *Psychological Science, 16*(8), 601–608.

Myllyneva, A., & Hietanen, J. K. (2015). There is more to eye contact than meets the eye. *Cognition, 134,* 100–109.

Nuku, P., & Bekkering, H. (2008). Joint attention: Inferring what others perceive (and don't perceive). *Consciousness and Cognition, 17,* 339–349.

Pelli, D. G. (1997). The VideoToolbox software for visual psychophysics: Transforming numbers into movies. *Spatial Vision, 10,* 437–442.

Rouder, J. N., Speckman, P. L., Sun, D., Morey, R. D., & Iverson, G. (2009). Bayesian *t* tests for accepting and rejecting the null hypothesis. *Psychonomic Bulletin & Review, 16,* 225–237.

Senju, A., & Csibra, G. (2008). Gaze following in human infants depends on communicative signals. *Current Biology, 18,* 668–671.

Shi, J., Weng, X., He, S., & Jiang, Y. (2010). Biological motion cues trigger reflexive attentional orienting. *Cognition, 117,* 348–354.

Shimizu, Y., & Johnson, S. C. (2004). Infants' attribution of a goal to a morphologically unfamiliar agent. *Developmental Science, 7*(4), 425–430.

Sweeny, T. D., Wurnitsch, N., Gopnik, A., & Whitney, D. (2013). Sensitive perception of a person's direction of walking by 4-year-old children. *Developmental Psychology, 49,* 2120–2124.

Teufel, C., Alexis, D. M., Clayton, N. S., & Davis, G. (2010). Mental-state attribution drives rapid, reflexive gaze following. *Attention, Perception, & Psychophysics, 72,* 695–705.

Teufel, C., Fletcher, P. C., & Davis, G. (2010). Seeing other minds: Attributed mental states influence perception. *Trends in Cognitive Sciences, 14,* 376–382.

Thompson, B., Hansen, B. C., Hess, R. F., & Troje, N. F. (2007). Peripheral vision: Good for biological motion, bad for signal noise segregation? *Journal of Vision, 12,* 1–7.

Thompson, J., & Parasuraman, R. (2012). Attention, biological motion, and action recognition. *NeuroImage, 59,* 4–13.

Thornton, I. M., & Vuong, Q. C. (2004). Incidental processing of biological motion. *Current Biology, 14,* 1084–1089.

Wang, L., Yang, X., Shi, J., & Jiang, Y. (2014). The feet have it: Local biological motion cues trigger reflexive attentional orienting in the brain. *NeuroImage, 84,* 217–224.

Wronski, C., & Daum, M. M. (2014). Spatial orienting following dynamic cues in infancy: Grasping hands versus inanimate objects. *Developmental Psychology, 50,* 2020–2029.

Zhao, J., Wang, L., Wang, Y., Weng, X., Li, S., & Jiang, Y. (2014). Developmental tuning of reflexive attentional effect to biological motion cues. *Scientific Reports, 4,* 5558.