Acta Psychologica 175 (2017) 28–32

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Averted body postures facilitate orienting of the eyes

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ARTICLE INFO

Keywords:
Body posture
Gaze-cueing
Eye movements
Attention

ABSTRACT

It is well established that certain social cues, such as averted eye gaze, can automatically initiate the orienting of another's spatial attention. However, whether human posture can also reflexively cue spatial attention remains unclear. The present study directly investigated whether averted neutral postures reflexively cue the attention of observers in a normal population of college students. Similar to classic gaze-cuing paradigms, non-predictive averted posture stimuli were presented prior to the onset of a peripheral target stimulus at one of five SOAs (100 ms–500 ms). Participants were instructed to move their eyes to the target as fast as possible. Eye-tracking data revealed that participants were significantly faster in initiating saccades when the posture direction was congruent with the target stimulus. Since covert attention shifts precede overt shifts in an obligatory fashion, this suggests that directional postures reflexively orient the attention of others. In line with previous work on gaze-cueing, the congruency effect of posture cue was maximal at the 300 ms SOA. These results support the notion that a variety of social cues are used by the human visual system in determining the "direction of attention" of others, and also suggest that human body postures are salient stimuli capable of automatically shifting an observer's attention.

1. Introduction

Given that the social world is an integral aspect of human existence, the social signals of others can be viewed as highly salient events in everyday life. Social cues, such as facial expressions and body postures, contain a wealth of information about the internal state of others and the surrounding environment. Such information can guide approach or avoidance and alert individuals to threats in the environment. Studies suggest that human infants can recognize and mimic the expressions of others within two days of birth (Field, Woodson, Greenberg, & Cohen, 1982) and acquire the ability to discriminate gaze direction by four months of age (Vecera & Johnson, 1995). Understanding how adults process the social information of others is a highly important aspect of cognitive science.

One of the most well studied forms of social cues is directed eye gaze. It has been shown that the direction in which a social partner's eyes are oriented reflexively cues the attention of others. In a typical gaze-cuing paradigm, modeled after Posner, Snyder, and Davidson's (1980) spatial cueing task, a face stimulus with non-predictive averted eye gaze is presented at central fixation, followed by the presentation of a peripheral target. In such a cueing task, participants are instructed to detect, localize, and identify the peripheral target stimulus. Numerous studies provide evidence of reflexive gaze cueing, as measured by shorter response times to targets appearing in the location congruent with gaze direction, even when it has been noted that the gaze does not predict the target's location (Baron-Cohen, 1995; Driver et al., 1999; Friesen & Kingstone, 1998). This reflexive gaze cueing effect endures even when the target is more likely to appear in the direction incongruent with that indicated by the gaze direction (Driver et al., 1999). The accumulated evidence supporting the theory that eye gaze uniquely cues attention is in line with the existence of an "eye-direction detector" module, which automatically detects and computes the direction of eye gaze based on the specific morphology of the eye (Baron-Cohen, 1995).

Beyond the extensive work investigating the ability of eye gaze to cue visuospatial attention, studies have also supported the notion that other social cues, such as head direction (Langton & Bruce, 1999) and hand gestures (Langton & Bruce, 2000), are also capable of directing attention. This suggests the existence of a more general "direction-of-attention detector" (Perrett & Emery, 1994) which postulates that information from eye gaze, as well as from head direction and body posture, all contribute to the cueing of attention (Langton, Watt, & Bruce, 2000).

Similar lines of argument have been made by Hietanen (2002,

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http://dx.doi.org/10.1016/j.actpsy.2017.02.006
Received 3 November 2015; Received in revised form 16 December 2016; Accepted 28 February 2017
Available online 07 March 2017

1999). It should also be noted that non-social cues, such as arrows or words, are also capable of cueing attention (Hommel, Pratt, Colzato, & Godijn, 2001; Ristic, Friesen, & Kingstone, 2002), however the focus of the present report is on how social signals can direct attention. If social information other than eye gaze can direct the attention of others, then it is conceivable that human postures may also serve as attentional cues, as posture direction can be a strong indicator of the location of one's attentional focus. However, to date, little work has investigated whether body postures can in fact direct attention.

Previous work has shown that human attention can be *captured* by either static (Bannerman, Milders, & Sahraie, 2010) or moving (Buzzell, Chubb, Safford, Thompson, & McDonald, 2013) depictions of the human body. Additionally, it has been shown that videos depicting the walking direction of humans can *guide* the attention of observers, as measured by manual response times (Shi, Weng, He, & Jiang, 2010). This suggests that in addition to human eye gaze and head direction, a human body in motion can *direct* attention. However, walking direction stimuli are dynamic displays that convey a direction of motion that may be independent of the social cue itself. Furthermore, it remains unclear if static postures alone could direct attention in a manner similar to eye gaze or head direction. This latter point is particularly important, given that at least one study has demonstrated that when free-viewing computer-generated natural scenes, body posture appears to direct attention (Zwickel & Võ, 2010). However, it should be noted that viewing naturalistic scenes is very different than the methodology typically employed to test for attentional guidance by gaze direction. Thus, it is important that researchers test whether postures can indeed direct attention using methodology similar to a traditional gaze-cueing paradigm.

As it turns out, understanding social cueing becomes more complicated when the eyes and body are both visible. Attention cueing does not occur for averted postures when both the eye gaze and the orientation of the posture match, but does occur when they mismatch (Hietanen, 1999, 2002). Specifically, averted gaze cues attention when the body (or head, if only the head is visible) is oriented toward the viewer (Hietanen, 1999, 2002). That is, if the body or head is facing forward toward the viewer, then laterally averted eyes will cue attention. The opposite occurs with averted postures (or head, if only the head is visible) when the stimulus is looking at the observer (Hietanen, 1999, Pomianowska, Germeys, Verfaillie, & Newell, 2012). That is, no cueing (even reverse cueing) occurs when the eyes are looking at the observer and the body or head is averted toward a stimulus. Pomianoswska and colleagues have suggested that this reverse cueing effect might occur because the observer is encoding the cue in allocentric coordinates. For example, when the body is oriented toward the target, but the gaze is on the observer, this might imply that the cue is looking over it's shoulder, and therefore attention should be allocated in the opposite direction that the body is oriented.

To complicate things, Zwickel and Võ (2010) demonstrated using a free-viewing task that an oriented posture embedded in a scene can cause the eyes to be biased toward objects that intersect with the posture's orientation. Cueing does not occur for other objects with a facing direction, such as loud-speakers, which suggests that cueing only occurs for social objects. Unlike the studies discussed in the previous paragraph, the eyes were not visible. This would suggest that body orientation is able to cue attention in the absence of gaze information (but note that this effect only occurred when the eyes first landed on the head, and not the body). However, using a Posner-cueing type task, Gervais, Reed, Beall, and Roberts (2010) found postures (gaze was not visible) that had an implied direction of action (e.g. throwing, running) cued attention, whereas postures with no implied direction of action (e.g. standing, squatting to jump up) did not. Similarly Azarian, Esser, and Peterson (2015) found no cueing for neutral standing postures (gaze was not visible), but did find cueing by threatening postures, but only for anxious individuals.

One possibility for this discrepancy could be that social cueing occurs differently during free viewing. Another possibility is that a carry-over effect occurred in the studies by Gervais et al. (2010) and Azarian et al. (2015). That is, the presence of the other stimuli in the study, such as action-oriented or threatening postures, might have overridden the ability of neutral postures to cue attention. The goal of our study is to determine whether neutral postures can cue attention when the possibility of a carry-over effect has been removed.

In the present study, we investigated whether static body postures without facial features direct attention in a manner similar to gaze. Participants performed a spatial cuing task in which non-predictive averted postures preceded the presentation of a target stimulus presented in the periphery. Using eye tracking, we investigated whether postures facing the direction of target stimuli resulted in faster initiation of saccades to the target location. Given previous research demonstrating the absence of a posture-cueing effect at a 200 ms SOA, and an anti-cueing effect at a 500 ms SOA (Azarian et al., 2015), we chose to investigate posture cueing at a series of SOAs (100 ms–500 ms). If postural information is able to cue attention, we would expect participants to respond faster when posture direction is congruent with the target location. In line with previous research demonstrating that gaze-cueing effects typically emerge by approximately 300 ms (Driver et al., 1999; Friesen & Kingstone, 1998), we expected any posture-cueing effects to also manifest at a similar latency.

2. Methods

2.1. Participants

Twenty-eight George Mason University undergraduate students (16 female) ranging in age from 18 to 30 years (*M* age = 22.6 years) were recruited for the study. All participants had normal or corrected-to-normal vision.

2.2. Procedure

Participants completed a spatial cuing task in which averted, neutral body postures preceded target presentation (Fig. 1). At the beginning of each trial, a fixation cross was displayed at the center of the screen for

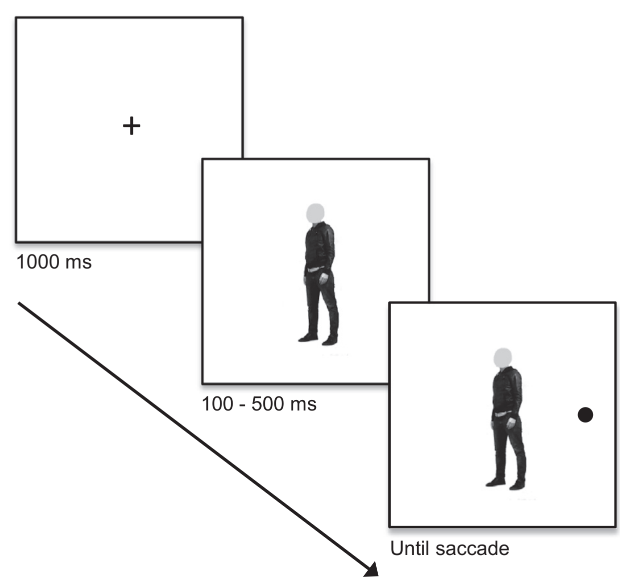

Fig. 1. Experimental task design. A fixation cross was displayed at the beginning of each trial for 1000 ms, followed by an averted posture cue for 100–500 ms (SOA manipulation) before the presentation of the peripheral target dot. A successful trial required a saccade toward the target dot. The posture cue and the target dot remained on the screen until the participant successfully made a saccade toward the target or 2000 ms had elapsed. The above example is an incongruent trial, in which the posture faces away from the saccade target.

1000 ms, directly followed by an averted posture cue. Then, in a non-predictive fashion, a target dot appeared either to the left or right of the posture cue, at one of five randomly selected SOAs (100 ms, 200 ms, 300 ms, 400 ms, 500 ms). A successful trial required a saccade toward, and fixation of, the target dot. The posture and the target dot remained on the screen until the participant successfully made a saccade toward the target or until 2000 ms had elapsed. Participants were instructed to keep their focus on the center of the screen until the target appeared, at which point they were to move their eyes to the target as quickly and accurately as possible. A saccade was recorded if eye movements deviated by $> 2.5^{\circ}$ laterally from the center of the posture cue. If participants moved their eyes before the target appeared, a message was flashed on the screen telling the participant that they had moved their eyes too quickly, and that trial was removed from analysis and randomly recycled later in the experiment. At the onset of the experiment, participants completed a practice block consisting of 12 trials, directly followed by the experiment block consisting of 180 trials.

2.3. Materials and apparatus

Three male actors were used to create directional body postures that faced either left or right, with each actor expressing one of three forms of neutral expression for a total of 18 postures. The three forms of neutral expression displayed minimal variation in stance and arm and hand position; e.g. hands at sides vs. closed, or feet spread apart vs. close together. Faces were blurred so that no gaze information was available. Presentation of target dot and posture stimuli were fully counterbalanced for each participant. Postural stimuli were grayscale images subtending $7^{\circ} \times 19^{\circ}$ visual angle and were presented in the center of a computer screen located 60 cm away from the participant. The target dot subtended 1° of visual angle and was presented either 14° to the left or right of the fixation cross, following posture stimulus onset.

A MacPro (2×2 Ghz Dual-Core Intel Xenon), equipped with a 20-inch CRT monitor operating at 75 Hz, with a resolution of 1024×768, was used to present the stimuli. The MacPro was networked to a Dell Pentium 4 that collected eye tracking data input from an Eyelink 2 eye tracker device (SR Research, Ontario, Canada), with 0.2 spatial resolution and at a sampling rate of 250 Hz.

2.4. Analysis of eye-tracking data

Saccadic response time (RT) was operationally defined as the time taken for an eye movement to be initiated toward the periphery after target onset, away from the posture stimulus located in the center of the screen. The minimum saccade amplitude was set to 2.5° in order to remove micro saccades from the analysis. Additionally, only trials in which the saccade reached the interest area surrounding the target, which was set to 200×200 pixels, were analyzed. Trials with a saccade RT > 500 ms, < 80 ms, or > 2 SD of the mean, were removed from the analysis. Mean saccadic RTs were entered into a 5 (SOA: 100, 200, 300, 400, 500 ms) $\times$ 2 (congruency: congruent, incongruent) repeated-measures ANOVA. Previously, Bayliss, di Pellegrino, and Tipper (2005) found weaker cueing by non-predictive central cues (gaze and arrows) for males compared to females. Although gender effects were not considered a primary focus of this report, a second 2 (congruency) $\times$ 5 (SOA) $\times$ 2 (gender) ANOVA was conducted, in which gender was included as a between-subjects effect.

3. Results

ANOVA results revealed a main effect of SOA, $F(4, 24) = 27.29$, $p < 0.001$, $\eta_p^2 = 0.50$), such that participants were faster to initiate saccades at longer SOAs. This finding is line with research showing that visual cues can serve as a warning signal to prepare upcoming responses (Luce, 1986). Importantly, there was also a main effect of congruency ($F(1, 27) = 4.97$, $p = 0.034$, $\eta^2_p = 0.155$), demonstrating that participants were faster to saccade toward targets that appeared on the side that the posture was facing (Fig. 2). Although no interaction between SOA and congruency was identified ($p = 0.57$), previous research (Azarian et al., 2015; Driver et al., 1999; Friesen & Kingstone, 1998) justified a series of follow-up *t*-tests in order to investigate the congruency effect at each SOA. In order to control the family-wise error rate, a Bonferroni correction was applied to the five follow-up *t*-tests investigating the congruency effect. After correcting for multiple comparisons, only the 300 ms SOA yielded a significant congruency effect ($t(1, 27) = 2.86$, *corrected* $p = 0.04$). See Fig. 2 for a depiction of saccade latencies as a function of congruency and SOA.

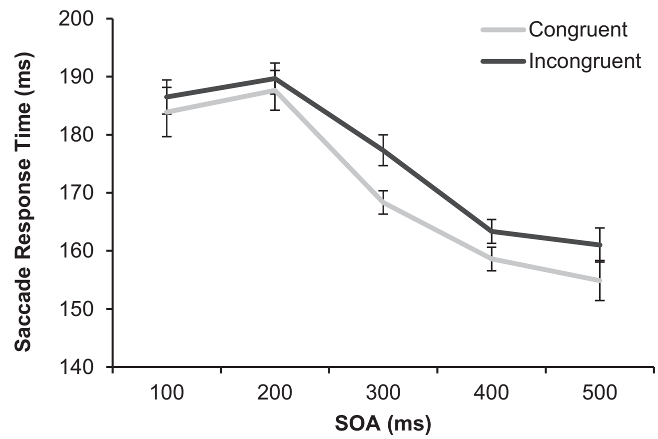

Fig. 2. Mean saccade response time as a function of congruency and SOA. Saccade response time was defined as the time it took for a saccade to be initiated in the direction of the target stimulus, following target onset. Saccade RT was significantly faster when the target appeared in a location congruent with posture direction. Additionally, saccade RT was faster at longer SOAs. Error bars reflect the standard error of the mean after the removal of within-subject variance (Cousineau, 2005).

The results of the second ANOVA in which gender was included as a between-subjects effect, identified no main effect of gender ($F(1, 26) = 3.67$, $p = 0.067$), nor a gender by congruency interaction ($F(1, 26) = 3.77$, $p = 0.064$). Although we found gender to have a non-significant effect on saccade latencies, the direction of the effect does agree with the demonstrations by Bayliss et al. (2005) that males show less cueing by task-irrelevant central cues.

4. Discussion

In the present experiment we tested whether averted postures are capable of directing human attention in a manner similar to eye gaze direction. Analysis of eye-tracking data confirmed our speculation that averted postures can direct attention, as evidenced by faster initiation of saccades to target locations that were congruent with posture direction. This finding suggests that static postures are capable of directing attention in a manner similar to averted gaze. Interestingly, a series of follow-up tests revealed that this posture-cueing effect was only significant at the 300 ms SOA, suggesting that posture-cueing occurs at a relatively early latency, but is not sustained by voluntary control.

The results of the current study suggest that the cueing effects previously seen in response to social cues such as eye gaze (Driver et al., 1999; Friesen & Kingstone, 1998), head direction (Langton & Bruce, 1999), and gestures (Langton & Bruce, 2000) extends to human postures. Additionally, this posture cueing effect is in line with a recent finding from our lab that threat-related (fearful and angry) emotional body postures automatically cue the attention of individuals with high anxiety (Azarian et al., 2015). However, the finding that unemotional/neutral body postures are capable of cueing attention in the general population is an important theoretical advancement. Our previous investigation focused specifically on high-anxious individuals, who are believed to have an altered threat-detection system (Azarian et al., 2015). Without demonstrating that normal individuals are also cued by postural stimuli, the generalizability of posture-cueing in humans remained unclear. The results of this study, on the other hand, indicate that neutral body postures are salient enough to cue attention in a normal sample of college students, suggesting that postures are reliable and informative cues of the social world. We note that this finding also builds on recent work demonstrating that videos of human walking direction can cue attention (Shi et al., 2010). However, the present study extends the work by Shi et al. (2010), by showing that when no actual or implied movement is present, static posture alone can cue attention, suggesting that crucial social information resides within the structure of the posture. Additionally, it should be noted that the study by Shi et al. (2010) measured manual response times, compared to the direct measurement of eye movements in the current study.

Previous studies investigating gaze cueing have identified effects beginning as early as 105 ms (Friesen & Kingstone, 1998), or sustained for as long as 700 ms (Driver et al., 1999), but gaze-cueing typically emerges by around 300 ms (Driver et al., 1999; Friesen & Kingstone, 1998). Although previous work by Azarian et al. (2015) found that threat-related postures cue highly anxious individuals, no neutral posture cueing effect was found at the 200 ms SOA in that study, and an anti-cueing effect was present at the 500 ms SOA. We previously suggested that the anti-cueing effect at 500 ms might reflect an IOR effect, driven by neutral posture cueing at an earlier, untested SOA. The results of the present study provide a critical extension of previous work by showing that neutral postures do indeed cue attention, and that this effect is maximal at the 300 ms SOA, similar to previous work within the gaze-cueing literature (Driver et al., 1999; Friesen & Kingstone, 1998). Although we no longer observed an anti-cueing effect at 500 ms in the present study, we note that, consistent with the pattern of results from the previous study, the posture-cueing effect was no longer significant at the 500 ms SOA. One possibility for why a significant anti-cueing effect was not observed at the 500 ms SOA in the present study is that in the current experiment, all trials involved neutral postures, whereas in the previous study by Azarian et al. (2015) neutral postures were only presented on 25% of trials. Thus, it is possible that the relative infrequency of neutral postures in the previous report by Azarian et al. (2015) led to attentional capture, an effect that was not present in the current report. This carryover effect would also explain why Gervais et al. (2010) failed to find cueing by neutral postures when they occurred in the same experiment as action-oriented postures.

The current finding that body postures direct attention is consistent with the presence of a “direction-of-attention detector”, in which information from multiple social signals, including posture, is integrated to compute the direction of another's attention (Perrett & Emery, 1994; Perrett, Hietanen, Oram, & Benson, 1992); also see work by Hietanen (2002, 1999). In their original formulation of the direction-of-attention theory, Perrett and Emery (1994) and Perrett et al. (1992) relied heavily on behavioral and physiological recordings from primates, demonstrating that the superior temporal sulcus (STS) responds most strongly to the conjunction of eye, head and posture stimuli, as opposed to eye gaze alone. This physiological work provided compelling evidence that social cues, other than eyes alone, contribute to attention. Following Perrett and colleagues' physiological work, behavioral studies in humans have confirmed that head direction can indeed reflexively cue attention (Langton & Bruce, 1999). However, there has remarkably been no work in humans confirming that posture can direct attention in the general population. The studies by Azarian et al. (2015) and Gervais et al. (2010) were concerned with cueing by emotion or action, respectively. Neutral postures in their studies served as a baseline, and it is likely that the presence of the other conditions led to a carry-over effect which reduced the cueing ability of neutral postures. Some evidence for cueing by postures comes from Zwickel and Võ (2010), who used a free-viewing task. Although postures cued attention in their task, other directional stimuli, such as a loud speaker, did not, suggesting that the posture-cueing was social in nature. The findings from the present study provide the first confirmatory evidence that the attention of normal adults can be cued based on the direction of neutral postures. Additionally, the time course of the posture-cueing effect is consistent with the notion that higher-level visual regions, such as the STS, drive attentional shifts in response to posture cues and like symbolic cues, would predict longer latencies than cues such as abrupt onsets (Cheal & Lyon, 1991; Juola, Koshino, & Warner, 1995).

The finding that human posture can cue attention raises an interesting question as to the relative contribution of various social cues in detecting the direction of a social partner's attention. Perrett and Emery (1994) and Perrett et al. (1992) originally suggested that eye, head and posture information contribute to attention detection at hierarchical levels of influence; eye gaze was believed to supersede information about head direction, and head direction in turn supersedes posture information. However, later work suggested that eye gaze and head direction provide at least mutual influences over the detection of another's attention (Langton, 2000; Langton & Bruce, 2000). Given the present finding that posture serves as an attentional cue in humans, future work should explore the relative contribution of postural cues when they conflict with eye gaze or head direction. Given that previous work has indicated that postures do not cue attention when posture and gaze are aligned (Hietanen, 1999, 2002), this suggests that the cueing observed in this experimental, as well as the experiment by Zwickel and Võ (2010), was due to the posture alone, and not due to the observer inferring eye gaze or head direction. Similar to Perrett and Emery (1994) and Perrett et al. (1992) we would hypothesize that the relative contribution of each social cue (gaze, head and posture direction) depends on their relative visibility. For example, at far distances, it is likely that head or posture direction would be more influential than gaze direction, based solely on their visibility. Additionally, it is conceivable that the relative influence of the various social cues would depend on task context. For example, posture information might be more influential in situations where it is more important to predict an individual's next likely action. Given the present support for posture as an attentional cue, future research should seek to understand the exact parameters that influence the posture-cueing effect.

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