AMERICAN PSYCHOLOGICAL ASSOCIATION

Emotion

ISSN: 1528-3542

2023, Vol. 23, No. 4, 1061–1074
https://doi.org/10.1037/emo0001145

Happy Is Stronger Than Sad: Emotional Information Modulates Social Attention

Tian Yuan, Haoyue Ji, Li Wang, and Yi Jiang
State Key Laboratory of Brain and Cognitive Science, Institute of Psychology, Chinese Academy of Sciences
Department of Psychology, University of Chinese Academy of Sciences

Social directional cues (e.g., gaze direction; walking direction) can trigger reflexive attentional orienting, a phenomenon known as social attention. Here, we examined whether this reflexive social attention could be modulated by the emotional content embedded in social cues. By introducing emotional (happy and sad) biological motion (BM) stimuli to the modified central cuing paradigm, we found that the happy but not the sad emotional gait could significantly boost attentional orienting effect relative to the neutral gait. Critically, this "happiness advantage" effect could be extended to social attention induced by gaze. Furthermore, the observed differential emotional modulations could not be simply explained by low-level physical differences between the emotional stimuli, as inverted social cues (i.e., BM and face) failed to produce such modulation effects. Overall, these findings highlight the role of emotional information in modulating the processing of social signals, and further suggest the existence of a general emotional modulation on social attention triggered by different types of social signals.

Keywords: social attention, emotion, biological motion, eye gaze

Supplemental materials: https://doi.org/10.1037/emo0001145.supp

As social species, humans have an extraordinary ability to readily detect interactive partners' focus of attention and further infer their internal states (e.g., beliefs, goals) via a variety of social signals (Birmingham & Kingstone, 2009; Frischen et al., 2007; Klein et al., 2009; Nummenmaa & Calder, 2009). This fundamental ability, referred to as social attention, plays a central role in facilitating interpersonal interactions and is especially vital for human survival (Klein et al., 2009; Shepherd, 2010). Eye gaze, as the "window to the soul," informs us about other individual's state of mind and serves as the critical information source for social attention behavior (Baron-Cohen, 1995; Itier & Batty, 2009; Langton et al., 2000). A modified central cuing paradigm has been introduced by Friesen and Kingstone (1998) to probe such social attention behavior. During this task, a nonpredictive eye gaze cue is presented at the center of the screen, followed by a peripheral target appearing either on the congruent location signaled by the central cue or on the opposite side (incongruent). It has been found that the nonpredictive gaze direction cue could trigger faster reaction times (RT) to targets in the congruent condition than in the incongruent condition. This effect occurs very fast and even when the gaze direction is counterpredictive of the target location, thus, disclosing its reflexive nature (Driver et al., 1999; Friesen & Kingstone, 1998; Friesen et al., 2004; Frischen et al., 2007; Langton & Bruce, 1999).

Alongside eye gaze, the movement of biological organisms presents another essential source of information regarding others' internal states. It has been well documented that observers are highly adept at recognizing the characteristics of biological motion (BM) cues, even when they are depicted solely by the motions of a few point lights attached to the major joints of living entities (i.e., point-light displays; Grossman et al., 2000; Johansson, 1973; Troje, 2002, 2008). Point-light BM cues, similar to faces, can provide a great amount of social information, such as gender (Kozlowski & Cutting, 1977; Pollick et al., 2005), actions (Decety & Grèzes, 1999; Dittrich, 1993; Vanrie & Verfaillie, 2004), intentions (Manera et al., 2010), and so forth (for a review, see Blake & Shiffrar, 2007). Crucially, the cognitive processing mechanism of BM is very similar to that of faces (Simion et al., 2011; Thompson & Hardee, 2008). For example, both point-light BM and face stimuli are preferred by newborns (Cassia et al., 2004; Simion et al., 2008; Thompson & Hardee, 2008;

This article was published Online First August 18, 2022.
Tian Yuan https://orcid.org/0000-0002-8570-1484
Li Wang https://orcid.org/0000-0002-2204-5192
Yi Jiang https://orcid.org/0000-0002-5746-7301
This research was supported by grants from the Ministry of Science and Technology of China (2021ZD0203800, 2022ZD0205100), the National Natural Science Foundation of China (31830037), the Strategic Priority Research Program (XDB32010300), the Key Research Program of Frontier Sciences (QYZDB-SSW-SMC030), and the Fundamental Research Funds for the Central Universities. We thank Nikolaus F. Troje for kindly providing us with the visual stimuli. We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study, and we follow JARS. This study's design and its analysis were not preregistered. All data, analysis code, and research materials generated during the current study are made available at the Knowledge Repository of Institute of Psychology, Chinese Academy of Sciences (http://ir.psych.ac.cn/handle/311026/38082; Yuan et al., 2021). The authors declared no conflicts of interest with respect to the authorship or the publication of this article.
Correspondence concerning this article should be addressed to Li Wang, State Key Laboratory of Brain and Cognitive Science, Institute of Psychology, Chinese Academy of Sciences, 16 Lincui Road, Chaoyang District, Beijing 100101, China. Email: wangli@psych.ac.cn

Valenza et al., 1996) and manifest a significant inversion effect (Chang et al., 2010; Freire et al., 2000; Ikeda et al., 2005; Leder & Bruce, 2000; Pavlova & Sokolov, 2000; Sumi, 1984; Troje & Westhoff, 2006; Yin, 1969). Moreover, deficient BM processing was observed in patients with congenital prosopagnosia, a selective impairment in face recognition (Lange et al., 2009), and was found to be correlated with impairments in face recognition for stroke patients (Saygin, 2007). Similarly, such an intimate link between BM and face processing was also obtained in the nonclinical population (Miller & Saygin, 2013). Further, neuroimaging studies have reliably reported that face and BM perception involved common brain regions (Blake & Shiffrar, 2007; Engell & McCarthy, 2013; Grossman et al., 2000; Peelen et al., 2006; Servos et al., 2002; Vaina et al., 2001). Collectively, these observations indicate the existence of a potentially shared mechanism of face and BM perception and highlight the importance to delineate such a broader social perception system using face and BM as different visual stimuli (Minnebusch & Daum, 2009; Simion et al., 2011; Thompson & Hardee, 2008).

In particular, walking direction of BM, being an especially important attribute conveying the disposition and goals of a biological entity, can also trigger a reflexive attentional effect analogous to that induced by gaze direction (Liu et al., 2021; Shi et al., 2010; Yu et al., 2020). This BM-triggered attentional effect persists when only the feet motion cue is displayed and observers are naïve to its biological nature (Wang et al., 2014). Moreover, such attentional orienting behavior triggered by the point-light walker occurs early in life, as evidenced in 6-month-old infants and preschool children (Bardi et al., 2011; Zhao et al., 2014). Importantly, our recent studies have demonstrated that this BM-triggered social attention ability is supported by genetic bases and neural mechanisms that are shared with the attentional effects triggered by gaze cues, but not with those induced by nonsocial arrow cues (Ji et al., 2020; Wang et al., 2020). Taken together, these findings indicate the robustness and uniqueness of social attention triggered by eye gaze and walking direction, which might be linked with the evolutionary significance of these social signals.

In addition to direction signals, social cues can also convey emotionally relevant information. These emotional signals, such as facial expressions, offer important clues to others' internal affective states. When combined with direction signals, they provide insight into an individual's affective evaluation regarding the nature (good or bad) of the event/object he or she is attending to. For example, a happy face with averted gaze, compared with the neutral one, communicates a greater chance for the presence of a reward. Hence, this extra clue should enhance cuing effect so as to facilitate the detection of potential reward or punishments in the environment. Following this idea, multiple previous studies have examined the modulation of emotions on gaze cuing, while the results are rather mixed. Some evidence revealed a modulation of facial expressions on gaze-mediated orienting (Bayless et al., 2011; Graham et al., 2010; Lassalle & Itier, 2015b; McCrackin & Itier, 2018a; Neath et al., 2013; Pecchinenda & Petrucci, 2021; Pecchinenda et al., 2008). Conversely, reports from other studies have demonstrated that gaze cuing effect is independent of facial expression processing (Coy et al., 2019; Hietanen & Leppänen, 2003). Several factors have been identified to account for these discrepant findings, such as stimulus onset asynchrony, task demands, individual differences and so forth (Bayliss et al., 2010; Friesen et al., 2011; Graham et al., 2010; Lassalle & Itier, 2015a, 2015b; McCrackin & Itier, 2018b; Pecchinenda & Petrucci, 2016). Among them, one particular factor worthy of consideration is the low-level physical features of emotional faces, such as the size of the eyes or sclera/pupil contrast in fearful and surprised faces (Tipples, 2005), which might confound the modulation effect induced by facial emotion per se. Yet to date, it remains difficult to control for these low-level differences in emotional face stimuli. It is, therefore, important to investigate whether this emotional modulation observed with gaze-mediated orienting similarly exists in the attentional effect triggered by point-light BM stimuli, another type of social cue with analogous processing mechanism but different physical properties.

Unlike the face images, the irrelevant physical confounders (e.g., body shape) are entirely removed for the minimalistic point-light BM, leaving key dynamic information conveying emotion (e.g., velocity, bounciness and swing; Barliya et al., 2013; Chouchourelou et al., 2006; Halovic & Kroos, 2018a, 2018b; Roether et al., 2009). For instance, happy BM would exhibit an appearance of bounciness with a faster pace and longer arm swing, while sad BM was characterized by a slouching gait with short slow strides and smaller arm movement. Numerous studies have found that the distinctly expressed emotions contained in point-light displays, such as happiness, sadness, and anger, could be successfully recognized by observers (Alaerts et al., 2011; Bachmann et al., 2020; Montepare et al., 1987; Ogren et al., 2019). More importantly, the point-light BM stimuli, though varying significantly from faces in the way to express emotions, share a very similar emotion processing mechanism with that of faces. For instance, the emotional faces and point-light BM stimuli, compared with the neutral counterparts, could both evoke stronger neural responses in the brain regions critically involved in social cues and emotion processing (e.g., the superior temporal sulcus; Atkinson et al., 2012; Bachmann et al., 2018; Engell & Haxby, 2007; Peelen et al., 2007; Pessoa et al., 2002; Zhu et al., 2013). Besides, the observed behavioral and neural responses to the emotional information conveyed by BMs and faces were found to be impaired in individuals with social–cognitive deficits (e.g., autism; Atkinson, 2009; Harms et al., 2010; Hubert et al., 2007; Mazzoni et al., 2022; Nackaerts et al., 2012; Okruszek, 2018; Pavlova, 2012). Furthermore, in parallel with face studies that have reported an interaction of facial expressions and other face information (Becker et al., 2007; Pourtois et al., 2010), it has been demonstrated that the emotional information of point-light displays could also modulate other aspects of BM processing (Halovic & Kroos, 2009, 2018b). For example, emotional cues could bias the gender perception of BM. Specifically, angry walkers were more likely to be judged as males while sad walkers were more likely to be identified as females (Johnson et al., 2011). Some studies have shown that the emotional content also enhanced the detection performance of a point-light walker masked by random moving dots. In particular, consistent with the happiness advantage observed in faces (Becker et al., 2011; Calvo & Beltrán, 2013; Leppänen & Hietanen, 2004; Shimamura et al., 2006), happy walkers also showed a superiority effect in detection over sad or angry walkers (Chouchourelou et al., 2006; Ikeda & Watanabe, 2009; H. Lee & Kim, 2017; Spencer et al., 2016), which could be attributed to a general positivity bias due to past experiences of encountering situations of either oneself being happy or observing others in happy moods more frequently (Diener & Diener, 1996).

Although the vital role of emotional gait in cognitive processing of BM cues has received some attention, whether it would interact with the processing of walking direction remains largely unaddressed. More specifically, it is heretofore unknown whether emotional gait and walking direction, the two important sources of others' internal states provided by BM, can also interact with each other to modulate reflexive attentional orienting like those reported in face studies (e.g., Bayless et al., 2011; Graham et al., 2010; Lassalle & Itier, 2015b; McCrackin & Itier, 2018a; Neath et al., 2013; Pecchinenda & Petrucci, 2021; Pecchinenda et al., 2008). Given that BM-mediated attentional effect was found to be supported by a specialized mechanism tuned to social signals (Ji et al., 2020; Wang et al., 2020), probing the emotional modulation of the BM-triggered social attention effect could be informative for the issue on whether emotions modulate social attention.

To fill this gap, we adopted the emotional (happy and sad) point-light walkers together with the well-studied neutral one for use in a social attention task. Specifically, the emotional BM stimuli employed here were parametric, and the critical parameter for happy-sad classification is the second harmonic to the vertical movements (Troje, 2002, 2008). The power of the second harmonic is relatively low for the sad walkers, while it is higher for the happy walkers, which generates an appearance of bounciness in the happy walkers. In addition to BM stimuli, the emotional (happy and sad) and neutral faces were employed as the central cues. Even though BM and face stimuli vary significantly in terms of low-level visual features, they share some processing mechanisms, especially for emotion perception (Blake & Shiffrar, 2007; Simion et al., 2011; Thompson & Hardee, 2008), and could induce an analogous social attention effect (Ji et al., 2020; Wang et al., 2020). These two types of cues, when adopted in the same cuing task, can inform us whether the same emotional modulation could be observed for social attention triggered by social signals that are totally different in visual features. This could facilitate our understanding of a general emotional modulation on social attention as well as alleviate the debate on the explanations of low-level versus high-level processing. Note that although previous studies have already examined the modulation of facial expressions on gaze cuing (Bayliss et al., 2010; Coy et al., 2019; Dawel et al., 2015; Hietanen & Leppänen, 2003; Lassalle & Itier, 2015b; Pecchinenda et al., 2008; see also Dalmaso et al., 2020 for a review), there still lacks the direct comparison between happy and sad facial expressions, and the current study hence could provide new insights into this emotional modulation. Besides, similar to former research (Bayless et al., 2011; Ogren et al., 2019; Shi et al., 2010; Wang et al., 2014; Zhao et al., 2014), we utilized the inverted emotional BM and face stimuli as central cues to further rule out the possible influences from low-level visual features.

Method

Participants

A total of 144 participants (93 females) ranging from 18 to 30 years old ($M \pm SD = 23 \pm 2.69$) were recruited in the study, with 36 in each of the four experiments. All had normal or corrected-to-normal vision and gave written informed consent in accordance with the procedure and protocols approved by the institutional review board of the Institute of Psychology, Chinese Academy of Sciences. They were all naïve to the purpose of the experiments. Prior power analyses (matched-pairs t-tests, one-tailed) using G*Power (Version 3.1.9.4; Faul et al., 2007) indicated that a sample size of at least 15 participants would afford 80% power with alpha at .05 to detect a medium-high attentional effect (Cohen's $d = .70$) triggered by central BM and eye gaze cues, which were found in previous studies with identical designs (Lassalle & Itier, 2015b; Experiment 2; Shi et al., 2010). To adequately detect a potential interaction in the current study, we further expanded the sample size to 36 per experiment. The sensitivity power analysis indicated that the within-subjects ANOVA with 36 participants would be sensitive to effects of $\eta_p^2 = .04$ with 80% power ($\alpha = .05$). This means that our study could reliably detect effects larger than $\eta_p^2 = .04$, which is a small-to-medium effect and is comparable to that reported in previous studies (Chen et al., 2021; McCrackin & Itier, 2018a).

Stimuli

All stimuli were presented using MATLAB (Mathworks, Inc.) together with the Psychophysics Toolbox extensions (Brainard, 1997; Pelli, 1997) on a 23.8-in. Dell monitor. The parametric emotional (happy and sad) and neutral point-light walkers with leftward or rightward walking direction were adopted from Troje (2002, 2008). Each BM cue comprised 15 point-light dots depicting the motions of the head, pelvis, thorax, and major joints (i.e., shoulders, elbows, wrists, hips, knees, and ankles). Each gait cycle was 1 s and contained 30 frames. The emotional state of this stimuli set was indexed by a normalized Z score on an axis reflecting the differences between happy and sad walkers in terms of a linear classifier. We adopted the neutral walker that scored 0 on the linear axis, together with the happy walker 6 *SD*s into the happy part of the axis and the sad walker 6 *SD*s into the sad part of the axis (see https://www.biomotionlab.ca/html5-bml-walker/ for an interactive animation). Note that the scores were computed within a 10-dimensional subspace spanned by the first 10 principal components based on a Fourier-based representation of observers' emotional ratings of 80 actual walkers (half male; Troje, 2008). This approach matches the BM stimuli in terms of frequency and phase, while exaggerates the diagnostic features that the classifier extracts to generate walking patterns with the respective properties and attributes. Here, the critical feature for this happy-sad classification is the second harmonic to the vertical movements, which creates an appearance of bounciness in the happy walkers. It should be pointed out that the identity and gender of this BM stimuli set were ambiguous, as they were the averages of 80 actual walkers (half male). In Experiment 1, the upright point-light walkers were used as the central cues. For each trial, a point-light walker with a specific direction (left or right) and emotion (neutral, sad or happy) was displayed, and the starting frame of the point-light walker was randomized to avoid participants' anticipations. In Experiment 2, the central cues were the inverted counterparts by mirror flipping the upright BM vertically. The inversion disrupted the holistic processing of emotional information while the low-level features (e.g., total motion) were kept unchanged (Ogren et al., 2019).

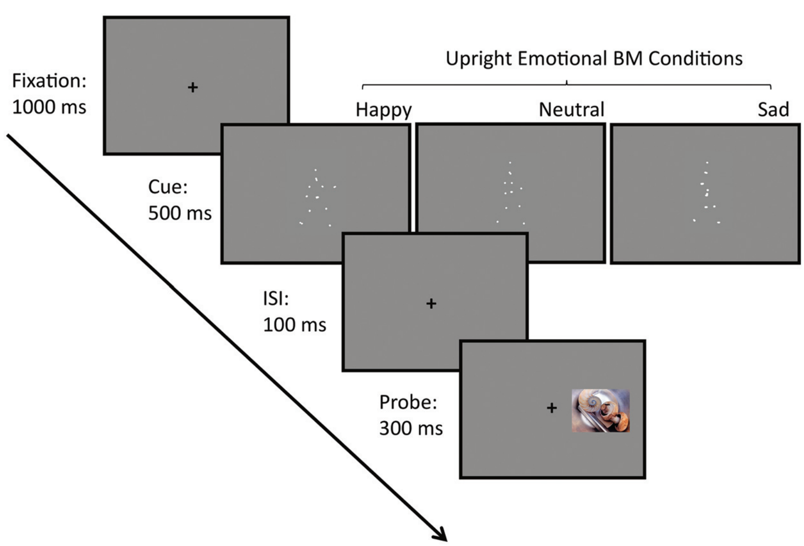
The face images of one female actor taken from the NimStim face-stimulus set (Tottenham et al., 2009), displaying neutral, happy, and sad expressions, were used in Experiment 3 and Experiment 4. This selection of adopting only one face was based on the BM experiments and former similar studies (Dawel et al., 2015; Friesen et al., 2011; Ji et al., 2020; Wang et al., 2020). The face images were cropped in an ellipse to remove features outside of the face. The position of the iris of the eyes was modified by using Photoshop software to generate leftward and rightward gaze cues. The upright faces were presented as central cues in Experiment 3 and their inverted counterparts were used in Experiment 4.

The target stimuli used in all four experiments were 10 neutral pictures selected from International Affective Picture System (IAPS; Lang et al., 1997). These pictures are medium in valence (M = 5.1, SD = .45, maximum = 5.8, minimum = 4.5, on a 1–9 scale) with relatively low arousal (M = 4.36, SD = .26, maximum = 4.92, minimum = 4.1). The content of the pictures included people, animals, foodstuffs and landscapes. Since these target pictures were equally presented for the three emotional conditions, this choice should not influence the emotional modulation effect. Moreover, there were quite a few studies that have used neutral pictures rather than Gabor stimuli as the probing target, as pictures were thought to be of more interest to participants (Bayliss et al., 2010; Pecchinenda & Petrucci, 2016, 2021).

Procedure

In line with previous studies on BM-triggered attentional effect (Ji et al., 2020; Wang et al., 2020; Yu et al., 2020), a BM-cuing task without catch trials was adopted in Experiment 1 and Experiment 2. All stimuli were presented on a gray background and viewed by participants from a distance of 54 cm with their heads on a chinrest. Each trial began with fixation on a central cross (1.1° × 1.1°) for 1,000 ms. Then, an upright (Experiment 1) or inverted (Experiment 2) BM sequence (8.9° × 13.2°) with emotions (i.e., neutral, happy, or sad) was presented at the center of the screen for 500 ms. The BM cue walked either toward the left or the right side without translational motion. After a 100-ms interstimulus interval (ISI) during which only the fixation was displayed, a target picture was presented for 300 ms as a probe on either the left or the right visual field with a horizontal offset of 10.5° from the fixation (see Figure 1). Participants were required to press one of two keys on a standard keyboard with their index fingers to indicate the location of the target ("F" for the left target or "J" for the right target) as quickly and accurately as possible. On the congruent trials, the target picture appeared at the location cued by walking direction of BM, whereas on the incongruent trials, the target picture appeared opposite to the cued location. According to the recent BM cuing studies (Ji et al., 2020; Wang et al., 2014; Yu et al., 2020), 40 trials were adopted in each of six experimental conditions created by crossing emotional cue (neutral, happy, or sad) and cue-target congruency (congruent or incongruent). There were 240 trials in each experiment. Test trials were presented in a new random order for each participant, and there was a short rest break after every 30 trials. At the beginning of the experiment, participants were explicitly told that the BM cues were nonpredictive of the target location, and they were instructed to maintain their fixation at the central cross throughout the trial.

Figure 1
Schematic Representation of the Experimental Procedure of the BM Cuing Task in Experiment 1



Note. A happy/neutral/sad biological motion (BM) sequence either walking left or right was presented at the center of the screen for 500 ms followed by a target picture shown for 300 ms as a peripheral probe. Participants were asked to respond to the target location through key pressing. The procedure of Experiment 2 was identical to that of Experiment 1, except that the inverted BM stimuli were employed as the central cues. See the online article for the color version of this figure.

The designs and procedures of Experiment 3 and Experiment 4 were similar to those in Experiment 1 and Experiment 2, except that an upright (Experiment 3) or inverted (Experiment 4) face either gazing leftward or rightward was employed as the central cue (i.e., gaze-cuing task). Specifically, to give the impression of implied motion, a neutral face with direct gaze (6.4° × 10.2°) was presented for 500 ms. Afterward, the neutral face with gaze averted toward the left or the right was displayed for 200 ms, followed by the same face with facial expression (neutral, happy, or sad) for 300 ms (see Figure 2). This dynamic gaze cuing paradigm was realistic and commonly used in the research field of emotional gaze cuing (e.g., Carlson, 2016; Lassalle & Itier, 2013; Liu et al., 2019; Neath et al., 2013; Pecchinenda & Petrucci, 2016, 2021). Nevertheless, the use of dynamic sequences would unavoidably lead to a difference in facial motion between emotional and neutral conditions. Thus, we conducted a supplemental experiment to control for the difference in facial motion between emotional and neutral conditions. This supplemental experiment followed exactly the same procedure of Experiment 3, except that the neutral face with averted gaze (the last frame of the face sequence) was replaced by the open mouth face in the neutral condition. This change in stimuli produced a facial motion for the neutral condition, thereby matching the difference in facial motion between the emotional and the neutral conditions (see online supplemental material for more details).

Transparency and Openness

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study; we also follow JARS (Kazak, 2018). All data, analysis code, and research materials generated during the current study are made available at the Knowledge Repository of Institute of Psychology, Chinese Academy of Sciences (http://ir.psych.ac.cn/handle/311026/38082; Yuan et al., 2021). This study's design and its analysis were not preregistered.

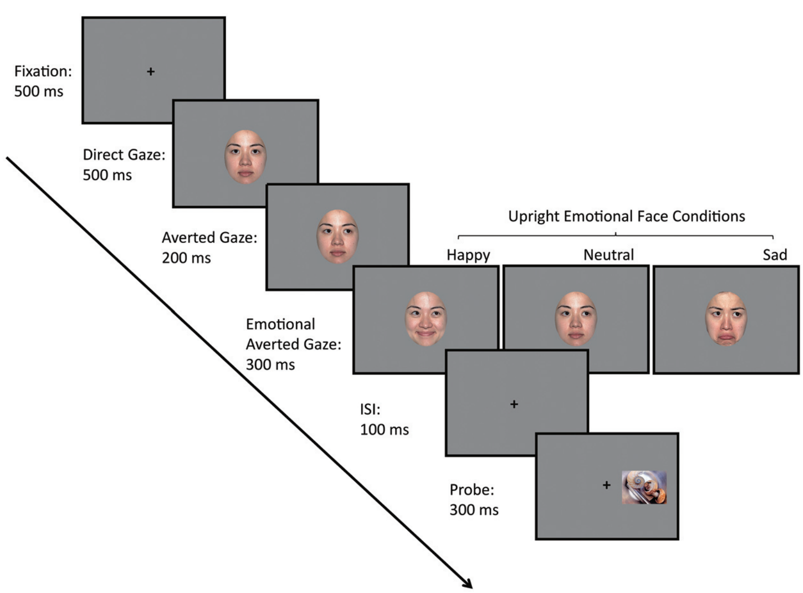
Results

For all four experiments, trials with incorrect responses and RTs shorter than 150 ms or longer than 1,500 ms followed by RTs beyond 2 *SD*s above or below the mean (collapsed across experimental conditions) were excluded from the statistical analyses. Overall, the percentage of trial exclusion was less than 5%. Furthermore, the location discrimination performance was close to perfection in both BM and face experiments (above 99%), reflecting that the participants did not make a response based on inference. The mean RTs for each experimental condition from all experiments are shown in Table 1.

Experiment 1: Upright BM as the Central Cue

In Experiment 1, we first ran a 3 (emotional cue: neutral, happy or sad) × 2 (congruency: congruent vs. incongruent) repeated

Figure 2
Schematic Representation of the Experimental Procedure of the Gaze Cuing Task in Experiment 3



Note. The procedure was similar in structure to the BM cuing task, with the difference being that a happy/neutral/sad face with averted eye gaze was displayed as the central cue. In the same vein, the central face stimuli were inverted in Experiment 4. The face images adapted in our experiments were from the NimStim database (Tottenham et al., 2009), NimStim model number 16 (https://danlab.psychology.columbia.edu/content/nimstim-set-facial-expressions). Adapted with permission. Model 18 instead of model 16 is depicted here to comply with conditions of use of the NimStim database. ISI = interstimulus interval. See the online article for the color version of this figure.

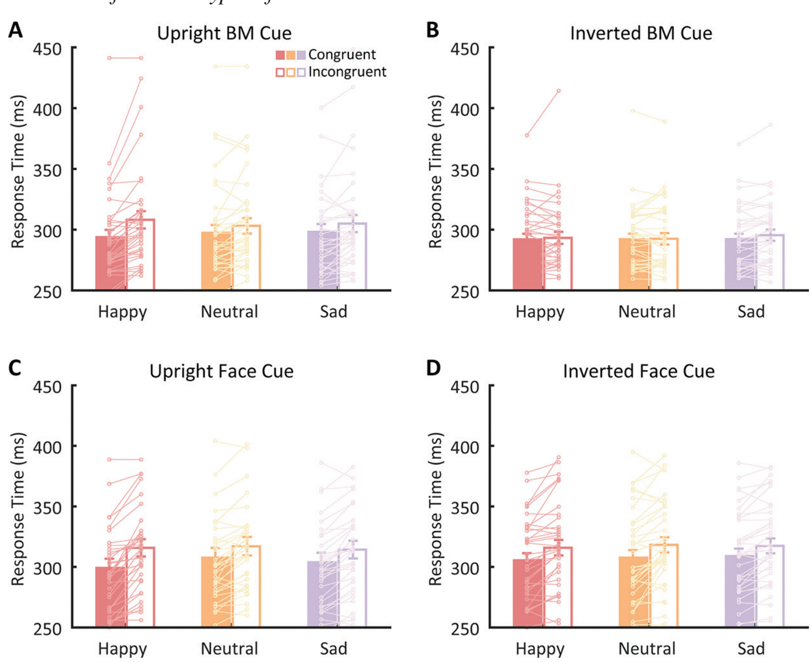
Table 1
Mean RTs (ms) in Each Condition With Standard Errors in Parentheses

Cue type	Happy		Neutral		Sad	
	Congruent	Incongruent	Congruent	Incongruent	Congruent	Incongruent
Upright BM	294 (6)	308 (7)	297 (6)	303 (6)	298 (7)	305 (7)
Inverted BM	292 (5)	293 (5)	292 (5)	293 (5)	292 (4)	296 (5)
Upright face	299 (8)	316 (5)	308 (8)	317 (8)	304 (8)	314 (7)
Inverted face	305 (6)	316 (7)	308 (6)	318 (6)	309 (6)	317 (4)

Note. BM = biological motion.

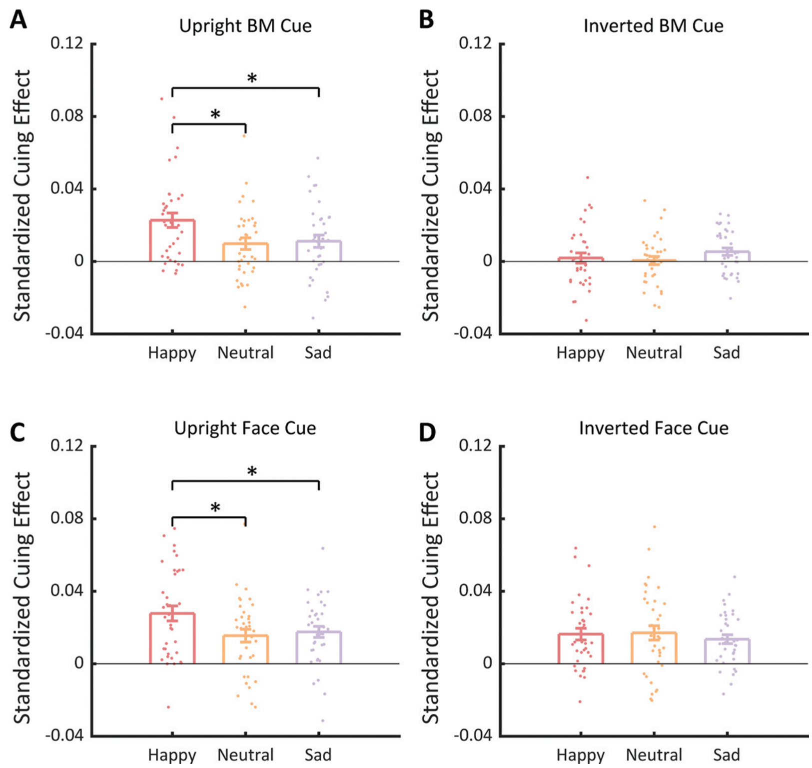
measures analysis of variance (ANOVA) on RTs. The main effect of congruency was significant, $F(1, 35) = 27.38$, $p < .001$, $\eta_p^2 = .44$ (Figure 3A), while no main effect of emotional cue was found, $F(2, 70) = .52$, $p = .596$, $\eta_p^2 = .02$. Importantly, there was a significant interaction between emotional cue and congruency, $F(2, 70) = 5.60$, $p = .006$, $\eta_p^2 = .14$. In line with previous research (Ji et al., 2020; Shi et al., 2010; Wang et al., 2014, 2020; Yu et al., 2020; Zhao et al., 2014), nonpredictive neutral BM cues could trigger a significant reflexive attentional orienting effect, as revealed by a shorter RT in the congruent condition than that in the incongruent condition (297 ms vs. 303 ms, $t(35) = -2.87$, $p = .007$, Cohen's $d = .48$, 95% confidence interval (CI) for the mean difference [−10, −2]; Figure 3A). Moreover, this attentional effect could also be observed with emotional BM cues (happy: 294 ms vs. 308 ms, $t(27) = -5.07$, $p < .001$, Cohen's $d = .85$, 95% CI for the mean difference [−20, −9]; sad: 298 ms vs. 305 ms, $t(35) = -3.23$, $p = .003$, Cohen's $d = .54$, 95% CI for the mean difference [−11, −3]; Figure 3A). To further probe the modulation effect of emotional information on the magnitude of BM-mediated orienting, a standardized cuing effect (CE) index was produced by dividing the difference in the mean RT obtained under the incongruent condition versus that in the congruent condition by their sum $((RT_{incon} - RT_{con})/(RT_{incon} + RT_{con}))$. A subsequent one-way repeated measures ANOVA was conducted for this standardized cuing effect. Results revealed a significant main effect of emotional cue, $F(2, 70) = 6.02$, $p = .004$, $\eta_p^2 = .15$. Post hoc t-tests (Bonferroni-corrected) showed that happy point-light walkers induced a significantly stronger attentional effect than sad walkers, $t(35) = 2.83$, $p = .018$, Cohen's $d = .47$, 95% CI for the mean difference [.002, .022] (Figure 4A) and neutral walkers, $t(35) = 3.16$, $p = .007$, Cohen's $d = .53$, 95% CI for the mean difference [.003, .023] (Figure 4A), whereas there was no significant difference between the attentional effects triggered by sad and neutral walkers, $t(35) = .33$, $p = 1.000$, Cohen's $d = .06$, 95% CI for the mean difference [−.009, .011] (Figure 4A).

Figure 3
Mean Reaction Time in Congruent and Incongruent Trials Plotted Against Emotional Conditions for Four Types of Central Cues



Note. Each line represents one subject. Error bars showed standard errors of the mean. BM = biological motion. See the online article for the color version of this figure.

Figure 4
Mean Magnitude of the Standardized Cuing Effects Plotted Against Emotional Conditions for Four Types of Central Cues



Note. (A) In Experiment 1, happy upright biological motion (BM). cues triggered a significantly stronger cuing effect than neutral and sad cues. (B) In Experiment 2, inverted BM cues failed to produce such emotional modulation effects. (C) In Experiment 3, a similar emotional modulation effect was observed with upright face cues: the cuing effect induced by happy faces was stronger than that by neutral or sad faces. (D) In Experiment 4, inverted face cues could give rise to cuing effects but there were no significant differences among the emotional conditions. Each point represents one individual data. Error bars showed standard errors of the mean. * $p < .05$. See the online article for the color version of this figure.

These findings suggest that the happy but not the sad emotional gait could exert influences on the social attention induced by walking direction of BM cues.

Experiment 2: Inverted BM as the Central Cue

To rule out the possibility that some low-level visual features rather than the emotional information per se might account for the obtained emotional modulation effect, we used the inverted BM cues that shared identical low-level features with the upright ones in Experiment 2. An identical 3 × 2 repeated measures ANOVA revealed neither a main effect (emotional cue: $F(2, 70) = 1.18$, $p = .313$, $\eta_p^2 = .03$; congruency: $F(1, 35) = 3.04$, $p = .090$, $\eta_p^2 = .08$, Figure 3B) nor an interaction, $F(2, 70) = 1.12$, $p = .333$, $\eta_p^2 = .03$. Moreover, the follow-up one-way repeated measures ANOVA on the standardized cuing effect revealed no significant main effect of emotional cue, $F(2, 70) = 1.24$, $p = .296$, $\eta_p^2 = .03$ (Figure 4B). Critically, a mixed 2 (cue orientation: upright, inverted) × 3 (emotional cue: happy, sad, neutral) ANOVA on standardized CEs crossing Experiment 1 and Experiment 2 showed a significant interaction between cue orientation and emotional cue, $F(2, 140) = 4.61$, $p = .012$, $\eta_p^2 = .06$. These results indicated that the observed emotional modulation on BM-mediated orienting did not arise from the processing of low-level visual features.

Experiment 3: Upright Face as the Central Cue

In Experiment 3, we adopted emotional faces with averted eye gaze as the central cues to investigate whether the observed emotional modulation effect could be extended to another type of social cues. Results revealed significant main effects of congruency, $F(1, 35) = 39.08$, $p < .001$, $\eta_p^2 = .53$ (Figure 3C) and emotional cue, $F(1.66, 58.06) = 6.76$, $p = .004$, $\eta_p^2 = .16$; Greenhouse-Geisser corrected. Similar to Experiment 1, the two-way interaction also reached significance, $F(2, 70) = 6.49$, $p = .003$, $\eta_p^2 = .16$. Further analyses showed that both neutral (308 ms vs. 317 ms, $t(35) = -4.21$, $p < .001$, Cohen's $d = .70$, 95% CI for the mean difference [−14, −5], Figure 3C) and emotional (happy: 299 ms vs. 316 ms,

$t(35) = -6.39$, $p < .001$, Cohen's $d = 1.07$, 95% CI for the mean difference [−22, −11]; sad: 304 ms vs. 314 ms, $t(35) = -5.05$, $p < .001$, Cohen's $d = .84$, 95% CI for the mean difference [−15, −6], Figure 3C) gaze cues could trigger reflexive attentional orienting effect, consistent with previous findings (Dawel et al., 2015; Driver et al., 1999; Friesen & Kingstone, 1998; Lassalle & Itier, 2015b). Again, we found a significant main effect of emotional cue by conducting the one-way repeated measures ANOVA for the standardized cuing effect, $F(2, 70) = 7.11$, $p = .002$, $\eta_p^2 = .17$. Further analyses (Bonferroni-corrected) revealed a larger cuing effect in the happy face condition than that in the sad, $t(35) = 2.93$, $p = .014$, Cohen's $d = .49$, 95% CI for the mean difference [.002, .019] (Figure 4C) or the neutral face condition, $t(35) = 3.52$, $p = .002$, Cohen's $d = .59$, 95% CI for the mean difference [.004, .021] (Figure 4C), and comparable cuing effects between the sad and the neutral face conditions, $t(35) = .60$, $p = 1.000$, Cohen's $d = .10$, 95% CI for the mean difference [−.006, .011] (Figure 4C). These results showed an emotional modulation effect on gaze-mediated orienting tuned to happy but not sad facial expression. Importantly, such modulation could not be simply explained by the dynamic difference between the emotional face and the neutral face conditions, as the pattern of the emotional modulation effect persisted even when the amount of changes in face features shown by the neutral and the emotional face cues were well matched (see online supplemental material for more details). Moreover, a mixed 2 (cue type: BM, face) × 3 (emotional cue: happy, sad, neutral) ANOVA on standardized CEs was conducted to examine whether or not this emotional modulation effect of gaze-mediated orienting varied from that of BM-mediated orienting obtained in Experiment 1. Results revealed a significant main effect of emotional cue, $F(2, 140) = 12.92$, $p < .001$, $\eta_p^2 = .16$, but neither the main effect of cue type, $F(1, 70) = 2.07$, $p = .155$, $\eta_p^2 = .03$, nor its interaction with emotional cue, $F(2, 140) = .03$, $p = .968$, $\eta_p^2 = .00$, reached significance. These results demonstrated an equivalent emotional modulation effect on the attentional orienting effect triggered by BM and gaze cues.

Experiment 4: Inverted Face as the Central Cue

We further employed inverted face cues in an additional control experiment to ensure that the observed effect in Experiment 3 reflected the modulation of emotional information rather than that of low-level visual properties. A main effect of congruency was observed, $F(1, 35) = 44.23$, $p < .001$, $\eta_p^2 = .56$ (Figure 3D), but neither the main effect of emotional cue, $F(2, 70) = 1.79$, $p = .174$, $\eta_p^2 = .05$, nor the interaction, $F(2, 70) = .45$, $p = .638$, $\eta_p^2 = .01$, was significant. Moreover, no significant main effect of emotional cue was found for the standardized cuing effect, $F(2, 70) = .46$, $p = .632$, $\eta_p^2 = .01$ (Figure 4D). These findings indicated that similar cuing effects were triggered by inverted face cues regardless of facial expressions. Combining the results obtained from Experiment 3 and Experiment 4, we found a significant interaction between cue orientation (upright, inverted) and emotional cue (happy, sad, neutral; $F(2, 140) = 3.13$, $p = .047$, $\eta_p^2 = .04$), providing evidence against the explanation of low-level visual features for the emotional modulation on social attention.

To recapitulate briefly, the converging findings of Experiments 1– 4 together demonstrated that happy but not sad emotion strengthened the reflexive attentional orienting effect triggered by both BM and gaze cues.

Discussion

Pointing direction (e.g., walking direction and gaze direction) and emotion, being the two fundamentally important attributes of social signals, can both communicate the internal states and intentions of other individuals. Here, we demonstrated that these two essential social information sources could interact with each other to alter socially coordinated attentional processes. By introducing emotional BM and face stimuli (i.e., happy, neutral, and sad) to the modified central cuing paradigm, our present study investigated whether the processing of emotional information could exert an impact on social attention. The results found that the emotions conveyed by BM cues could enhance this attentional orienting, and such modulation was pronounced for happy but not sad cues. Critically, this emotional modulation disappeared when the BM cues were presented upside down. Furthermore, a similar emotional modulation effect was obtained with gaze-mediated orienting when the face cue conveyed a happy but not sad expression after the gaze shift. Though there were still orienting effects induced by inverted face cues, emotional information failed to exert distinct influences on this process. Overall, these findings together highlighted that happy but not sad emotion embedded in these two types of social signals could interact with pointing directions to modulate social attention. This common "happiness advantage" on social attention behaviors further suggests the existence of a general emotional modulation on social attention triggered by different types of social signals.

To our knowledge, the current study provides the first evidence that attentional shifting induced by walking direction of BM can be modulated by emotional gaits. The extant mainstream literature has been particularly concerned about the reflexive attentional orienting effect by emotionally neutral BM cues, either with or without a global configuration (Ding, Gao, et al., 2017; Ji et al., 2020; Shi et al., 2010; Wang et al., 2014, 2020; Yu et al., 2020; Zhao et al., 2014). Our findings extend this line of inquiry and demonstrate similar attentional effects induced by emotional BM cues. More importantly, this BM-triggered attentional effect is modulated by the embedded emotional information. It should be noted that the appearance of bounciness is the critical aspect of BM that differentiates happy from sad and neutral walkers (Troje, 2008), and thus, leads to the emotional modulation effect observed in the current study. Additionally, the observed emotional modulation of BM-triggered attentional effect strongly implies that the processing of walking direction interacts with the concurrent emotion perception. It is noteworthy that the emotion system has been assumed to play a crucial role in various BM perceptual processes (e.g., BM detection or gender discrimination; Bachmann et al., 2020; Halovic & Kroos, 2018b; Halovic et al., 2020; Johnson et al., 2011; Krüger et al., 2013; H. Lee & Kim, 2018; Lorey et al., 2012). Here, our findings echoed with these studies and shed new light on the interaction between emotion perception and BM-triggered attentional orienting.

Furthermore, our study contributes to the debate on whether emotions affect social attention (Bayless et al., 2011; Graham et al., 2010; Lassalle & Itier, 2015b; McCrackin & Itier, 2018a; Pecchinenda et al., 2008). In the current study, we found the modulation effect of facial expressions on gaze cuing, replicating previous positive findings (Lassalle & Itier, 2013, 2015b). Moreover, our results offered fresh insights into this emotional modulation by demonstrating a stronger attentional effect triggered by happy rather than sad and neutral gaze cues. It has been suggested that the low-level physical differences in emotional faces (e.g., sclera/pupil contrast) might confound with the observed emotional modulation effect (Bayless et al., 2011; Pecchinenda & Petrucci, 2021; Tipples, 2005). Here we employed inverted face cues that shared identical low-level features with the upright ones in the control experiment and demonstrated that the effects of gaze direction and facial expressions on attentional allocation are independent: Similar attentional orienting effects were found in the inverted condition, but the magnitudes were not different among facial expression types. This absence of interaction in the inverted face condition suggested that low-level physical differences did not drive the emotional modulation effect obtained with upright face cues, but rather the emotional significance communicated by facial expressions did. On the other hand, minimalistic point-light BM stimuli, exhibiting emotional information through the kinematics of a few moving dots at the major joints, were used in our study. Although BM cues are very different from face cues in terms of visual features, an analogous emotional modulation effect on attentional orienting was still observed with these point-light BM cues. As such, it verifies the existence of the interaction between emotion perception and social attention in another type of social signal that is totally different in terms of low-level visual features. Collectively, the current study alleviated the concern regarding the confounding factor of physical features, and enlightened future studies to bridge the gap between the two lines of investigation related to BM and face perception, especially in the emotion domain. It should be pointed out that the BM and face cues varied inherently in their motion state, as faces with averted gaze involved implied motion while the BM stimuli were real motion. Several studies have reported that real motion would evoke stronger pupillary responses (Castellotti et al., 2021) and be overestimated in duration (Sgouramani et al., 2019) compared with implied motion. However, face cues involving implied motion could trigger larger attentional orienting effect than that induced by BM stimuli with real motion (Wang et al., 2020). Moreover, some other gaze cuing studies demonstrated that static and dynamic gaze cues elicited comparable cuing effects (Hietanen & Leppänen, 2003; Zhang et al., 2019). Taken together, these findings indicate that the cue's motion state is not very important for the magnitude of social attention. Nevertheless, there is still a lack of investigations using gaze cues with real motion in the field of social attention. Future research adopting the dynamic point-light displays of face cues (Atkinson et al., 2012) could be beneficial for the exploration of emotional modulation on social attention.

Noticeably, the current study also provides the first evidence for the existence of a general emotional modulation shared by different types of social attention behaviors. It has been well demonstrated that BM and eye gaze could both induce a significant social attention effect (Driver et al., 1999; Shi et al., 2010). Moreover, our latest study has found a robust cross-category adaptation effect between gaze- and BM-mediated attentional orienting, reflecting that common neural substrates might be involved in triggering these two different types of social attention behaviors. In addition, our recent behavioral genetic study has revealed that these two types of social attention abilities share common genetic bases (Wang et al., 2020). On the other hand, former studies have consistently reported a close connection between the emotion processing of BM and that of faces. For example, they both show a happiness advantage in detection and recognition (Becker et al., 2011; Calvo & Beltrán, 2013; Chouchourelou et al., 2006; Ikeda & Watanabe, 2009; H. Lee & Kim, 2017; Leppänen & Hietanen, 2004; Shimamura et al., 2006; Spencer et al., 2016). Besides, the ability to recognize emotions from point-light BM and face images was strongly correlated (Actis-Grosso et al., 2015; Alaerts et al., 2011; Henry et al., 2012; Isernia et al., 2020; Miller & Saygin, 2013). Neuroimaging studies have also found that overlapping brain regions (e.g., STS) were implicated in the perception of emotions from these two types of social signals (Basil et al., 2017; Pitcher et al., 2014; Zhu et al., 2013). These findings together indicate that BM and face cues could induce an analogous social attention effect, and they would share common emotion processing mechanisms. In the current study, we found that the emotional information affected the gaze- and BM-mediated attentional orienting effect in a similar manner. On the basis of previous studies and our own observations, we believe that the observed general emotional modulation on social attention might not rely purely on the respective low-level features of different social signals but essentially stem from the common emotion perception. Further, we speculate that there might be a potentially shared mechanism underlying the emotional modulation on social attention triggered by these two types of social signals. These assumptions would need to be verified by future investigations directly probing the neural mechanisms underpinning the emotional modulation on social attention triggered by eye gaze and BM.

It is worth noting that the emotional modulation effects of BM- and gaze-mediated orienting observed in the current study are specific to happy but not sad emotion. This "happiness advantage" effect lends support to the notion of a general positivity bias, which was thought to benefit from the observer's positively biased expectation and mood (Cummins & Nistico, 2002; Hoorens, 2014). It has been demonstrated that positive stimuli tend to take up less cognitive resources and are more noticeable than negative stimuli (du Rocher & Pickering, 2019; L. O. Lee & Knight, 2009). The present study extends these findings by demonstrating that the happiness advantage is also true for social attention. This happiness advantage could be linked with the basic processing superiority that the happy cues hold over the sad ones. Previous studies have found that happy faces were more efficiently recognized than sad faces (Calvo & Beltrán, 2013; Leppänen & Hietanen, 2004). Consistently, a similar happiness superiority effect has also been observed with BM stimuli (Chouchourelou et al., 2006; Ikeda & Watanabe, 2009; H. Lee & Kim, 2017). Such superiority accelerates the recognition of happy emotion and may, therefore, facilitate the inference of other individuals' internal states, leading to an enhanced attentional orienting effect for happy but not sad social cues (McCrackin & Itier, 2018a; Pecchinenda & Petrucci, 2021). Moreover, from a functional perspective, happiness may signify the presence of something pleasant (e.g., reward), and it is therefore adaptive to prompt faster attentional orienting toward the event/object cued by social signals conveying happy emotion to speed up the identification of a potential reward.

With regard to the underlying neural mechanisms, brain regions that have been previously implicated in social attention and emotional processing likely subserve the emotional modulation effect observed in the current study. Neuroimaging and neuropsychiatric studies have demonstrated that the superior temporal sulcus (STS) region, known to be largely involved in social attention (Akiyama et al., 2008; Kingstone et al., 2004), is also indispensable to the emotion perception of social stimuli (e.g., BM, face; Basil et al., 2017; Engell & Haxby, 2007; Sliwinska & Pitcher, 2018) and has functional interconnections with the areas dedicated to emotional processing (e.g., amygdala; Calder & Young, 2005; Haxby et al., 2000; Pitcher et al., 2017). Therefore, the emotional modulation on social attention might be a reflection of these interactive collaborations. It is not surprising that the modulation effect is tuned to happy emotion, because it has been found that happy emotion prompts stronger responses in the potential underlying neural systems (e.g., amygdala) compared with sad emotion (Adolphs & Tranel, 2004; Juruena et al., 2010; Killgore & Yurgelun-Todd, 2004). Future research could adopt brain imaging techniques so as to identify the common neural basis underlying the modulation effect of the emotional information on the reflexive orienting elicited by different types of social cues.

Finally, several limitations of the current study should be acknowledged. First, we have used only one female face image for the face experiments. Though there were quite a few studies investigating the emotional modulation of gaze-cuing effect that have only employed one face stimulus (Bayliss et al., 2010; Dawel et al., 2015; Friesen et al., 2011; Graham et al., 2010; Kuhn & Tipples, 2011), it is important for future studies to adopt multiple faces to generalize our findings. Next, we employed the inverted BM stimuli as the control stimuli, which were widely used in the research field of BM perception (Atkinson et al., 2007; Ding, Yin, et al., 2017; Grossman et al., 2005; Klin et al., 2009; Ogren et al., 2019; Shi et al., 2010; Wang et al., 2014; Zhao et al., 2014). Nevertheless, it should be pointed out that the nonbiological motion sequences, which were derived from the fragments identical to the BM stimuli but with critical biological characteristics removed, could serve as another type of control stimuli to examine if the observed emotional modulation effect was indeed triggered by the biological characteristics of BM signals (Shi et al., 2010; Wang & Jiang, 2012; Wang et al., 2014; Yu et al., 2020). Further, future research investigating the emotional modulation effects on social attention in the autistic population may help to provide new insights into the mechanism underlying the modulation and highlight its connection with social deficits, which has noticeable theoretical and clinical significance.

In conclusion, the current study investigated the modulation of emotional information on social attention and found stronger attentional effects for happy social cues compared with sad and neutral social cues, confirming an advantage of happy over sad. Moreover, the similar effects induced by the two types of social cues (BM and gaze) further suggest a general and shared "social attention detector" in the human visual system. These findings also highlight the critical role of emotion perception in modulating the processing of meaningful social signals.

References

Actis-Grosso, R., Bossi, F., & Ricciardelli, P. (2015). Emotion recognition through static faces and moving bodies: A comparison between typically developed adults and individuals with high level of autistic traits. *Frontiers in Psychology*, *6*, 1570. https://doi.org/10.3389/fpsyg.2015.01570

Adolphs, R., & Tranel, D. (2004). Impaired judgments of sadness but not happiness following bilateral amygdala damage. *Journal of Cognitive Neuroscience*, *16*(3), 453–462. https://doi.org/10.1162/089892904322926782

Akiyama, T., Kato, M., Muramatsu, T., Maeda, T., Hara, T., & Kashima, H. (2008). Gaze-triggered orienting is reduced in chronic schizophrenia. *Psychiatry Research*, *158*(3), 287–296. https://doi.org/10.1016/j.psychres.2006.12.004

Alaerts, K., Nackaerts, E., Meyns, P., Swinnen, S. P., & Wenderoth, N. (2011). Action and emotion recognition from point light displays: An investigation of gender differences. *PLoS ONE*, *6*(6), e20989. https://doi.org/10.1371/journal.pone.0020989

Atkinson, A. P. (2009). Impaired recognition of emotions from body movements is associated with elevated motion coherence thresholds in autism spectrum disorders. *Neuropsychologia*, *47*(13), 3023–3029. https://doi.org/10.1016/j.neuropsychologia.2009.05.019

Atkinson, A. P., Tunstall, M. L., & Dittrich, W. H. (2007). Evidence for distinct contributions of form and motion information to the recognition of emotions from body gestures. *Cognition*, *104*(1), 59–72. https://doi.org/10.1016/j.cognition.2006.05.005

Atkinson, A. P., Vuong, Q. C., & Smithson, H. E. (2012). Modulation of the face- and body-selective visual regions by the motion and emotion of point-light face and body stimuli. *NeuroImage*, *59*(2), 1700–1712. https://doi.org/10.1016/j.neuroimage.2011.08.073

Bachmann, J., Munzert, J., & Krüger, B. (2018). Neural underpinnings of the perception of emotional states derived from biological human motion: A review of neuroimaging research. *Frontiers in Psychology*, *9*, 1763. https://doi.org/10.3389/fpsyg.2018.01763

Bachmann, J., Zabicki, A., Munzert, J., & Krüger, B. (2020). Emotional expressivity of the observer mediates recognition of affective states from human body movements. *Cognition and Emotion*, *34*(7), 1370–1381. https://doi.org/10.1080/02699931.2020.1747990

Bardi, L., Regolin, L., & Simion, F. (2011). Biological motion preference in humans at birth: Role of dynamic and configural properties. *Developmental Science*, *14*(2), 353–359. https://doi.org/10.1111/j.1467-7687.2010.00985.x

Barliya, A., Omlor, L., Giese, M. A., Berthoz, A., & Flash, T. (2013). Expression of emotion in the kinematics of locomotion. *Experimental Brain Research*, *225*(2), 159–176. https://doi.org/10.1007/s00221-012-3357-4

Baron-Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind*. The MIT Press. https://doi.org/10.7551/mitpress/4635.001.0001

Basil, R. A., Westwater, M. L., Wiener, M., & Thompson, J. C. (2017). A causal role of the right superior temporal sulcus in emotion recognition from biological motion. *bioRxiv*. https://doi.org/10.1101/079756

Bayless, S. J., Glover, M., Taylor, M. J., & Itier, R. J. (2011). Is it in the eyes? Dissociating the role of emotion and perceptual features of emotionally expressive faces in modulating orienting to eye gaze. *Visual Cognition*, *19*(4), 483–510. https://doi.org/10.1080/13506285.2011.552895

Bayliss, A. P., Schuch, S., & Tipper, S. P. (2010). Gaze cueing elicited by emotional faces is influenced by affective context. *Visual Cognition*, *18*(8), 1214–1232. https://doi.org/10.1080/13506285.2010.484657

Becker, D. V., Anderson, U. S., Mortensen, C. R., Neufeld, S. L., & Neel, R. (2011). The face in the crowd effect unconfounded: Happy faces, not angry faces, are more efficiently detected in single- and multiple-target visual search tasks. *Journal of Experimental Psychology: General*, *140*(4), 637–659. https://doi.org/10.1037/a0024060

Becker, D. V., Kenrick, D. T., Neuberg, S. L., Blackwell, K. C., & Smith, D. M. (2007). The confounded nature of angry men and happy women. *Journal of Personality and Social Psychology*, *92*(2), 179–190. https://doi.org/10.1037/0022-3514.92.2.179

Birmingham, E., & Kingstone, A. (2009). Human social attention: A new look at past, present, and future investigations. *Annals of the New York Academy of Sciences*, *1156*(1), 118–140. https://doi.org/10.1111/j.1749-6632.2009.04468.x

Blake, R., & Shiffrar, M. (2007). Perception of human motion. *Annual Review of Psychology*, *58*(1), 47–73. https://doi.org/10.1146/annurev.psych.57.102904.190152

Brainard, D. H. (1997). The psychophysics toolbox. *Spatial Vision*, *10*(4), 433–436. https://doi.org/10.1163/156856897X00357

Calder, A. J., & Young, A. W. (2005). Understanding the recognition of facial identity and facial expression. *Nature Reviews Neuroscience*, *6*(8), 641–651. https://doi.org/10.1038/nrn1724

Calvo, M. G., & Beltrán, D. (2013). Recognition advantage of happy faces: Tracing the neurocognitive processes. *Neuropsychologia*, *51*(11), 2051–2061. https://doi.org/10.1016/j.neuropsychologia.2013.07.010

Carlson, J. M. (2016). Facilitated orienting underlies fearful face-enhanced gaze cueing of spatial location. *Cogent Psychology*, *3*(1), 1147120. https://doi.org/10.1080/23311908.2016.1147120

Cassia, V. M., Turati, C., & Simion, F. (2004). Can a nonspecific bias toward top-heavy patterns explain newborns' face preference?. *Psychological Science*, *15*(6), 379–383. https://doi.org/10.1111/j.0956-7976.2004.00688.x

Castellotti, S., Francisci, C., & Del Viva, M. M. (2021). Pupillary response to real, illusory, and implied motion. *PLoS ONE*, *16*(7), e0254105. https://doi.org/10.1371/journal.pone.0254105

Chang, D. H., Harris, L. R., & Troje, N. F. (2010). Frames of reference for biological motion and face perception. *Journal of Vision*, *10*(6), 22. https://doi.org/10.1167/10.6.22

Chen, Z., McCrackin, S. D., Morgan, A., & Itier, R. J. (2021). The gaze cueing effect and its enhancement by facial expressions are impacted by task demands: Direct comparison of target localization and discrimination tasks. *Frontiers in Psychology*, *12*, 618606. https://doi.org/10.3389/fpsyg.2021.618606

Chouchourelou, A., Matsuka, T., Harber, K., & Shiffrar, M. (2006). The visual analysis of emotional actions. *Social Neuroscience*, *1*(1), 63–74. https://doi.org/10.1080/17470910600630599

Coy, A. L., Nelson, N. L., & Mondloch, C. J. (2019). No experimental evidence for emotion-specific gaze cueing in a threat context. *Cognition and Emotion*, *33*(6), 1144–1154. https://doi.org/10.1080/02699931.2018.1554554

Cummins, R. A., & Nistico, H. (2002). Maintaining life satisfaction: The role of positive cognitive bias. *Journal of Happiness Studies*, *3*(1), 37–69. https://doi.org/10.1023/A:1015678915305

Dalmaso, M., Castelli, L., & Galfano, G. (2020). Social modulators of gaze-mediated orienting of attention: A review. *Psychonomic Bulletin & Review*, *27*(5), 833–855. https://doi.org/10.3758/s13423-020-01730-x

Dawel, A., Palermo, R., O'Kearney, R., Irons, J., & McKone, E. (2015). Fearful faces drive gaze-cueing and threat bias effects in children on the lookout for danger. *Developmental Science*, *18*(2), 219–231. https://doi.org/10.1111/desc.12203

Decety, J., & Grèzes, J. (1999). Neural mechanisms subserving the perception of human actions. *Trends in Cognitive Sciences*, *3*(5), 172–178. https://doi.org/10.1016/S1364-6613(99)01312-1

Diener, E., & Diener, C. (1996). Most people are happy. *Psychological Science*, *7*(3), 181–185. https://doi.org/10.1111/j.1467-9280.1996.tb00354.x

Ding, X., Gao, Z., & Shen, M. (2017). Two equals one: Two human actions during social interaction are grouped as one unit in working memory. *Psychological Science*, *28*(9), 1311–1320. https://doi.org/10.1177/0956797617707318

Ding, X., Yin, J., Shui, R., Zhou, J., & Shen, M. (2017). Backward-walking biological motion orients attention to moving away instead of moving toward. *Psychonomic Bulletin & Review*, *24*(2), 447–452. https://doi.org/10.3758/s13423-016-1083-9

Dittrich, W. H. (1993). Action categories and the perception of biological motion. *Perception*, *22*(1), 15–22. https://doi.org/10.1068/p220015

Driver, J., IV, Davis, G., Ricciardelli, P., Kidd, P., Maxwell, E., & Baron-Cohen, S. (1999). Gaze perception triggers reflexive visuospatial orienting. *Visual Cognition*, *6*(5), 509–540. https://doi.org/10.1080/135062899394920

du Rocher, A. R., & Pickering, A. D. (2019). The effects of social anxiety on emotional face discrimination and its modulation by mouth salience. *Cognition and Emotion*, *33*(4), 832–839. https://doi.org/10.1080/02699931.2018.1478279

Engell, A. D., & Haxby, J. V. (2007). Facial expression and gaze-direction in human superior temporal sulcus. *Neuropsychologia*, *45*(14), 3234–3241. https://doi.org/10.1016/j.neuropsychologia.2007.06.022

Engell, A. D., & McCarthy, G. (2013). Probabilistic atlases for face and biological motion perception: An analysis of their reliability and overlap. *NeuroImage*, *74*, 140–151. https://doi.org/10.1016/j.neuroimage.2013.02.025

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/BF03193146

Freire, A., Lee, K., & Symons, L. A. (2000). The face-inversion effect as a deficit in the encoding of configural information: Direct evidence. *Perception*, *29*(2), 159–170. https://doi.org/10.1068/p3012

Friesen, C. K., & Kingstone, A. (1998). The eyes have it! Reflexive orienting is triggered by nonpredictive gaze. *Psychonomic Bulletin & Review*, *5*(3), 490–495. https://doi.org/10.3758/BF03208827

Friesen, C. K., Halvorson, K. M., & Graham, R. (2011). Emotionally meaningful targets enhance orienting triggered by a fearful gazing face. *Cognition and Emotion*, *25*(1), 73–88. https://doi.org/10.1080/02699931003672381

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. https://doi.org/10.1037/0096-1523.30.2.319

Frischen, A., Bayliss, A. P., & Tipper, S. P. (2007). Gaze cueing of attention: Visual attention, social cognition, and individual differences. *Psychological Bulletin*, *133*(4), 694–724. https://doi.org/10.1037/0033-2909.133.4.694

Graham, R., Kelland Friesen, C., Fichtenholtz, H. M., & LaBar, K. S. (2010). Modulation of reflexive orienting to gaze direction by facial expressions. *Visual Cognition*, *18*(3), 331–368. https://doi.org/10.1080/13506280802689281

Grossman, E. D., Battelli, L., & Pascual-Leone, A. (2005). Repetitive TMS over posterior STS disrupts perception of biological motion. *Vision Research*, *45*(22), 2847–2853. https://doi.org/10.1016/j.visres.2005.05.027

Grossman, E., Donnelly, M., Price, R., Pickens, D., Morgan, V., Neighbor, G., & Blake, R. (2000). Brain areas involved in perception of biological motion. *Journal of Cognitive Neuroscience*, *12*(5), 711–720. https://doi.org/10.1162/089892900562417

Halovic, S., & Kroos, C. (2009, April 6–9). *Facilitating the perception of anger and fear in male and female walkers* [Paper presentation]. Symposium on mental states, emotions and their embodiment, Edinburgh, Scotland.

Halovic, S., & Kroos, C. (2018a). Not all is noticed: Kinematic cues of emotion-specific gait. *Human Movement Science*, *57*, 478–488. https://doi.org/10.1016/j.humov.2017.11.008

Halovic, S., & Kroos, C. (2018b). Walking my way? Walker gender and display format Confounds the perception of specific emotions. *Human Movement Science*, *57*, 461–477. https://doi.org/10.1016/j.humov.2017.10.012

Halovic, S., Kroos, C., & Stevens, C. (2020). Adaptation aftereffects influence the perception of specific emotions from walking gait. *Acta Psychologica*, *204*, 103026. https://doi.org/10.1016/j.actpsy.2020.103026

Harms, M. B., Martin, A., & Wallace, G. L. (2010). Facial emotion recognition in autism spectrum disorders: A review of behavioral and neuroimaging studies. *Neuropsychology Review*, *20*(3), 290–322. https://doi.org/10.1007/s11065-010-9138-6

Haxby, J. V., Hoffman, E. A., & Gobbini, M. I. (2000). The distributed human neural system for face perception. *Trends in Cognitive Sciences*, *4*(6), 223–233. https://doi.org/10.1016/S1364-6613(00)01482-0

Henry, J. D., Thompson, C., Rendell, P. G., Phillips, L. H., Carbert, J., Sachdev, P., & Brodaty, H. (2012). Perception of biological motion and emotion in mild cognitive impairment and dementia. *Journal of the International Neuropsychological Society*, *18*(5), 866–873. https://doi.org/10.1017/S1355617712000665

Hietanen, J. K., & Leppänen, J. M. (2003). Does facial expression affect attention orienting by gaze direction cues? *Journal of Experimental Psychology: Human Perception and Performance*, *29*(6), 1228–1243. https://doi.org/10.1037/0096-1523.29.6.1228

Hoorens, V. (2014). Positivity bias. In A. C. Michalos (Ed.), *Encyclopedia of quality of life and well-being research* (pp. 4938–4941). Springer. https://doi.org/10.1007/978-94-007-0753-5_2219

Hubert, B., Wicker, B., Moore, D. G., Monfardini, E., Duverger, H., Da Fonséca, D., & Deruelle, C. (2007). Brief report: Recognition of emotional and non-emotional biological motion in individuals with autistic spectrum disorders. *Journal of Autism and Developmental Disorders*, *37*(7), 1386–1392. https://doi.org/10.1007/s10803-006-0275-y

Ikeda, H., & Watanabe, K. (2009). Anger and happiness are linked differently to the explicit detection of biological motion. *Perception*, *38*(7), 1002–1011. https://doi.org/10.1068/p6250

Ikeda, H., Blake, R., & Watanabe, K. (2005). Eccentric perception of biological motion is unscalably poor. *Vision Research*, *45*(15), 1935–1943. https://doi.org/10.1016/j.visres.2005.02.001

Isernia, S., Sokolov, A. N., Fallgatter, A. J., & Pavlova, M. A. (2020). Untangling the ties between social cognition and body motion: Gender impact. *Frontiers in Psychology*, *11*, 128. https://doi.org/10.3389/fpsyg.2020.00128

Itier, R. J., & Batty, M. (2009). Neural bases of eye and gaze processing: The core of social cognition. *Neuroscience and Biobehavioral Reviews*, *33*(6), 843–863. https://doi.org/10.1016/j.neubiorev.2009.02.004

Ji, H., Wang, L., & Jiang, Y. (2020). Cross-category adaptation of reflexive social attention. *Journal of Experimental Psychology: General*, *149*(11), 2145–2153. https://doi.org/10.1037/xge0000766

Johansson, G. (1973). Visual perception of biological motion and a model for its analysis. *Perception & Psychophysics*, *14*(2), 201–211. https://doi.org/10.3758/BF03212378

Johnson, K. L., McKay, L. S., & Pollick, F. E. (2011). He throws like a girl (but only when he's sad): Emotion affects sex-decoding of biological motion displays. *Cognition*, *119*(2), 265–280. https://doi.org/10.1016/j.cognition.2011.01.016

Juruena, M. F., Giampietro, V. P., Smith, S. D., Surguladze, S. A., Dalton, J. A., Benson, P. J., Cleare, A. J., & Fu, C. H. (2010). Amygdala activation to masked happy facial expressions. *Journal of the International Neuropsychological Society*, *16*(2), 383–387. https://doi.org/10.1017/S1355617709991172

Kazak, A. E. (2018). Editorial: Journal article reporting standards. *American Psychologist*, *73*(1), 1–2. https://doi.org/10.1037/amp0000263

Killgore, W. D. S., & Yurgelun-Todd, D. A. (2004). Activation of the amygdala and anterior cingulate during nonconscious processing of sad versus happy faces. *Neuroimage*, *21*(4), 1215–1223. https://doi.org/10.1016/j.neuroimage.2003.12.033

Kingstone, A., Tipper, C., Ristic, J., & Ngan, E. (2004). The eyes have it!: An fMRI investigation. *Brain and Cognition*, *55*(2), 269–271. https://doi.org/10.1016/j.bandc.2004.02.037

Klein, J. T., Shepherd, S. V., & Platt, M. L. (2009). Social attention and the brain. *Current Biology*, *19*(20), R958–R962. https://doi.org/10.1016/j.cub.2009.08.010

Klin, A., Lin, D. J., Gorrindo, P., Ramsay, G., & Jones, W. (2009). Two-year-olds with autism orient to non-social contingencies rather than biological motion. *Nature*, *459*(7244), 257–261. https://doi.org/10.1038/nature07868

Kozlowski, L. T., & Cutting, J. E. (1977). Recognizing the sex of a walker from a dynamic point-light display. *Perception & Psychophysics*, *21*(6), 575–580. https://doi.org/10.3758/BF03198740

Krüger, S., Sokolov, A. N., Enck, P., Krägeloh-Mann, I., & Pavlova, M. A. (2013). Emotion through locomotion: Gender impact. *PLoS ONE*, *8*(11), e81716. https://doi.org/10.1371/journal.pone.0081716

Kuhn, G., & Tipples, J. (2011). Increased gaze following for fearful faces. It depends on what you're looking for!. *Psychonomic Bulletin & Review*, *18*(1), 89–95. https://doi.org/10.3758/s13423-010-0033-1

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). International affective picture system (IAPS): Technical manual and affective ratings. *NIMH Center for the Study of Emotion and Attention*, *1*, 39–58. https://doi.org/10.1007/978-3-319-28099-8_42-1

Lange, J., de Lussanet, M., Kuhlmann, S., Zimmermann, A., Lappe, M., Zwitserlood, P., & Dobel, C. (2009). Impairments of biological motion perception in congenital prosopagnosia. *PLoS ONE*, *4*(10), e7414. https://doi.org/10.1371/journal.pone.0007414

Langton, S. R., & Bruce, V. (1999). Reflexive visual orienting in response to the social attention of others. *Visual Cognition*, *6*(5), 541–567. https://doi.org/10.1080/135062899394939

Langton, S. R., Watt, R. J., & Bruce, I. (2000). Do the eyes have it? Cues to the direction of social attention. *Trends in Cognitive Sciences*, *4*(2), 50–59. https://doi.org/10.1016/S1364-6613(99)01436-9

Lassalle, A., & Itier, R. J. (2013). Fearful, surprised, happy, and angry facial expressions modulate gaze-oriented attention: Behavioral and ERP evidence. *Social Neuroscience*, *8*(6), 583–600. https://doi.org/10.1080/17470919.2013.835750

Lassalle, A., & Itier, R. J. (2015a). Autistic traits influence gaze-oriented attention to happy but not fearful faces. *Social Neuroscience*, *10*(1), 70–88. https://doi.org/10.1080/17470919.2014.958616

Lassalle, A., & Itier, R. J. (2015b). Emotional modulation of attention orienting by gaze varies with dynamic cue sequence. *Visual Cognition*, *23*(6), 720–735. https://doi.org/10.1080/13506285.2015.1083067

Leder, H., & Bruce, V. (2000). When inverted faces are recognized: The role of configural information in face recognition. *Quarterly Journal of Experimental Psychology A: Human Experimental Psychology*, *53*(2), 513–536. https://doi.org/10.1080/713755889

Lee, H., & Kim, J. (2017). Facilitating effects of emotion on the perception of biological motion: Evidence for a happiness superiority effect. *Perception*, *46*(6), 679–697. https://doi.org/10.1177/0301006616681809

Lee, H., & Kim, J. (2018). The role of trait anxiety and emotional information in the perception of biological motion. *The Korean Journal of Cognitive and Biological Psychology*, *30*(1), 15–33. https://doi.org/10.22172/cogbio.2018.30.1.002

Lee, L. O., & Knight, B. G. (2009). Attentional bias for threat in older adults: Moderation of the positivity bias by trait anxiety and stimulus modality. *Psychology and Aging*, *24*(3), 741–747. https://doi.org/10.1037/a0016409

Leppänen, J. M., & Hietanen, J. K. (2004). Positive facial expressions are recognized faster than negative facial expressions, but why? *Psychological Research*, *69*(1–2), 22–29. https://doi.org/10.1007/s00426-003-0157-2

Liu, J., Shi, Y., Whitaker, L., Tian, Y., & Hu, Z. (2019). Facial expressions modulate the gaze orienting effect on sound localization judgement. *Visual Cognition*, *27*(2), 109–119. https://doi.org/10.1080/13506285.2019.1606128

Liu, W., Yuan, X., Liu, D., Wang, L., & Jiang, Y. (2021). Social attention triggered by eye gaze and walking direction is resistant to temporal decay. *Journal of Experimental Psychology: Human Perception and Performance*, *47*(9), 1237–1246. https://doi.org/10.1037/xhp0000939

Lorey, B., Kaletsch, M., Pilgramm, S., Bischoff, M., Kindermann, S., Sauerbier, I., Stark, R., Zentgraf, K., & Munzert, J. (2012). Confidence in emotion perception in point-light displays varies with the ability to perceive own emotions. *PLoS ONE*, *7*(8), e42169. https://doi.org/10.1371/journal.pone.0042169

Manera, V., Schouten, B., Becchio, C., Bara, B. G., & Verfaillie, K. (2010). Inferring intentions from biological motion: A stimulus set of point-light communicative interactions. *Behavior Research Methods*, *42*(1), 168–178. https://doi.org/10.3758/BRM.42.1.168

Mazzoni, N., Ricciardelli, P., Actis-Grosso, R., & Venuti, P. (2022). Difficulties in recognising dynamic but not static emotional body movements in autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *52*(3), 1092–1105. https://doi.org/10.1007/s10803-021-05015-7

McCrackin, S. D., & Itier, R. J. (2018a). Both fearful and happy expressions interact with gaze direction by 200 ms SOA to speed attention orienting. *Visual Cognition*, *26*(4), 231–252. https://doi.org/10.1080/13506285.2017.1420118

McCrackin, S. D., & Itier, R. J. (2018b). Individual differences in the emotional modulation of gaze-cuing. *Cognition and Emotion*, *33*(4), 768–800. https://doi.org/10.1080/02699931.2018.1495618

Miller, L. E., & Saygin, A. P. (2013). Individual differences in the perception of biological motion: Links to social cognition and motor imagery. *Cognition*, *128*(2), 140–148. https://doi.org/10.1016/j.cognition.2013.03.013

Minnebusch, D. A., & Daum, I. (2009). Neuropsychological mechanisms of visual face and body perception. *Neuroscience and Biobehavioral Reviews*, *33*(7), 1133–1144. https://doi.org/10.1016/j.neubiorev.2009.05.008

Montepare, J. M., Goldstein, S. B., & Clausen, A. (1987). The identification of emotions from gait information. *Journal of Nonverbal Behavior*, *11*(1), 33–42. https://doi.org/10.1007/BF00999605

Nackaerts, E., Wagemans, J., Helsen, W., Swinnen, S. P., Wenderoth, N., & Alaerts, K. (2012). Recognizing biological motion and emotions from point-light displays in autism spectrum disorders. *PLoS ONE*, *7*(9), e44473. https://doi.org/10.1371/journal.pone.0044473

Neath, K., Nilsen, E. S., Gittsovich, K., & Itier, R. J. (2013). Attention orienting by gaze and facial expressions across development. *Emotion*, *13*(3), 397–408. https://doi.org/10.1037/a0030463

Nummenmaa, L., & Calder, A. J. (2009). Neural mechanisms of social attention. *Trends in Cognitive Sciences*, *13*(3), 135–143. https://doi.org/10.1016/j.tics.2008.12.006

Ogren, M., Kaplan, B., Peng, Y., Johnson, K. L., & Johnson, S. P. (2019). Motion or emotion: Infants discriminate emotional biological motion based on low-level visual information. *Infant Behavior and Development*, *57*, 101324. https://doi.org/10.1016/j.infbeh.2019.04.006

Okruszek, Ł. (2018). It is not just in faces! Processing of emotion and intention from biological motion in psychiatric disorders. *Frontiers in Human Neuroscience*, *12*, 48. https://doi.org/10.3389/fnhum.2018.00048

Pavlova, M. A. (2012). Biological motion processing as a hallmark of social cognition. *Cerebral Cortex*, *22*(5), 981–995. https://doi.org/10.1093/cercor/bhr156

Pavlova, M., & Sokolov, A. (2000). Orientation specificity in biological motion perception. *Perception & Psychophysics*, *62*(5), 889–899. https://doi.org/10.3758/BF03212075

Pecchinenda, A., & Petrucci, M. (2016). Emotion unchained: Facial expression modulates gaze cueing under cognitive load. *PLoS ONE*, *11*(12), e0168111. https://doi.org/10.1371/journal.pone.0168111

Pecchinenda, A., & Petrucci, M. (2021). Emotion first: Children prioritize emotional faces in gaze-cued attentional orienting. *Psychological Research*, *85*(1), 101–111. https://doi.org/10.1007/s00426-019-01237-8

Pecchinenda, A., Pes, M., Ferlazzo, F., & Zoccolotti, P. (2008). The combined effect of gaze direction and facial expression on cueing spatial attention. *Emotion*, *8*(5), 628–634. https://doi.org/10.1037/a0013437

Peelen, M. V., Atkinson, A. P., Andersson, F., & Vuilleumier, P. (2007). Emotional modulation of body-selective visual areas. *Social Cognitive and Affective Neuroscience*, *2*(4), 274–283. https://doi.org/10.1093/scan/nsm023

Peelen, M. V., Wiggett, A. J., & Downing, P. E. (2006). Patterns of fMRI activity dissociate overlapping functional brain areas that respond to biological motion. *Neuron*, *49*(6), 815–822. https://doi.org/10.1016/j.neuron.2006.02.004

Pelli, D. G. (1997). The VideoToolbox software for visual psychophysics: Transforming numbers into movies. *Spatial Vision*, *10*(4), 437–442. https://doi.org/10.1163/156856897X00366

Pessoa, L., McKenna, M., Gutierrez, E., & Ungerleider, L. G. (2002). Neural processing of emotional faces requires attention. *Proceedings of the National Academy of Sciences of the United States of America*, *99*(17), 11458–11463. https://doi.org/10.1073/pnas.172403899

Pitcher, D., Duchaine, B., & Walsh, V. (2014). Combined TMS and FMRI reveal dissociable cortical pathways for dynamic and static face perception. *Current Biology*, *24*(17), 2066–2070. https://doi.org/10.1016/j.cub.2014.07.060

Pitcher, D., Japee, S., Rauth, L., & Ungerleider, L. G. (2017). The superior temporal sulcus is causally connected to the amygdala: A combined TBS-fMRI study. *The Journal of Neuroscience*, *37*(5), 1156–1161. https://doi.org/10.1523/JNEUROSCI.0114-16.2016

Pollick, F. E., Kay, J. W., Heim, K., & Stringer, R. (2005). Gender recognition from point-light walkers. *Journal of Experimental Psychology: Human Perception and Performance*, *31*(6), 1247–1265. https://doi.org/10.1037/0096-1523.31.6.1247

Pourtois, G., Spinelli, L., Seeck, M., & Vuilleumier, P. (2010). Modulation of face processing by emotional expression and gaze direction during intracranial recordings in right fusiform cortex. *Journal of Cognitive Neuroscience*, *22*(9), 2086–2107. https://doi.org/10.1162/jocn.2009.21404

Roether, C. L., Omlor, L., Christensen, A., & Giese, M. A. (2009). Critical features for the perception of emotion from gait. *Journal of Vision*, *9*(6), 15. https://doi.org/10.1167/9.6.15

Saygin, A. P. (2007). Superior temporal and premotor brain areas necessary for biological motion perception. *Brain: A Journal of Neurology*, *130*(Pt. 9), 2452–2461. https://doi.org/10.1093/brain/awm162

Servos, P., Osu, R., Santi, A., & Kawato, M. (2002). The neural substrates of biological motion perception: An fMRI study. *Cerebral Cortex*, *12*(7), 772–782. https://doi.org/10.1093/cercor/12.7.772

Sgouramani, H., Moutoussis, K., & Vatakis, A. (2019). Move still: The effects of implied and real motion on the duration estimates of dance steps. *Perception*, *48*(7), 616–628. https://doi.org/10.1177/0301006619854914

Shepherd, S. V. (2010). Following gaze: Gaze-following behavior as a window into social cognition. *Frontiers in Integrative Neuroscience*, *4*, 5. https://doi.org/10.3389/fnint.2010.00005

Shi, J., Weng, X., He, S., & Jiang, Y. (2010). Biological motion cues trigger reflexive attentional orienting. *Cognition*, *117*(3), 348–354. https://doi.org/10.1016/j.cognition.2010.09.001

Shimamura, A. P., Ross, J. G., & Bennett, H. D. (2006). Memory for facial expressions: The power of a smile. *Psychonomic Bulletin & Review*, *13*(2), 217–222. https://doi.org/10.3758/BF03193833

Simion, F., Di Giorgio, E., Leo, I., & Bardi, L. (2011). The processing of social stimuli in early infancy: From faces to biological motion perception. *Progress in Brain Research*, *189*, 173–193. https://doi.org/10.1016/B978-0-444-53884-0.00024-5

Simion, F., Regolin, L., & Bulf, H. (2008). A predisposition for biological motion in the newborn baby. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(2), 809–813. https://doi.org/10.1073/pnas.0707021105

Sliwinska, M. W., & Pitcher, D. (2018). TMS demonstrates that both right and left superior temporal sulci are important for facial expression recognition. *NeuroImage*, *183*, 394–400. https://doi.org/10.1016/j.neuroimage.2018.08.025

Spencer, J. M. Y., Sekuler, A. B., Bennett, P. J., Giese, M. A., & Pilz, K. S. (2016). Effects of aging on identifying emotions conveyed by point-light walkers. *Psychology and Aging*, *31*(1), 126–138. https://doi.org/10.1037/a0040009

Sumi, S. (1984). Upside-down presentation of the Johansson moving light-spot pattern. *Perception*, *13*(3), 283–286. https://doi.org/10.1068/p130283

Thompson, J. C., & Hardee, J. E. (2008). The first time ever I saw your face. *Trends in Cognitive Sciences*, *12*(8), 283–284. https://doi.org/10.1016/j.tics.2008.05.002

Tipples, J. (2005). Orienting to eye gaze and face processing. *Journal of Experimental Psychology: Human Perception and Performance*, *31*(5), 843–856. https://doi.org/10.1037/0096-1523.31.5.843

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., Marcus, D. J., Westerlund, A., Casey, B. J., & Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research*, *168*(3), 242–249. https://doi.org/10.1016/j.psychres.2008.05.006

Troje, N. F. (2002). Decomposing biological motion: A framework for analysis and synthesis of human gait patterns. *Journal of Vision*, *2*(5), 371–387. https://doi.org/10.1167/2.5.2

Troje, N. F. (2008). Retrieving information from human movement patterns. In *Understanding events: From perception to action* (pp. 308–334). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195188370.003.0014

Troje, N. F., & Westhoff, C. (2006). The inversion effect in biological motion perception: Evidence for a "life detector"? *Current Biology*, *16*(8), 821–824. https://doi.org/10.1016/j.cub.2006.03.022

Vaina, L. M., Solomon, J., Chowdhury, S., Sinha, P., & Belliveau, J. W. (2001). Functional neuroanatomy of biological motion perception in humans. *Proceedings of the National Academy of Sciences of the United States of America*, *98*(20), 11656–11661. https://doi.org/10.1073/pnas.191374198

Valenza, E., Simion, F., Cassia, V. M., & Umiltà, C. (1996). Face preference at birth. *Journal of Experimental Psychology: Human Perception and Performance*, *22*(4), 892–903. https://doi.org/10.1037/0096-1523.22.4.892

Vanrie, J., & Verfaillie, K. (2004). Perception of biological motion: A stimulus set of human point-light actions. *Behavior Research Methods, Instruments, & Computers*, *36*(4), 625–629. https://doi.org/10.3758/BF03206542

Wang, L., & Jiang, Y. (2012). Life motion signals lengthen perceived temporal duration. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(11), E673–E677. https://doi.org/10.1073/pnas.1115515109

Wang, L., Wang, Y., Xu, Q., Liu, D., Ji, H., Yu, Y., Hu, Z., Yuan, P., & Jiang, Y. (2020). Heritability of reflexive social attention triggered by eye gaze and walking direction: Common and unique genetic underpinnings. *Psychological Medicine*, *50*(3), 475–483. https://doi.org/10.1017/S003329171900031X

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*(1), 217–224. https://doi.org/10.1016/j.neuroimage.2013.08.041

Yin, R. K. (1969). Looking at upside-down faces. *Journal of Experimental Psychology*, *81*(1), 141–145. https://doi.org/10.1037/h0027474

Yu, Y., Ji, H., Wang, L., & Jiang, Y. (2020). Cross-modal social attention triggered by biological motion cues. *Journal of Vision*, *20*(10), 21. https://doi.org/10.1167/jov.20.10.21

Yuan, T., Ji, H., Wang, L., & Jiang, Y. (2021). *Happy is stronger than sad: Emotional information modulates social attention*. PSYCH OpenIR. http://ir.psych.ac.cn/handle/311026/38082

Zhang, X., Zhang, Z., Zhang, Z., Tang, Y., & Liu, W. (2019). The role of the motion cue in the dynamic gaze-cueing effect: A study of the lateralized ERPs. *Neuropsychologia*, *124*, 151–160. https://doi.org/10.1016/j.neuropsychologia.2018.12.016

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*(1), 5558–5558. https://doi.org/10.1038/srep05558

Zhu, Q., Nelissen, K., Van den Stock, J., De Winter, F. L., Pauwels, K., de Gelder, B., Vanduffel, W., & Vandenbulcke, M. (2013). Dissimilar processing of emotional facial expressions in human and monkey temporal cortex. *NeuroImage*, *66*, 402–411. https://doi.org/10.1016/j.neuroimage.2012.10.083

Received July 15, 2021
Revision received May 27, 2022
Accepted June 1, 2022 ■