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Social Attention as a General Mechanism? Demonstrating the Influence of Stimulus Content Factors on Social Attentional Biasing

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Humans spontaneously attend to faces and eyes. Recent findings, however, suggest that this social attentional biasing may not be driven by the social value of faces but by general factors, like stimulus content, visual context, or task settings. Here, we investigated whether the stimulus content factors of global luminance, featural configuration, and perceived attractiveness may independently drive social attentional biasing. Six experiments were run. In each, participants completed a dot-probe task where the presentation of a face, a house, and two neutral images was followed by the presentation of a response target at one of those locations. Experiments 1 and 2 assessed social attentional biasing when the face had higher overall global luminance. Experiments 3 and 4 assessed social attentional biasing when the face (but not the comparison house) retained the typical canonical configuration of internal features. Experiments 5 and 6 examined social attentional biasing when the face was more attractive than the house. Experiments 1, 3, and 5 measured manual responses when participants were instructed to maintain fixation. Experiments 2, 4, and 6 measured both manual and oculomotor responses when no instructions about eye movements were provided. The results indicated no reliable social attentional biasing in Experiments 1 to 5, however, a reliable saccadic bias toward the eyes of attractive upright faces was found in Experiment 6. Together, these results show that perceived facial attractiveness may be an important general factor in social attentional biasing.

Public Significance Statement

It is commonly understood that humans attend to faces preferentially. Recent work has challenged the notion that this effect is attributable to the inherent social value of faces by showing that spontaneous attending to faces is abolished when nonsocial factors—specifically, content within faces (e.g., luminance, configuration, attractiveness), contexts within which faces are presented in (e.g., background information), and task requirements (e.g., method of response)—are systematically controlled. Here, we show that attending to faces may be biased by the content factor of perceived facial attractiveness and not other factors like global luminance or featural configuration. This suggests that perceived facial attractiveness may be a key factor in instantiating social attentional biasing.

Keywords: attentional biasing, attractiveness, faces, social attention, stimulus content

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The answer to the question “are faces special” is often an obvious one. Routine behaviors like looking for a friend in a café anecdotally support the notion that faces are a special type of stimulus conveying information about others’ gaze, emotions, or intentions (Bruce & Young, 1986; Darwin, 2013; Willis & Todorov, 2006). However, the answer to the question “do faces

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engage perceptual and attentional processes in a unique manner" is a less obvious one.

Within the perceptual domain, face processing has been dominated by two views that differ on whether faces are processed in a specialized manner. The domain-specific view postulates that faces are a unique stimulus that depends on specific visual processing (Allison et al., 2000; Perrett et al., 1988, 1992; Tsao et al., 2006), engage distributed face-specific brain networks (Bentin et al., 1996; Gauthier et al., 2000; Haxby et al., 1994; Kanwisher & Yovel, 2006; Nummenmaa & Calder, 2009; Perrett et al., 1985, 1992; Puce et al., 1998; Yovel et al., 2003), and afford specific behavioral advantages (Farah et al., 1998; Frank et al., 2009; Simion & Giorgio, 2015; Tanaka & Simonyi, 2016; Yin, 1969). In contrast, the domain-general view maintains that faces are not unique but a stimulus category for which humans have gained high perceptual expertise, thus resulting in enhanced processing, behavioral, and neural advantages for this category of stimuli (Eimer, 2018; Gauthier et al., 1999; Gauthier, Skudlarski, et al., 2000; Gauthier, Tarr, et al., 2000; Tarr & Gauthier, 2000).

Within the attentional domain, spontaneous attentional biasing toward faces (or *social attention*) has been less contentious, as numerous studies have so far demonstrated that faces and their features, especially eyes, bias attention both covertly (i.e., attentional shifts independent of eye movements; Jonides, 1981) and overtly (i.e., attentional shifts accompanied by eye movements; Posner, 1980). Covertly, attentional effects are indexed by manual performance facilitation for targets that appear following social (e.g., a face) compared with nonsocial (e.g., a house) cues. Here, the data show preferential attention to faces across a wide array of attentional tasks (e.g., dot-probe, Bindemann et al., 2007; go/no-go, Bindemann et al., 2005; RSVP, Ariga & Arihara, 2018; visual search, Lavie et al., 2003; change detection, Ro et al., 2001; inattentional blindness, Devue et al., 2009). Overtly, attentional effects are indexed by examining the number and duration of eye movements made toward faces relative to comparison stimuli. Here as well, participants preferentially look at faces and facial features, including eyes, relative to other nonsocial objects (Yarbus, 1967). This finding has also been replicated across free-viewing naturalistic tasks (Birmingham et al., 2008a, 2008b; Cerf et al., 2009; Laidlaw et al., 2012), saccadic choice tasks (Crouzet et al., 2010), cuing tasks (Theeuwes & Van der Stigchel, 2006), and oculomotor capture tasks (Devue et al., 2012).

Thus, while prevailing research suggests that faces engage perceptual processes in either a domain-specific or domain-general manner, past attentional work has been contextualized within the notion that faces and eyes engage attentional processes in a manner that is theoretically and conceptually consistent with domain-specificity. However, recent findings have started to cast doubt on this conclusion by reporting no evidence of social attentional biasing once the face stimuli and the task are controlled for nonsocial extraneous factors.

In one of the first studies to show this result, Pereira et al. (2020) used the dot-probe procedure to present participants with images of a face, house, and neutral cues (i.e., scrambled face and house images), which were followed by a response target that occurred equiprobably at one of these possible locations. Importantly, the authors controlled the stimuli and task for three types of extraneous factors that are independent of face information, but are known to play a powerful role in attentional biasing – (a) stimulus content factors, which are tied to the internal characteristics of the stimuli, (b) visual context factors, which impact overall perception of stimuli, and (c) task settings, which are external to the stimuli but may still bias performance. To control for stimulus content, the face and the house image cues were positioned equidistant from fixation, equated for overall global luminance, configuration of internal features (i.e., the spatial arrangement of two eyes and a mouth for the face mapped on to the spatial arrangement of two windows and a door for the house), and perceived attractiveness. To control for visual context, a single image of a face and a house was used, with all background information removed and all stimuli presented against a uniform gray screen. To control for task settings, the identical task was used to measure social attentional biasing in manual and oculomotor measures, neither cue was spatially or semantically informative about the target, and the response keys and response types were not confounded with the cue position, target position, or target type. When the stimuli and task were controlled in this manner, the data surprisingly revealed no evidence of spontaneous attentional biasing toward faces in manual responses and a numerically small, but statistically reliable, oculomotor bias toward the eye region of the face. Perhaps critically, once extraneous factors were reintroduced by using the stimuli and task structure of a previously published work (Bindemann et al., 2007), robust attentional biasing effects toward faces emerged.

Further studies reported similar evidence in support of this conclusion. Pereira et al. (2019) examined whether the removal of the visual context factor of background information was a determining element in the abolishment of social attentional biasing. Using the same dot-probe procedure and manual and oculomotor measures, the data once again indicated no reliable evidence of spontaneous attentional biasing toward faces or facial features in manual responses and an infrequent but reliable eye movement bias toward the eyes of the face. Similarly, Pereira et al. (2022) demonstrated that the visual context factor of face novelty did not impact manual responses but affected eye movement biasing toward the eyes of infrequently presented faces. This work dovetails with findings showing that visual context factors like self-relevance and valence (McCrackin et al., 2021; McCrackin & Itier, 2018, 2021) and task settings like instructions and task demands (Burra et al., 2018; Võ et al., 2012) can modulate the strength and/or impact the presence of social attentional biasing. As such, social attentional biasing may in part be based on the influence of stimulus content, visual context, or task settings, and not on the intrinsic social value of faces themselves, highlighting a critical need for more studies to delineate the specific impact of these factors on attentional mechanisms.

The Present Study

Here, we examined the role of stimulus content factors in social attentional biasing. This is a critical question to address because the removal of stimulus content information, via equating global luminance, featural configuration, and perceived attractiveness in past work (Pereira et al., 2020), may have inadvertently also removed essential visual components that signal social information in faces. Importantly, each of these visual attributes has also been documented to engage spatial attention, irrespective of the social value of stimuli (Cerf et al., 2008; Eastwood et al., 2001; Hedger et al., 2019; Itier et al., 2006; Rousselet et al., 2014). Although some past work has controlled for certain extraneous factors, no study to our knowledge has equated all factors within the same task. For example, Bindemann et al. (2007; Bindemann & Burton, 2008) compared attentional effects for social and nonsocial cues, but they did not equate these cues for potential luminance differences, featural configuration, or perceived attractiveness. Sui and Liu (2009) controlled for global luminance but did not account for differences in featural configuration between their face distractor and target stimuli. While controlling for stimulus size and distance, Langton et al. (2008) did not account for differences in perceived attractiveness between their face distractors and target object stimuli. Instead, to index global stimulus differences in perceptual processing for faces, some investigators opted to control for potential differences in stimulus content across social and nonsocial stimuli by contrasting performance between upright and inverted faces (Frank et al., 2009; Simion & Giorgio, 2015; Yin, 1969). Although this is a generally well-accepted and reasonable comparison that can account for some visual attribute differences (e.g., edge density, local luminance contrasts; Maurer et al., 2002; Sekuler et al., 2004), there are other attributes (e.g., perceived attractiveness) that may survive face inversion and not be as well controlled for by this common approach (Leder et al., 2017). Thus, in addition to the control of corresponding visual context and task factors and the typical control between upright and inverted stimuli, direct manipulation of the individual stimulus content factors of global luminance, featural configuration, and perceived attractiveness are needed to determine the guiding role that these factors may play in social attention biasing (Bindemann et al., 2005; Laidlaw et al., 2012; Nummenmaa & Calder, 2009; Olk & Garay-Vado, 2011).

To this aim, we ran six experiments that examined the impact of specific stimulus content factors—global luminance, featural configuration, and perceived attractiveness—on social attentional biasing. In each experiment, participants completed a dot-probe task in which the presentation of face, house, and comparison (scrambled face and house) cue images were followed by the presentation of a response target at either the prior location of the eyes or mouth of the face, the top or bottom of the house, or the upper and lower comparison cue. While holding visual context and task factors constant, each experiment assessed the fate of social attentional biasing when only one stimulus content factor was examined. That is, in Experiments 1 and 2, overall global luminance was higher for the face relative to the house cue; in Experiments 3 and 4, the face cue displayed typical configuration of internal features while the comparison house cue did not; and in Experiments 5 and 6, the face cue was perceived as more attractive than the house cue. In addition, and paralleling past work (Pereira et al., 2019, 2020, 2022), the experiments measured both manual and oculomotor responses. In Experiments 1, 3, and 5, we instructed participants to maintain central fixation and measured their manual responses to the target. In Experiments 2, 4, and 6, we did not provide participants with any instructions about eye movements, and in addition to manual responses, we also measured their natural oculomotor responses during the task.

To understand potential perceptual processing differences across stimulus content manipulations, we also controlled for other properties of the task by presenting cue stimuli in both upright and inverted orientations (Frank et al., 2009; Simion & Giorgio, 2015; Yin, 1969) and systematically manipulating whether the faces appeared in the left or right visual field (Kanwisher et al., 1997; Kanwisher & Yovel, 2006; Puce et al., 1998; Rossion et al., 2003; Yovel et al., 2003). To assess any potential differences in the time course of social attentional biasing, presentation time between the onset of the cue and target varied across short and long intervals.

If a stimulus content factor—global luminance, featural configuration, or perceived attractiveness—played a significant role in social attentional biasing, we expected to find reliable attentional effects toward faces and/or eyes when that individual factor was manipulated. Such a pattern of data would suggest that attentional biasing for faces may at least partly be driven by general stimulus properties that broadly impact attentional mechanisms. If, however, no reliable attentional biasing effects toward faces and/or eyes are observed across these manipulations, it would suggest that these individual stimulus content factors likely do not play a determining role in social attentional effects.

Experiment 1

Experiment 1 examined the role of global facial luminance in social attentional biasing in manual responses when participants were instructed to maintain central fixation.

Global luminance, represented by the average intensity or brightness of a stimulus, is a salient attentional cue (Johannes et al., 1995; Smith, 1998; Turatto & Galfano, 2000). Past work has demonstrated the impact of luminance information, both across an entire image and within stimuli, on perceptual and cognitive processing (Benedetto et al., 2014; Cherng et al., 2020; Henderson et al., 2008; Wang et al., 2021), and studies have further demonstrated effects within the attention domain as well. For example, increased overall luminance (Posner, 1980; Smith, 1998; Yantis & Hillstrom, 1994) and heightened luminance contrast differences between the luminance of a stimuli compared with its background (Badcock et al., 2005; Bell & Badcock, 2008; Itti & Koch, 2000; Spehar & Owens, 2012) are known to reliably capture attention. Within faces specifically, local luminance information from luminance contrast differences in facial features like eyes (Ando, 2002, 2004) and between the eyes and mouth compared with the rest of the face (Etcoff et al., 2011; Russell, 2003) is also found to contribute to global luminance and holistic information about the face (Doherty et al., 2015; Lee et al., 2013; Lewis & Edmonds, 2003). Together, these findings suggest that global face luminance incorporates relevant information about both overall and local facial features, which can reliably bias attention.

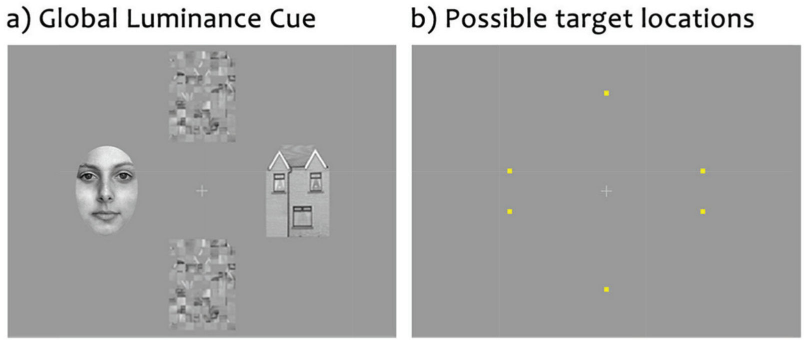
To examine this question, in Experiment 1, we preserved the typical luminance profile of the face and house cues (see Figure 1), which resulted in the face cue containing higher global luminance than the house cue. All other stimulus content, visual context, and task factors were controlled between the face and house stimuli. If global luminance differences between the cues facilitate social attentional biasing, we expected to find faster responses for targets occurring at the previous location of the face relative to the house and neutral cues.

Method

Participants

Thirty volunteers (25 women, 5 men, M_{age} = 20.2 years, SD_{age} = 1.1 years), with normal or corrected-to-normal vision, participated. This sample size reflects an a priori power analysis (*F* test family, ANOVA: repeated measures; G*Power; Faul et al., 2007), which indicated that data from six to 38 participants were needed to detect effects ranging from .65–.15, respectively (as estimated from η_p^2

Figure 1
Cue and Target Screens for Experiment 1



Note. An illustration of (a) the cue screen for Experiment 1, where the face cue contained greater global luminance than the house cue, and (b) the target screen (square target displayed) depicting all six possible target locations. The depicted face image is shown as an example and was not used in the present study. See the online article for the color version of this figure.

based on relevant prior studies investigating social attentional biasing; Bindemann & Burton, 2008; Bindemann et al., 2007; Langton et al., 2008; Ro et al., 2001), with corresponding power values from .95–.97. We considered this range of effects because estimated magnitudes of attentional biasing for faces from past research typically utilize a variety of face stimuli and do not directly overlap with the manipulations used in the current study. The closest overlap comes from Pereira et al. (2020, Experiment 4), wherein a sample size of 20 participants was sufficient to detect effects of .44 (as estimated from η_p^2) and yielded post hoc power of .96.

Informed written consent was obtained from all participants and they received course credits upon study completion. The study was conducted in accordance with the Declaration of Helsinki, and all protocol and procedures were approved by the University research ethics board.

Apparatus

All stimuli were presented on a 16” CRT monitor at an approximate viewing distance of 60 cm, with the stimulus presentation sequence controlled by MATLAB’s Psychophysics toolbox (Brainard, 1997).

Stimuli

Figure 1 illustrates the cue screen and all possible target locations. All stimuli (cues and targets) were set against a uniform 60% gray background to control for potential luminance contrast differences between the cues/target and the background (Badcock et al., 2005; Bell & Badcock, 2008; Spehar & Owens, 2012). The fixation screen included a white fixation cross measuring 1° × 1° of visual angle, which was positioned at the center of the screen. The cue screen (1a) consisted of the fixation cross and gray-scale photographs of (a) a female face looking straight ahead with a neutral expression and the hairline removed, (b) a house with no contextual background, and (c) a neutral image consisting of a fused overlay of the face and house photographs scrambled using 22-pixel blocks.[1] House cues were used as a comparison stimuli due to the overlap in visual category attributes they share with face cues, for example, they are both exemplars of an overarching basic category, have consistent placement of internal features, and relative familiarity (Filliter et al., 2016; Summerfield et al., 2006). Neutral cues were included because they are often beneficial in revealing the magnitude of social attentional biasing, that is, whether differential facilitation exists for social versus nonsocial information in relation to a common comparison stimulus (Birmingham & Kingstone, 2009). Each image measured 4.2° × 6° and was centrally positioned 6.3° away from the fixation cross, such that the central location of the eyes, mouth, top house, and bottom house were all equidistant from the fixation cross, regardless of cue orientation or face position manipulation.

To manipulate global luminance, we used luminance-uncorrected images for the face and house cues. These images were preferred over computationally manipulated ones to preserve the natural luminance within the face and house images. In this manner, average gray-scale luminance, computed using the MATLAB SHINE toolbox (Willenbockel et al., 2010) and ranging from 0–1, was numerically higher for the face than the house cue (Face = .63, House = .58, Neutral = .61), with similar numerical differences existing between the upper and lower halves of each cue (Eyes = .63, Mouth = .62, Top House = .58, Bottom House = .58). Furthermore, when segmenting each cue into 1° × 1° blocks, higher average gray scale luminance was found for the face versus the house cue, $t(158) = 4.70$, $p < .05$, $d = .74$, two-tailed.

In addition, all other stimulus content factors remained equated between the face and house cue. That is, featural configuration was matched by ensuring that the face and house cues had a consistent placement of internal configuration of features, and perceived attractiveness was matched by using a face and house cue that received equivalent attractiveness ratings[2] (Face $M = 2.89$, $SD = 1.68$, range =

[1] Cue images were obtained from Pereira et al. (2020).

[2] Twenty-eight additional naïve participants were presented with 64 different face and house photographs from the Glasgow Unfamiliar Face Database (Burton et al., 2010). The photographs were presented on a computer screen, one at a time, and participants were asked to rate each image on perceived attractiveness using a Likert scale ranging from 1 = *very unattractive* to 6 = *very attractive*. In the online supplemental materials, we illustrate the range of individual perceived attractiveness ratings for the face and house images used in the current set of studies.

1–6; House $M = 2.96$, $SD = .96$, range = 1–5), which did not differ reliably, $t(27) = .17$, $p = .87$, $d_z = .03$, two-tailed, paired.

The target screen (1b) consisted of the fixation cross and a single target (yellow circle or square, measuring .3° × .3° each) positioned 7.2° away from the fixation cross, ensuring that all target properties (i.e., size, position, and common uniform background) were equated and controlled across the experiment.

Thus, aside from a difference in overall luminance between the face and house cues, all other stimulus content, visual context, and task parameters (i.e., stimulus size, distance from fixation, background information, as well as task and response properties) remained equated.

Design

The dot-probe target discrimination task was a repeated measures design with five equiprobable factors: *Cue orientation* (upright, inverted), *Face position* (left visual field, right visual field), *Target location* (eyes, mouth, top house, bottom house, upper neutral, lower neutral), *Target identity* (circle, square), and *Cue-target interval* (250, 360, 560, 1,000 ms).

Cue orientation varied between upright and inverted images (i.e., the face, house, and comparison neutral cues could be presented either all upright or all inverted). Given the general processing and behavioral preferences for upright faces (Frank et al., 2009; Simion & Giorgio, 2015; Yin, 1969), this factor was manipulated to examine whether any effects of social attentional biasing were specific to faces in an upright orientation. *Face position* varied between the left and right visual fields, with the house image always placed in the opposite visual field. This factor was manipulated to examine any possible advantageous processing effects of lateralized social information processing in the right hemisphere of the brain (Kanwisher et al., 1997; Kanwisher & Yovel, 2006; Puce et al., 1998; Rossion et al., 2003; Yovel et al., 2003). *Target location* varied between the previous spatial location occupied by the eyes, the mouth, the top of the house, the bottom of the house, or the center of the upper or lower neutral image. This key manipulation was included to capture any performance differences for targets occurring at the previous location of the face and its facial features relative to the comparison stimuli. *Target identity* varied between a yellow circle and a yellow square to collect both response time and response accuracy. *Cue-target interval* varied between 250, 360, 560, and 1,000 ms to assess any differences in the time course of social attentional biasing (Bindemann et al., 2007; Pereira et al., 2019, 2020, 2022).

All factor combinations were presented equally often throughout the task sequence. The cues were spatially uninformative about the target location and its identity, as each target was equally likely to occur at any of the possible target locations. Conditions were intermixed and presented in a randomized order, so participants had no incentive induced by the task to attend to any particular cue.

Procedure

At the start of the experiment, participants were instructed to maintain central fixation. After the initial presentation of the fixation display for 600 ms, participants were presented with the cue display for 250 ms. This was followed by the presentation of the fixation display for 0, 110, 310, or 750 ms (constituting 250-, 360-, 560-, and 1,000-ms cue-target intervals, respectively). Then, a single response target was presented at the location previously occupied by the eyes, mouth, top house, bottom house, upper neutral, or lower neutral image. The target remained visible until response or until 1,500 ms had elapsed. Participants were instructed to identify the target quickly and accurately by pressing the ‘b’ or ‘h’ keys on the keyboard. Target identity-key response assignment was counterbalanced between participants.

Participants were informed about the task sequence, that the target was equally likely to be a circle or a square, that the target could appear in any of the possible locations, and that there was no spatial relationship between the cue content, cue orientation, cue placement, target location, or target identity. The experiment consisted of 960 trials divided equally across five testing blocks. Ten practice trials were run at the start. In total, the experiment took 60 minutes to complete.

Results

First, we examined the data for errors. Trials with response anticipations (response times [RTs] < 100 ms; .1% of all trials), timeouts (RTs > 1,000 ms; 3.0%), and incorrect key presses (key press other than ‘b’ or ‘h’; .1%) were removed from analyses. Then, accuracy for each trial was calculated based on whether participants correctly responded to the identity of the target. Overall, response accuracy was high at 92%. All further analyses for manual response time were conducted on correct trials only.

Based on previous findings (Pereira et al., 2019, 2020, 2022), which repeatedly and convincingly indicated no reliable social attentional biasing for upright or inverted faces, as well as a lack of meaningful interactions with this key main effect, we first examined the data in each experiment using an a priori hypothesis to test for the presence of an overall social attentional bias. To perform these analyses, we compared mean correct RTs using one-way repeated measures ANOVAs across Face, House, and Neutral target locations for Upright and Inverted cues.

If no evidence of social attentional biasing was found, we followed up the absence of this effect with Bayesian analyses to assess the relative strength of our null findings (i.e., BF_{10}, which provides evidence in favor of the alternative hypothesis; Dienes, 2011; Leppink et al., 2017).[3] To do so, we used a two-tailed Gaussian prior distribution centered around a mean of 17.67 ms and *SD* of 7.55 ms, reflecting the magnitude of social attentional biasing reported in previous literature (Bindemann et al., 2007, Experiments 1a and 1b). While Bayes factor values are best interpreted on a scale rather than as a cut-off, a $BF_{10} < .33$ is typically taken as evidence supporting the null and a $BF_{10} > 3.00$ as evidence supporting the alternative hypothesis. If on the other hand significant attentional biasing was found, that is, the ANOVA indicated faster RTs for targets occurring at the location of the Face relative to targets occurring at the House, we then examined the contribution of all factors by running a repeated measures ANOVA with *Cue orientation* (upright, inverted), *Face position* (left visual field, right visual field), *Target location* (eyes, mouth, top house, bottom

[3] Bayes calculator: http://www.lifesci.sussex.ac.uk/home/Zoltan_Dienes/inference/bayes_factor.swf.

house, upper neutral, lower neutral), and *Cue-target interval* (250, 360, 560, 1,000 ms).[4]

Across manual RT analyses, Greenhouse–Geiser corrections were applied for any violations of sphericity. Paired two-tailed t-tests were used for any post hoc comparisons, which were corrected for multiple comparisons using the Holm-Bonferroni procedure (Holm, 1979) and are shown below as corresponding adjusted *p* values (α_{FW} = .05; Ludbrook, 2000).

As shown in Figure 2, which plots mean correct RTs as a function of target position for Upright (2a) and Inverted (2b) cues, no overall social attentional biasing effects were found. Specifically, we found a main effect of Target location for both Upright (Mauchly's test of sphericity, $\chi^2(2) = 12.14$, $p < .01$), $F(1.48,42.91) = 157.34$, $p < .01$, $\eta_p^2 = .84$, and Inverted cues, $F(2, 58) = 83.32$, $p < .01$, $\eta_p^2 = .74$, reflecting overall slower responses to targets occurring at the location of the Neutral cues relative to targets occurring at the Face or House cues (Upright *t*s > 12.67, *ps* < .01, d_zs > 2.31; Inverted *t*s > 9.99, *ps* < .01, d_zs > 1.82). No significant differences were found for targets occurring at the previous location of the Face versus House (Upright, 571 ms versus 570 ms, respectively; $t[29] = .82$, $p = .42$, $d_z = .15$; Inverted, 571 ms versus 569 ms, respectively; $t[29] = .93$, $p = .36$, $d_z = .17$).

Bayesian analyses supported these results, returning a BF_{10} value of .01 for the Face versus House contrast for Upright cues and a BF_{10} of .02 for Inverted cues.

Discussion

Experiment 1 examined whether social attention biasing occurred when overall luminance within the face cue was higher, thus preserving its natural appearance, than overall luminance within the comparison house cue. We found no evidence for social attentional biasing in manual responses across both null hypothesis significance testing and Bayesian analyses. Therefore, when eye movements are restricted, increased global luminance of a face does not appear to drive preferential social attentional biasing when other stimulus content and visual context factors are held constant.

Next, we examined whether this finding held when no instructions were provided to participants regarding maintaining central fixation.

Experiment 2

Experiment 2 examined the role of global facial luminance in social attentional biasing in both manual and oculomotor responses when no instruction about eye movements was given. That is, in addition to measuring manual responses, Experiment 2 also assessed participants natural oculomotor behavior during the task using an eye tracker.

If global luminance differences between the cues facilitated social attentional biasing toward the face when eye movements were not restricted, we expected to find faster responses for targets occurring at the previous location of the face relative to the house and neutral cues and greater proportion of eye movements directed toward the face and/or eyes.

Method

Thirty new volunteers (24 women, 6 men, M_{age} = 20.9 years, SD_{age} = 1.6 years) participated. All apparatus, stimuli, design, and procedures were identical to Experiment 1, except: (a) eye movements were tracked using a remote EyeLink 1000 eye tracker (SR Research; Mississauga, ON) recording with a sampling rate of 500 Hz and a spatial resolution of .05°. Although viewing was binocular, only the right eye was tracked, with saccades defined as eye movements with an amplitude of at least .5°, an acceleration threshold of 9,500°/s^2, and a velocity threshold of 30°/s; (b) participants were not given any instructions about restricting or initiating eye movements, which allowed us to examine their natural oculomotor behavior during the task; and (c) a nine-point calibration procedure was performed at the start of the experiment to ensure high eye tracking accuracy, with spatial error rechecked before every trial using a single-point central calibration dot. Average spatial error was no greater than .5°, with maximum error not exceeding 1°. With the addition of eye tracking, the experiment took 90 minutes in total to complete.

Results

Manual RT

As with Experiment 1, we first examined the data for errors and accuracy. Anticipations (.03%), timeouts (2.0%), and incorrect key presses (.03%) were removed from analyses. Overall response accuracy was 96%. Manual RTs were assessed as in Experiment 1 using the same analytic criteria.

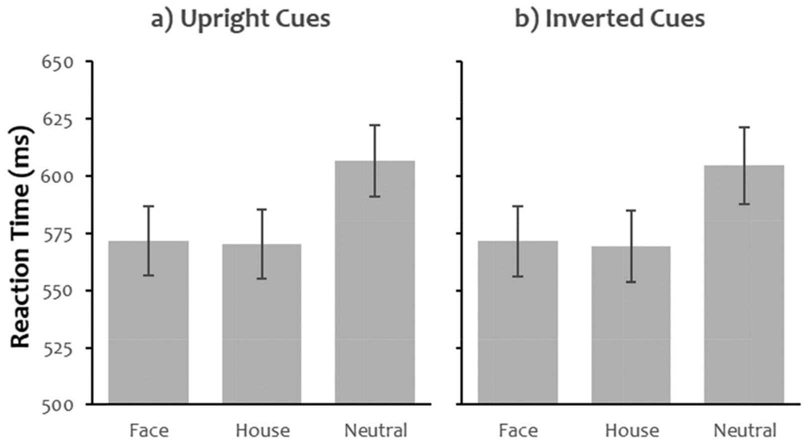
Like Experiment 1, manual data for Experiment 2, illustrated in Figure 3, showed slower overall RTs for targets occurring at the location of the Neutral cues relative to the targets occurring at the Face or House cues for both Upright, $F(2, 58) = 78.60$, $p < .01$, $\eta_p^2 = .73$; *t*s > 9.47, *p*s < .01, d_zs > 1.73, and Inverted conditions, $F(2, 58) = 91.49$, $p < .01$, $\eta_p^2 = .76$; *t*s > 10.10, *p*s < .01, d_zs > 1.84. Once again, no significant differences were found for targets occurring at the previous location of the Face versus House (Upright, 565 ms versus 572 ms, respectively; $t(29) = 1.49$, $p = .15$, $d_z = .27$; Inverted, 567 ms versus 565 ms, respectively; $t(29) = .87$, $p = .39$, $d_z = .16$). BF_{10} for the Face versus House contrast for Upright cues once again supported these results with a value of .61 (BF_{10} = .02 for Inverted).

Eye Movement Data

Because no instructions about eye movements were given, oculomotor behavior was not response relevant and thus we only examined eye movements occurring during the cue period (i.e., 250 ms). Following from previous work indicating a small but reliable oculomotor preference for faces and eyes (Pereira et al., 2019, 2020, 2022), we analyzed the proportion of first saccades that were launched from the central fixation cross in the direction of one of the cues during the 250 ms cue time (i.e., saccades did not have to terminate on the cues, but be launched *in the direction* of the cue). To perform this analysis, as illustrated in Figure 4, we

[4] For completeness, in the online supplemental materials, we present all omnibus analyses for mean correct RTs, which expectedly yielded corresponding effects.

Figure 2
Experiment 1 Manual RT Results



Note. Mean correct RTs as a function of overall Target position for (a) Upright and (b) Inverted cues. Error bars represent 95% CIs.

first defined regions of interest (ROIs) around the cues, which encompassed 30° radial windows for each of the Eyes, Mouth, Top house, and Bottom house cues, and 70° radial windows for each of the Upper neutral and Lower neutral cues, spanning an average of 43° radial window for all ROIs. Then, for each participant, we examined the trials that contained a first saccade made from the fixation cross to one of the ROIs during this cue period. Proportion of saccades toward each ROI for each participant was calculated by tallying the number of trials that contained first saccades toward each ROI divided by the number of trials when first saccades occurred during the cue period. Furthermore, to account for size differences in the radial windows between the Eyes, Mouth, Top house, and Bottom house ROIs (30° windows for each) versus the Upper neutral and Lower neutral ROIs (70° windows for each), as per prior work (Pereira et al., 2020), proportion of saccades toward the Upper and Lower neutral ROIs were corrected for the window size to ensure that these regions did not capture a greater proportion of saccades simply due to their larger radial window (i.e., proportion of saccades were scaled by 3/7th).

On average, participants saccaded away from the fixation cross during the cue presentation period rarely, on only 6% of trials (SD = 9%, range = 1–48%). On these trials, saccades were launched toward one of the ROIs 97% of the time.[5] Mean saccadic RT, defined as the time between the onset of the cue and the start of the saccade, was 150 ms (SD = 54 ms).

Like manual RT analyses, proportion of saccades were examined for the presence of overall social attentional biasing across Face, House, and Neutral ROIs for Upright and Inverted cues. Data were followed by Bayesian analyses if null effects were found or omnibus repeated measures ANOVAs with *Cue orientation* (upright, inverted), *Face position* (left visual field, right visual field), and *ROI* (eyes, mouth, top house, bottom house, upper neutral, lower neutral) if social attentional biasing was present. Greenhouse–Geiser corrections were applied for sphericity violations, paired two-tailed t-tests were used for post hoc comparisons, and multiple comparisons were corrected using the Holm-Bonferroni procedure with corresponding adjusted p values shown below.

Mean overall proportion of saccades is illustrated in Figure 5 as a function of ROI. The ANOVA indicated main effects of ROI for both Upright, $F(2, 58) = 7.65$, $p < .01$, $\eta_p^2 = .21$, and Inverted cues, $F(2, 58) = 6.97$, $p < .01$, $\eta_p^2 = .19$. For Upright cues, a greater proportion of saccades were directed toward the Face cue relative to both House and Neutral cues (.17 versus .10 versus .07, respectively; ts > 2.51, ps < .04, d_zs > .46; all other p = .12, d_z = .29). For Inverted cues, an overall higher proportion of saccades were directed to both Face and House cues relative to Neutral cues (.17 versus .18 versus .07, respectively; ts > 3.18, ps < .01, d_zs > .58; all other p = .82, d_z = .04).

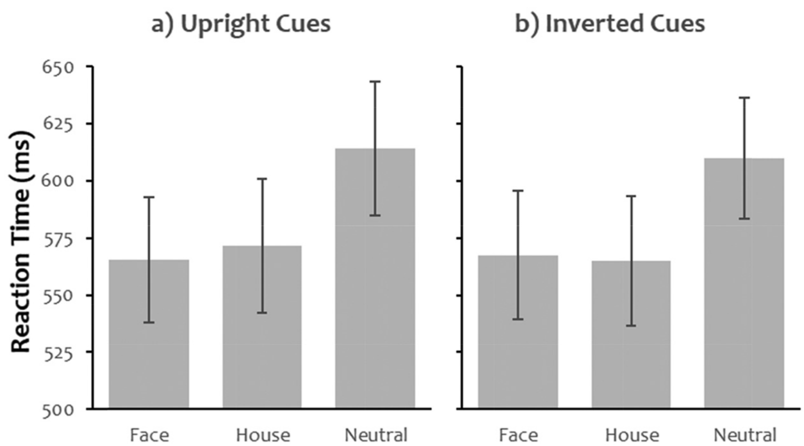
Because the data indicated an overall oculomotor bias toward faces, we next examined how proportion of breakaway saccades varied as a function of *Cue orientation* (upright, inverted), *Face position* (left visual field, right visual field), and *ROI* (eyes, mouth, top house, bottom house, upper neutral, lower neutral). Figure 6 illustrates the mean proportion of saccades as a function of all ROIs.

We found a main effect of *Cue orientation*, $F(1, 29) = 4.80$, p = .04, $\eta_p^2 = .14$, reflecting an overall greater proportion of saccades when cues were Inverted compared with Upright. There was also a main effect of *ROI* (Mauchly's test of sphericity, $\chi^2(14) = 43.31$, $p < .01$), $F(3.06,88.81) = 6.86$, $p < .01$, $\eta_p^2 = .19$, with an overall lower proportion of saccades directed toward the Lower Neutral cue than the Eyes, Mouth, Top House, and Bottom House regions (ts > 3.34, ps < .03, d_zs > .61). No overall significant differences emerged in the proportion of saccades directed toward the Eyes, Mouth, Top House, and Bottom House cues (ts < 2.80, ps > .09, d_zs < .51).

Two interactions were significant. The first was between *ROI* and *Cue orientation* (Mauchly's test of sphericity, $\chi^2(14) = 76.50$,

[5] In the online supplemental materials, Tables S1, S2, and S3 (for Experiments 2, 4, and 6, respectively) show the number of trials containing saccades during the cue period for each participant, in total, and as a function of ROI (eyes, mouth, top house, bottom house, upper neutral, lower neutral).

Figure 3
Experiment 2 Manual RT Results

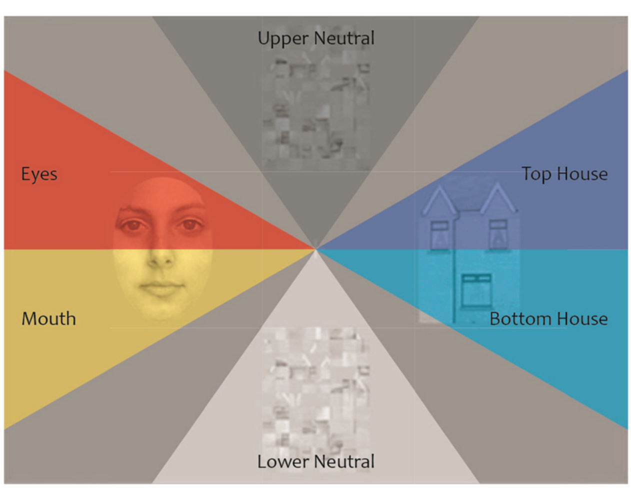


Note. Mean correct RTs as a function of overall Target position for (a) Upright and (b) Inverted cues. Error bars represent 95% CIs.

$p < .01$), $F(2.54,73.81) = 3.27$, $p = .03$, $\eta_p^2 = .11$ A greater proportion of saccades were directed toward the Eyes versus the Lower Neutral cue for both Upright, $t(29) = 3.47$, $p = .03$, $d_z = .63$ (all other $ps > .09$, d_zs $< .54$), and Inverted conditions, $t(29) = 3.95$, $p = .01$, $d_z = .72$. Further, when the cues were Inverted, a greater proportion of saccades were also directed toward the Top House cue compared with the Bottom House, Upper Neutral, and Lower Neutral cues ($ts > 3.11$, $ps < .05$, d_zs $> .57$; all other $ps > .14$, d_zs $< .49$). However, no differences were found in proportion of saccades toward the Eyes, Mouth, Top House, and Bottom House ($ts < 2.38$, $ps > .22$, d_zs $< .43$).

The second interaction was between *ROI* and *Face position* (Mauchly's test of sphericity, $\chi^2(14) = 77.72$, $p < .01$), $F(2.45,71.04) = 3.62$, $p = .02$, $\eta_p^2 = .11$, which revealed that when the face was presented in the left visual field, a greater proportion of saccades were launched toward the Eyes versus the Lower Neutral cue, $t(29) = 3.37$, $p = .03$, $d_z = .62$ (all other $ps > .06$, d_zs $< .58$). When the face was presented in the right visual field, a lower proportion of saccades were launched toward the Lower Neutral cue compared with the Eyes, Top House, and Bottom House cues ($ts > 3.19$, $ps < .05$, d_zs $< .58$; all other $ps > .09$, d_zs $< .52$). Similar to the previous interaction, no differences were found in proportion of saccades toward the Eyes, Mouth, Top House, and Bottom House cues ($ts < 2.69$, $ps > .13$, d_zs $< .49$). No other effects or interactions were significant ($Fs < 1.93$, $ps > .14$, $\eta_p^2 < .06$).

Figure 4
Regions of Interest (ROI)

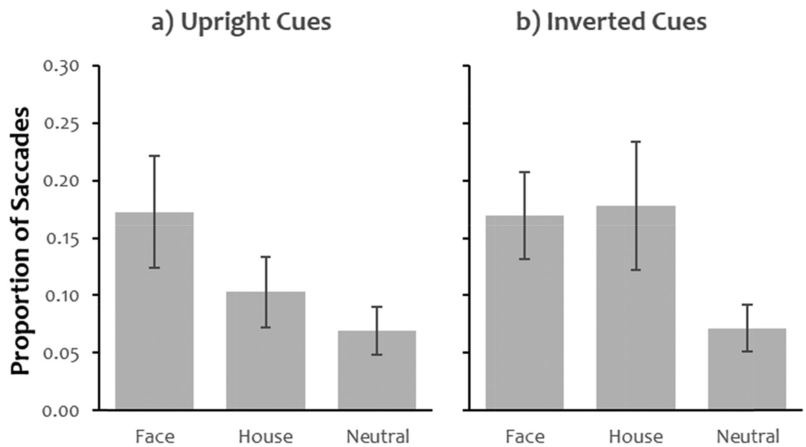


Note. ROIs were defined by a radial window, including the area of interest; red = eyes, yellow = mouth, dark blue = top house, light blue = bottom house, dark gray = upper neutral, light gray = lower neutral. See the online article for the color version of this figure.

Discussion

Experiment 2 examined social attention biasing when overall luminance within the face cue was higher than the comparison house cue and when participants were not instructed to maintain central fixation. Manual data replicated Experiment 1, with no evidence for social attentional biasing. Oculomotor data similarly showed that participants rarely disengaged from central fixation to look at the cues during the cue presentation time (i.e., on only 6% of all trials); however, when they did, they looked more frequently toward the face. As revealed by the comparison of upright and inverted cues, this effect was not specific to differences across the face and house cues and was also not specific to upright faces. That is, while the overall a priori analysis indicated greater overall number of oculomotor breakaways toward the face relative to the house cue, the follow-up ANOVA indicated that this effect was not specific to upright faces. As such, this effect may have been driven by an overall larger number of breakaway saccades for the eye region relative to the neutral cue when the face was shown in the left visual field and likely reflects overall difference in low level visual features in the stimuli rather than any specific bias toward the facial region (Turatto & Galfano, 2000). Therefore, when participants' natural oculomotor behavior is preserved, increased global luminance within the face does not lead to typical reinstantiation of social attentional biasing

Figure 5
Experiment 2 Oculomotor Results



Note. Mean proportion of trials containing a breakaway saccade during the cue presentation period that was directed towards a region of interest (ROI) for (a) Upright and (b) Inverted cues. Error bars represent 95% CIs. Summation of values across both Upright and Inverted cues reveals the total proportion of trials with breakaway saccades directed towards ROI regions (i.e., 0.76 proportion of trials directed to ROI regions [0.34 for Upright, 0.42 for Inverted] versus 0.24 to non-ROI regions).

when other stimulus content and visual context factors are held constant; however, it may lead to general oculomotor biasing toward more overall luminant region of the display.

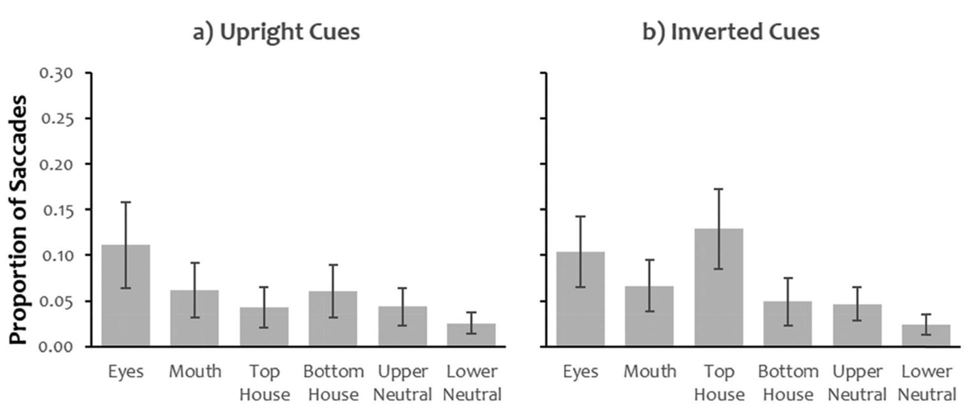
Next, we examined whether the presence of social attention biasing may depend on similar internal configuration of the comparison stimulus.

Experiment 3

Experiment 3 examined the role of internal canonical organization of faces in social attentional biasing in manual responses when participants are instructed to maintain central fixation.

Featural configuration represents the spatial relationship between the two eyes on top and one mouth centrally located on the bottom of faces. This spatial arrangement of features can affect facial processing and social attention at an early stage (Dakin & Watt, 2009; Goffaux & Dakin, 2010; Maurer et al., 2002; Pachai et al., 2013). Studies have demonstrated that face perception depends on the canonical representation of internal face features, such that upright faces are easier to perceive and identify than individual facial features or inverted faces (Frank et al., 2009; Hochberg & Galper, 1967; Simion & Giorgio, 2015; Yin, 1969), with additional studies demonstrating preferential oculomotor biasing toward faces with more consistent internal configuration

Figure 6
Experiment 2 Oculomotor Results



Note. Mean proportion of trials containing a breakaway saccade during the cue presentation period that was directed towards regions of interest (ROIs) for (a) Upright and (b) Inverted cues. Error bars represent 95% CIs. Summation of values across both Upright and Inverted cues reveals the total proportion of trials with breakaway saccades directed towards ROI regions.

(Johnson et al., 1991; Mondloch et al., 1999). Often, houses are used as comparison stimuli to faces as they display similar canonical configural structure but lack social content (Bruce & Young, 1986; Farah et al., 1998; Kanwisher & Yovel, 2006; O'Craven et al., 1999; Tanaka & Farah, 1993). However, keeping the internal configuration between face and houses on par in past work (Pereira et al., 2019, 2020, 2022) may have resulted in comparison house cues appearing too face-like, thus biasing attentional results toward null effects.

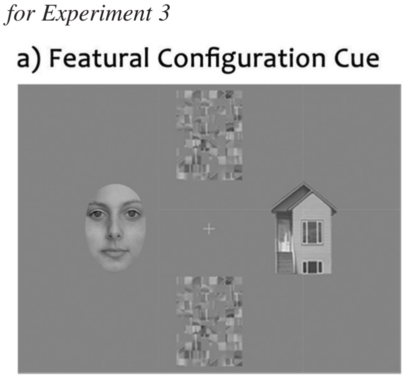
To examine the role of internal configuration in social attention biasing, in Experiment 3, we used a house cue that had a different configuration of internal features relative to the face cue. As illustrated in Figure 7, the house cue contained one door that was placed off to the side and only one central window. As before, the images were equated on all other factors, that is, size, distance from fixation, average global luminance, perceived attractiveness, uniform background, and task and response settings. Therefore, if unique featural configuration of faces is a key factor in social attentional biasing, we expected to find typical social attentional biasing effects indicating faster responses for targets occurring at the previous location of the face and eyes relative to the comparison house cue.

Method

Thirty new volunteers participated (24 women, 6 men, M_{age} = 20.3 years, SD_{age} = 1.3 years). None had participated in any previous experiments.

All parameters were identical to Experiment 1 except for the cue stimuli, which are illustrated in Figure 7. To manipulate featural configuration, the placement of the windows and door of the house cue did not match the internal spatial arrangement of the eyes and mouth of the face cue. All other stimulus content factors remained equated. That is, global luminance was equated across the face and house cues using the MATLAB SHINE toolbox (Face = .60, House = .61, Neutral = .60; split-half luminance, Eyes = .60, Mouth = .60, Top House = .60, Bottom House = .62; 1° × 1° luminance segmented block analysis for face versus house, $t[158]$ = 1.54, p = .13, d = .24, two-tailed), and perceived attractiveness was matched by utilizing face and house images that received equivalent attractiveness ratings (see Footnote 1; Face M = 2.93, SD = .77, range = 1–4; House M = 3.11, SD = 1.47, range = 1–6; $t[27]$ = .57, p = .57, d_z = .11, two-tailed, paired).

Figure 7
Cue Screen for Experiment 3



Note. An illustration of the cue screen for Experiment 3, where the internal featural configuration of the face cue did not match the internal featural configuration of the house cue.

Results

Anticipations (.3%), timeouts (3.6%), and incorrect key presses (.3%) were removed from analyses. Overall response accuracy was 92%.

As illustrated in Figure 8, which shows mean correct RTs for Upright (8a) and Inverted (8b) cues, there was once again no overall response advantage for targets occurring at the location of the face relative to the house cue. That is, the ANOVA showed overall slower RTs for targets occurring at the location of the Neutral cues relative to the targets occurring at the Face or House cues for Upright (Mauchly's test of sphericity, $\chi^2(2)$ = 9.46, p = .01), $F(1.55,45.08)$ = 75.82, $p < .01$, η^2_p = .72; ts > 9.02, ps < .01, d_zs > 1.65 and Inverted cues, $F(2, 58)$ = 84.48, $p < .01$, η^2_p = .74; ts > 10.07, ps < .01, d_zs > 1.84, with no significant differences for targets occurring at the previous location of the Face relative to the House (Upright, 583 ms versus 584 ms, respectively; $t(29)$ = .28, p = .78, d_z = .05; Inverted, 584 ms versus 581 ms, respectively; $t(29)$ = 1.34, p = .19, d_z = .24). Supporting this result, the Bayes analysis for Upright Face versus House contrasts yielded a BF_{10} of .03 (BF_{10} = .02 for Inverted).

Discussion

Experiment 3 examined whether equating the face and house stimuli on internal configuration of features impacted social attention bias. We hypothesized that if this variable was one of the driving factors of social attentional biasing, once the factor was reinstated, there should be reliable attentional effects toward faces. The data did not support this hypothesis, as we found no evidence of spontaneous social attentional biasing in manual responses across both null hypothesis significance testing and Bayesian analyses when participants were instructed to maintain central fixation.

The next experiment examined whether this finding was consistent when eye movements were not restricted and participants' natural oculomotor behavior was preserved.

Experiment 4

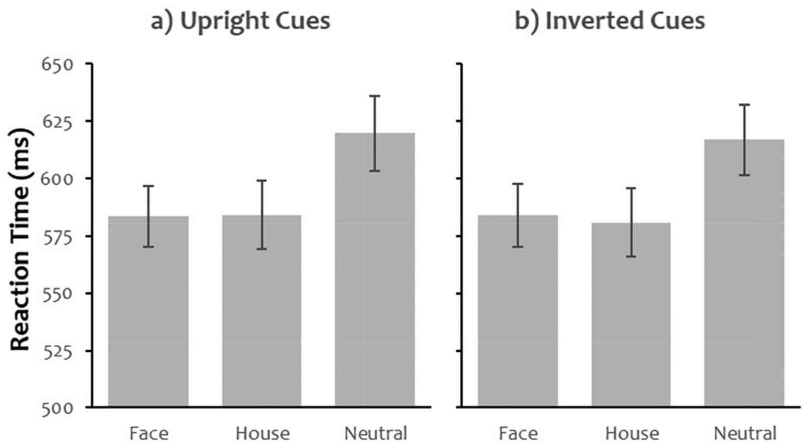
Experiment 4 examined whether social attentional biasing, as assessed via manual and oculomotor responses, depended on the internal canonical organization of faces when participants were provided with no instruction about eye movements.

If featural configuration of faces facilitates social attentional biasing, we expected to find faster responses for targets occurring at the previous location of the face and eyes relative to the comparison house cue, along with greater proportion of eye movements directed toward the face and eyes.

Method

Thirty additional volunteers (25 women, 5 men, M_{age} = 20.4 years, SD_{age} = 1.5 years) participated. The task and the stimuli were identical to Experiment 3, whereas the eye tracking parameters were identical to Experiment 2.

Figure 8
Experiment 3 Manual Response Time (RT) Results



Note. Mean correct RTs as a function of overall Target position for (a) Upright and (b) Inverted cues. Error bars represent 95% CIs.

Results

Manual RT

Anticipations (.02%), timeouts (1.2%), and incorrect key presses (.01%) were removed from analyses. Overall response accuracy was 96%.

Once again, and as depicted in Figure 9, no reliable social attentional biases were found. Significant main effects for Upright, $F(2, 58) = 63.57$, $p < .01$, $\eta_p^2 = .69$, and Inverted cues, $F(2, 58) = 72.81$, $p < .01$, $\eta_p^2 = .72$, indicated overall slower RTs for targets occurring at the previous location of the Neutral cues relative to the previous location of the Face and House cues (Upright, *t*s > 9.89, *p*s < .01, d_zs > 1.81; Inverted, *t*s > 10.39, *p*s < .01, d_zs > 1.90), with no significant differences for targets occurring at the previous location of the Face relative to the House (Upright, 557 ms versus 563 ms, respectively; $t(29) = 1.26$, $p = .22$, $d_z = .23$; Inverted, 562 ms versus 564 ms, respectively; $t(29) = .40$, $p = .70$, $d_z = .07$). BF_{10} for this analysis was .48 for Upright cues (BF_{10} = .08 for Inverted).

Eye Movement Data

Eye movements were analyzed as in Experiment 2. As before, during the cue period, saccadic breakaways from the central fixation cross were rare, occurring on 9% of trials (*SD* = 16%, range = 1–67%). Of these trials, saccades were launched toward an ROI 96% of the time. Mean saccadic RT was 155 ms (*SD* = 52 ms). Mean proportion of first saccades away from the fixation cross is illustrated in Figure 10 as a function of ROI for Upright (10a) and Inverted (10b) cues.

A main effect of ROI was significant for Upright (Mauchly's test of sphericity, $\chi^2(2) = 7.93$, $p = .02$), $F(1.60, 46.52) = 9.84$, $p < .01$, $\eta_p^2 = .25$, and Inverted cues, $F(1.88, 54.56) = 5.35$, $p = .01$, $\eta_p^2 = .16$, denoting a greater proportion of saccades directed toward the Face relative to both House and Neutral (Upright, .19 versus .08 versus .08, respectively; *ts* > 3.04, *ps* < .01, d_zs > .55; all other $p = .76$, $d_z = .06$; Inverted, .19 versus .10 versus .08, respectively; *ts* > 2.48, *ps* < .04, d_zs > .45; all other $p = .58$, $d_z = .10$).

Because the data indicated increased frequency of eye movements toward the Face region, we examined proportion of breakaway saccades as a function of *Cue orientation* (upright, inverted), *Face position* (left visual field, right visual field), and *ROI* (eyes, mouth, top house, bottom house, upper neutral, lower neutral). These data are illustrated in Figure 11.

The analysis indicated a main effect of *ROI*, $F(5, 145) = 5.67$, $p < .01$, $\eta_p^2 = .16$, showing an overall greater proportion of saccades directed toward the Eyes compared with the Top House, Bottom House, Upper Neutral, and Lower Neutral cues (*t*s > 3.18, *ps* < .04, d_zs > .58; all other *ps* > .23, d_zs < .45).

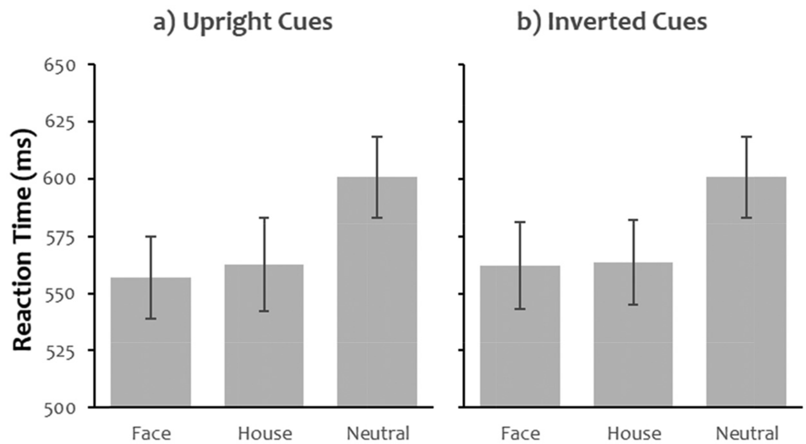
We also found a reliable interaction between *ROI* and *Face position* (Mauchly's test of sphericity, $\chi^2(14) = 29.05$, $p = .01$), $F(3.49, 101.11) = 2.74$, $p = .04$, $\eta_p^2 = .09$. When the face was presented in the left visual field, a greater proportion of saccades were launched toward the Eyes compared with the Top House, Bottom House, Upper Neutral, and Lower Neutral cues (*t*s > 3.65, *ps* < .01, d_zs > .67). Furthermore, there were also a greater proportion of saccades directed toward the Mouth compared with the Top House, Bottom House, and Lower Neutral cues (*t*s > 3.13, *ps* < .04, d_zs > .57; all other *ps* > .13, d_zs < .46). No such relationship was found when the face was presented in the right visual field (all *ps* > .99, d_zs < .35). However, this oculomotor biasing effect did not appear to be specific to Upright faces, as no interactions involving *Cue Orientation* were found, *ROI* × *Cue Orientation;* $F(5, 145) = 1.77$, $p = .12$, $\eta_p^2 = .06$; *ROI* × *Face Position* × *Cue Orientation*, $F(5, 145) = .85$, $p = .52$, $\eta_p^2 = .03$. No other effects reached significance (*F*s < .49, *ps* > .49, $\eta_p^2 < .02$).

Discussion

In Experiment 4, we examined whether social attentional biasing would occur when the internal configuration of features between the face and house stimuli were not equated and eye movements were not controlled.

Similar to Experiment 3, we found no evidence of spontaneous social attentional biasing in manual responses. Although oculomotor breakaway data indicated a greater proportion of first saccades

Figure 9
Experiment 4 Manual Response Time (RT) Results



Note. Mean correct RTs as a function of overall Target position for (a) Upright and (b) Inverted cues. Error bars represent 95% CIs.

directed toward the eyes of faces, similar to Experiment 2, this result was not specific to upright faces. That is, we found a nonspecific increased frequency of saccadic breakaways toward the eye region of the face relative to the house and neutral cues; however, this effect was not unique to upright faces, and as such could reflect overall differences in low-level visual properties of the stimuli rather than any specific social biasing by face cues. Thus, the results from Experiment 4 do not lend support to the hypothesis that the internal configuration of face stimuli may be a driving factor behind social attentional biasing as reported in previous literature.

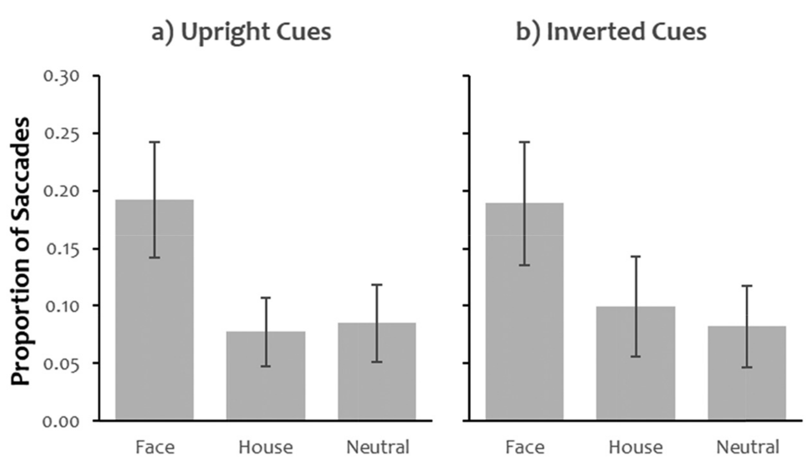
Next, we examined the role of perceived facial attractiveness in social attentional biasing.

Experiment 5

Experiment 5 examined whether perceived attractiveness of the face influenced social attentional biasing in manual responses when participants were instructed to maintain central fixation.

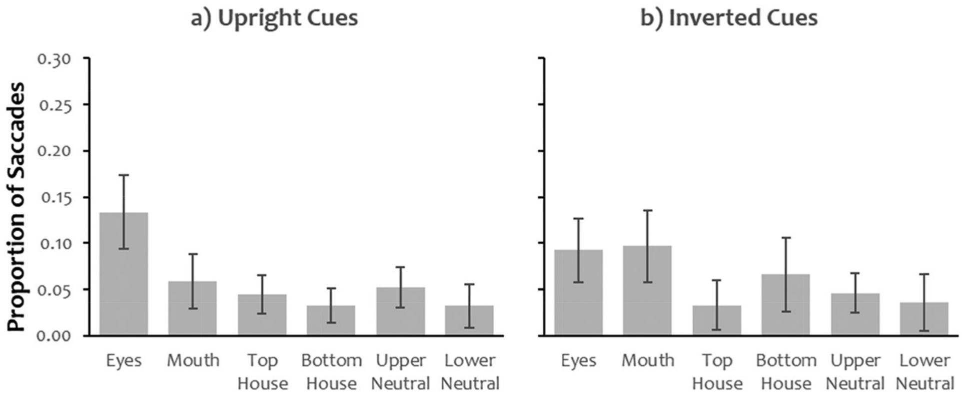
Facial attractiveness, defined as a representation of aesthetically pleasing information, is a powerful attentional cue. Since attractiveness appears to be processed rapidly (Locher et al., 1993; Olson & Marshuetz, 2005), it can play an important role in social attentional biasing. Indeed, past work shows that eye movements are more strongly biased toward attractive relative to unattractive faces (Aharon et al., 2001; Maner et al., 2007), while attentional

Figure 10
Experiment 4 Oculomotor Results



Note. Mean proportion of trials containing a breakaway saccade during the cue presentation period that was directed towards a region of interest (ROI) for (a) Upright and (b) Inverted cues. Error bars represent 95% CIs. Summation of values across both Upright and Inverted cues reveals the total proportion of trials with breakaway saccades directed towards ROI regions (i.e., 0.72 proportion of trials directed to ROI regions [0.35 for Upright, 0.37 for Inverted] versus 0.28 to non-ROI regions).

Figure 11
Experiment 4 Oculomotor Results



Note. Mean proportion of trials containing a breakaway saccade during the cue presentation period that was directed towards regions of interest (ROIs) for (a) Upright and (b) Inverted cues. Error bars represent 95% CIs. Summation of values across both Upright and Inverted cues reveals the total proportion of trials with breakaway saccades directed towards ROI regions.

work shows that attractive faces bias manual responses in a cuing task even when they are manipulated as task-irrelevant (Sui & Liu, 2009). Although houses may not have proportional attractiveness when compared with faces, studies have found that houses can differ in terms of their likeability and typicality (Filliter et al., 2016), which may be akin to the generalized information processing mechanisms used to judge attractiveness for faces (Halberstadt & Rhodes, 2003). Therefore, we reasoned that comparing measures of perceived attractiveness for a face that is rated as highly attractive and a house that is not rated as highly attractive would provide a good platform for such a comparison.

To examine this question in Experiment 5, as illustrated in Figure 12, we used a face cue that was perceived as more attractive than the comparison house cue. If perceived attractiveness was a key driving factor for social attentional biasing, we expected to find faster responses for targets occurring at the previous location of the face and eyes compared with the previous location of the house.

Method

Thirty new naïve volunteers participated (26 women, 4 men, $M_{\text{age}} = 21.0$ years, $SD_{age} = 2.2$ years).

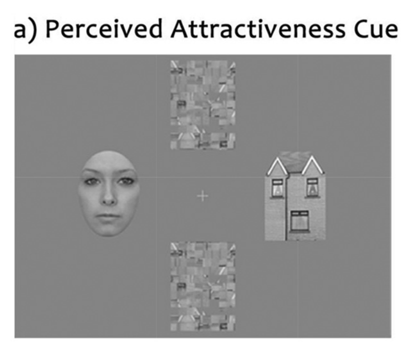
All factors were kept identical to Experiments 1 and 3 except for the stimuli, illustrated in Figure 12. Here, we used a face identity cue that received the highest attractiveness rating (Face M = 5.71, *SD* = .71, range = 3–6), whereas the house image used was the same as in Experiment 1, which received an average attractiveness rating (see Footnote 1; House *M* = 2.96, *SD* = .96, range = 1–5). The attractiveness ratings between the face and the house image differed reliably, $t(27) = 11.24$, $p < .01$, $d_z = 2.12$, two-tailed, paired. All other stimulus content factors, that is, global luminance (Face = .60, House = .58, Neutral = .60; split-half luminance, Eyes = .60, Mouth = .60, Top House = .58, Bottom House = .58; 1° × 1° luminance segmented block analysis for face versus house, $t(158) = 1.22$, $p = .22$, $d = .19$, two-tailed) and featural configuration, visual context factors (uniform background information), and task parameters (target and response settings) remained equated.

Results

Anticipations (.4%), timeouts (2.9%), and incorrect key presses (.4%) were removed from analyses. Overall response accuracy was 92%.

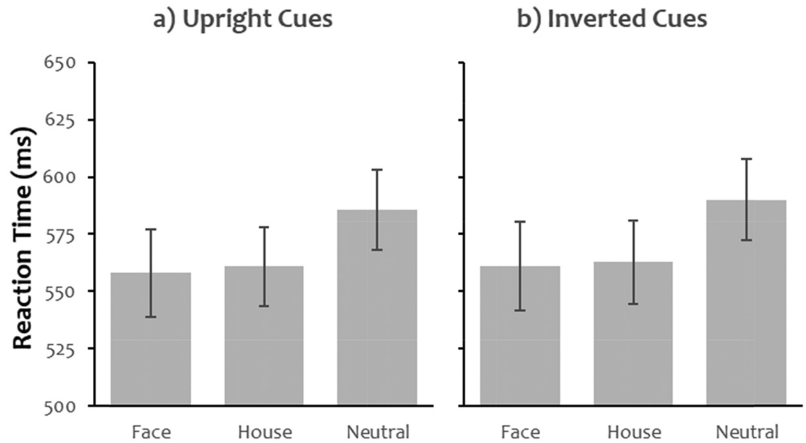
Mean correct RTs are illustrated in Figure 13 for Upright (13a) and Inverted (13b) cues, showing once again slowest RTs for targets occurring at the Neutral cue locations (Upright, $F(2, 58) = 53.54$, $p < .01$, $\eta_p^2 = .65$; *t*s > 7.95, *p*s < .01, d_zs > .1.45; Inverted, $F(2, 58) = 63.46$, $p < .01$, $\eta_p^2 = .69$; *t*s > 9.90, *p*s < .01, d_zs > 1.81), and no difference in overall RTs for targets occurring at the locations of the Face or House cues (Upright, 558 ms versus 561 ms, respectively; all other $p = .25$, $d_z = .22$; Inverted, 561 ms versus 563 ms, respectively; all other $p = .61$, $d_z = .09$). Bayes

Figure 12
Cue Screen for Experiment 5



Note. An illustration of the cue screen for Experiment 5, where the face cue had a higher rating of perceived attractiveness than the house cue. The depicted face image shown received the highest attractiveness rating and was used in the present study.

Figure 13
Experiment 5 Manual Response Time (RT) Results



Note. Mean correct RTs as a function of overall Target position for (a) Upright and (b) Inverted cues. Error bars represent 95% CIs.

factor analysis for Upright Face versus House contrasts yielded a value of .11 (BF_{10} = .06 for Inverted).

Discussion

In Experiment 5, we examined whether social attentional biasing was affected by facial attractiveness by presenting a face cue that had received the highest perceived attractiveness ratings. When participants were instructed to maintain central fixation, no overall social attentional bias was found, such that manual responses for targets occurring at the previous location of the face did not differ from when targets occurred at the previous location of the house.

In the next experiment, we examined whether these results held when examining participants' natural oculomotor behavior during the task.

Experiment 6

Experiment 6 examined whether social attentional biasing measured via manual and oculomotor responses was influenced by the perceived attractiveness of the face when no instruction about eye movement was given. If perceived attractiveness impacted social attentional biasing, we would expect faster manual responses for targets occurring at the previous location of the face and/or increased oculomotor breakaways toward the face cue.

Method

Thirty new volunteers participated (24 women, 6 men, M_{age} = 20.6 years, SD_{age} = 1.7 years). The stimuli were identical to Experiment 5. All other parameters were identical to Experiments 2 and 4.

Results

Manual RT

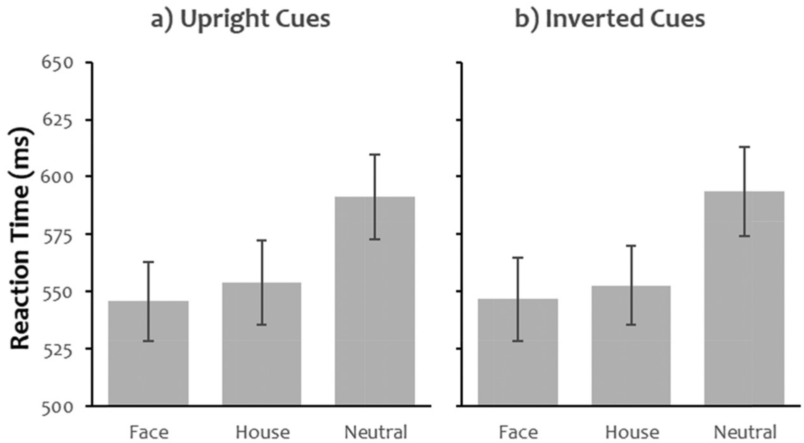
Anticipations (.2%), timeouts (1.2%), and incorrect key presses (.2%) were removed from analyses. Overall response accuracy was 97%.

Figure 14 shows these data. There were significant main effects of Target position for both Upright, $F(2, 58) = 96.44$, $p < .01$, $\eta_p^2 = .77$, and Inverted cues, $F(2, 58) = 131.19$, $p < .01$, $\eta_p^2 = .82$, denoting a presence of an overall attentional bias toward faces. That is, targets occurring at the previous location of the Face cue were responded to faster relative to targets occurring at the previous location of the House cue for both Upright (546 ms versus 554 ms, respectively; $t(29) = 2.52$, $p = .02$, $d_z = .46$) and Inverted cues (547 ms versus 553 ms, respectively; $t(29) = 2.28$, $p = .03$, d_z = .42). Of lesser interest, there were also slower overall responses for targets occurring at the previous location of the Neutral cues versus the Face and House cues (Upright, ts > 10.49, ps < .01, d_zs > 1.92; Inverted, ts > 12.65, ps < .01, d_zs > 2.31).

Next, we subjected the mean correct RTs to a repeated measures ANOVA with *Cue orientation* (upright, inverted), *Face position* (left visual field, right visual field), *Target location* (eyes, mouth, top house, bottom house, upper neutral, lower neutral), and *Cue-target interval* (250, 360, 560, 1,000 ms). However, as illustrated in Figure 15, the omnibus ANOVA returned no reliable main effects or interactions supporting social attention biasing nor indicating facilitation for targets occurring at the location of the Eyes or Mouth relative to those occurring at the location of the Top or Bottom House (548 ms versus 545 ms versus 553 ms versus 554 ms, respectively; ts < 2.89, ps > .05, d_zs < .53). Further, no effects were specific to upright faces and there were no effects or interactions involving Cue orientation, *Cue orientation* × *Target location*, $F(5, 145) = .83$, $p = .53$, $\eta_p^2 = .03$; *Cue orientation* × *Face position* × *Target location*, $F(5, 145) = .78$, p = .56, $\eta_p^2 = .03$; *Cue orientation* × *Cue-target interval* × *Target location*, $F(15, 435) = .77$, $p = .71$, $\eta_p^2 = .03$; *Cue orientation* × *Face position* × *Cue-target interval* × *Target location*, $F(15, 435) = .76$, $p = .72$, $\eta_p^2 = .03$.

Instead, of lesser theoretical interest, the omnibus analysis indicated a significant main effect of *Cue-target interval*, $F(3, 87)$ = 43.56, $p < .01$, $\eta_p^2 = .60$, with overall slower RTs for shorter versus longer cue-target intervals (250 ms versus all, ts > 6.91, ps < .01, d_zs > 1.26; all other ps > .25, d_zs < .33). This finding demonstrates the typical foreperiod effect found within attentional dot-

Figure 14
Experiment 6 Manual Response Time (RT) Results



Note. Mean correct RTs as a function of overall Target position for (a) Upright and (b) Inverted cues. Error bars represent 95% CIs.

probe tasks (Bertelson, 1967; Hayward & Ristic, 2013) and reflects an increased response preparation with a lengthening of the time between the cue and the target. There was also a significant main effect of *Target location* (Mauchly's test of sphericity, $\chi^2(14) = 34.58$, $p < .01$), $F(3.53,102.42) = 68.86$, $p < .01$, $\eta_p^2 = .70$, reflecting overall slower RTs for targets occurring at the previous location of the Neutral cues versus all other cues (ts > 9.28, ps $< .01$, d_zs > 1.69). No other effects were reliable (Fs < 1.40, ps $> .24$, $\eta_p^2 < .05$).

Therefore, even though manual RTs suggested the presence of an overall attentional bias for faces relative to house and neutral target locations, this effect did not persist for specific target locations and for upright cues.

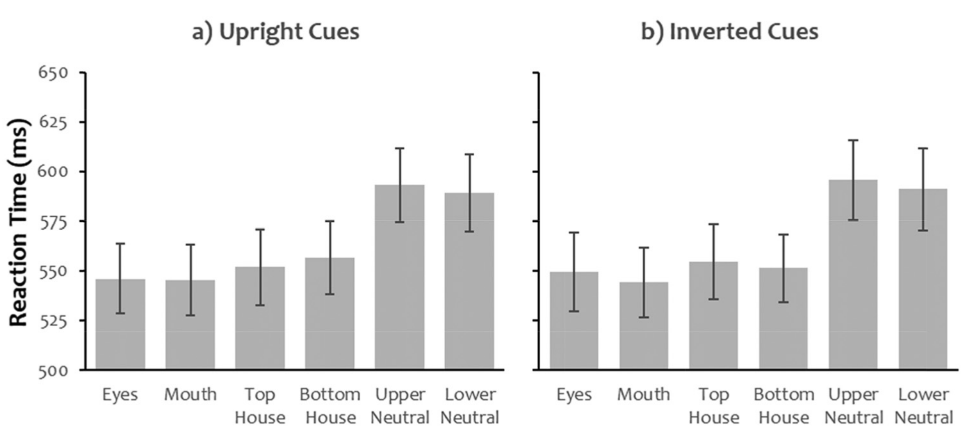
Eye Movement Data

As in previous experiments, participants saccaded away from central fixation on 9% of trials during the cue presentation (SD = 15%, range = 1–75%). Of these trials, saccades were launched toward an ROI on 95% of trials. Mean saccadic RT was 156 ms (SD = 53 ms). Mean proportion of saccades are illustrated in Figure 16 as a function of ROIs for Upright (16a) and Inverted (16b) cues.

There were reliable main effects of ROI for both Upright (Mauchly's test of sphericity, $\chi^2(2) = 14.86$, $p < .01$), $F(1.42,41.08) = 12.21$, $p < .01$, $\eta_p^2 = .30$, and Inverted conditions, $F(2, 58) = 3.65$, $p = .03$, $\eta_p^2 = .11$, indicating a greater proportion of saccades directed toward the Face versus the House and Neutral cues for Upright (.22 versus .10 versus .06, respectively; ts > 3.00, ps $< .01$, d_zs $> .55$; all other $t(29) = 1.52$, $p = .14$, $d_z = .28$) but not Inverted cues (.17 versus .10 versus .08, respectively; ts < 2.18, ps $> .11$, d_zs $< .40$).

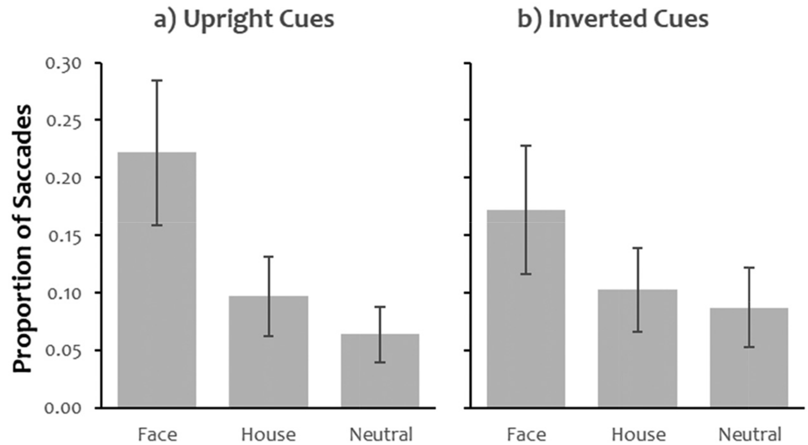
Thus, an omnibus ANOVA examined the proportion of breakaway saccades as a function of *Cue orientation* (upright, inverted), *Face position* (left visual field, right visual field), and *ROI* (eyes, mouth, top house, bottom house, upper neutral, lower neutral). The means are illustrated in Figure 17

Figure 15
Experiment 6 Manual Response Time (RT) Results



Note. Mean correct RTs as a function of all Target positions for (a) Upright and (b) Inverted cues. Error bars represent 95% CIs.

Figure 16
Experiment 6 Oculomotor Results



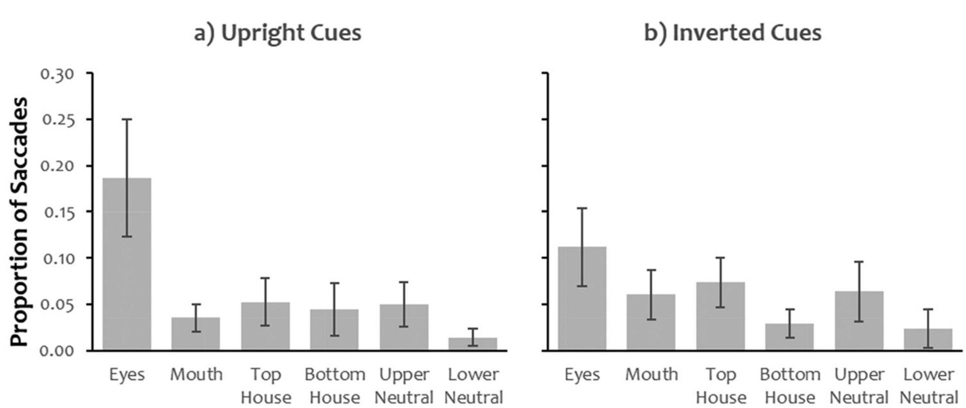
Note. Mean proportion of trials containing a breakaway saccade during the cue presentation period that was directed towards a region of interest (ROI) for (a) Upright and (b) Inverted cues. Error bars represent 95% CIs. Summation of values across both Upright and Inverted cues reveals the total proportion of trials with breakaway saccades directed towards ROI regions (i.e., 0.74 proportion of trials directed to ROI regions [0.38 for Upright, 0.36 for Inverted] versus 0.26 to non-ROI regions).

There was a main effect of *ROI* (Mauchly's test of sphericity, $\chi^2(14) = 86.98$, $p < .001$), $F(2.03,58.99) = 16.00$, $p < .01$, $\eta_p^2 = .36$, with an overall greater proportion of first saccades directed toward the Eyes versus all other regions (ts > 3.68, ps < .01, d_zs > .67) and an overall lower proportion of saccades directed toward the Lower Neutral versus the Top House and Upper Neutral cues (ts > 3.00, ps < .05, d_zs > .55; all other ps > .06, d_zs < .53).

This main effect was qualified by an interaction between *ROI* and *Cue orientation* (Mauchly's test of sphericity, $\chi^2(14) = 30.77$, $p = .01$), $F(3.35,97.16) = 4.85$, $p < .01$, $\eta_p^2 = .14$. When cues were Upright, a greater proportion of saccades were directed toward the Eyes compared with all other regions (ts > 3.93, ps < .01, d_zs > .72; all other ps > .06, d_zs < .54). When cues were Inverted, greater proportion of saccades were directed toward the Eyes versus Bottom House and Lower Neutral cues (ts > 3.66, ps < .01, d_zs > .67) and toward the Top House versus Bottom House cue, $t(29) = 3.81$, $p = .01$, $d_z = .70$ (all other ps > .05, d_zs < .56).

An interaction between *ROI* and *Face position* was also significant (Mauchly's test of sphericity, $\chi^2(14) = 60.42$, $p < .01$), $F(2.79,80.77) = 3.10$, $p = .04$, $\eta_p^2 = .10$. It further revealed that when the face was presented in the left visual field, an overall greater proportion of saccades were launched toward the Eyes versus all other regions (ts > 3.87, ps < .01, d_zs > .71) and a greater proportion of saccades toward the Mouth versus the

Figure 17
Experiment 6 Oculomotor Results



Note. Mean proportion of trials containing a breakaway saccade during the cue presentation period that was directed towards regions of interest (ROIs) for (a) Upright and (b) Inverted cues. Error bars represent 95% CIs. Summation of values across both Upright and Inverted cues reveals the total proportion of trials with breakaway saccades directed towards ROI regions.

Lower Neutral cue, $t(29) = 3.72$, $p = .01$, $d_z = .68$ (all other ps > .11, d_zs < .48). When the face was presented in the right visual field, a greater proportion of saccades were launched toward the Eyes compared with the Mouth, Bottom House, and Lower Neutral cues (ts > 3.24, ps < .04, d_zs > .59), and a greater proportion of saccades were launched toward the Top House versus Lower Neutral cue, $t(29) = 3.67$, $p = .01$, $d_z = .67$ (all other ps > .11, d_zs < .50). No other effects were found (Fs < .87, ps > .36, $\eta_p^2 < .03$).

Discussion

Experiment 6 examined whether perceived facial attractiveness impacted social attentional biasing when eye movements were not restricted. Within manual response data, there was a nonspecific overall social attentional bias toward the face, but this effect was not specific to upright faces or individual target locations. Within oculomotor data during the cue period, more robust social attentional biasing effects were found. When we examined spontaneous first saccades launched toward the cues, we found an increased proportion of saccades toward the eye region of the face, and particularly when faces were presented in an upright orientation and in the left visual field. Therefore, even though oculomotor biasing occurred on a small subset of all trials (i.e., 9%), a reliable number of saccades were preferentially launched toward the eyes of an attractive face. Together, the results from Experiment 6 identify perceived facial attractiveness as a potential key driving factor of social attention biasing.

General Discussion

When answering the question about whether faces bias attention preferentially, the field of attention has traditionally been situated within a domain-specific view, uncovering data consistent with the notion that faces and eyes engage attention preferentially due to their social nature. However, recent work (Pereira et al., 2019, 2020, 2022) has suggested that faces and facial features may instead bias attention in a manner that is better explained by generalized mechanisms, wherein extraneous factors such as stimulus content, visual context, and/or task settings may be the key gating components that drive such social attentional biases.

The present series of experiments examined the role of face stimulus content, namely global luminance, featural configuration, and perceived attractiveness, in spontaneous social attentional biasing by assessing performance in both manual (Ariga & Arihara, 2018; Bindemann et al., 2005, 2007; Lavie et al., 2003; Ro et al., 2001; Sato & Kawahara, 2015) and oculomotor measures (Birmingham et al., 2008a, 2008b; Laidlaw et al., 2012; Langton et al., 2008; Theeuwes & Van der Stigchel, 2006; Yarbus, 1967). Using the dot-probe paradigm, in a series of six experiments, we presented participants with displays containing images of face, house, and neutral cues, and measured their speed and accuracy to discriminate targets that occurred at one of the previous locations of the face (eyes, mouth), house (top, bottom), or neutral (upper, lower) cues. We manipulated stimulus content information between the face and house stimuli by assessing if differences in global luminance (Experiments 1 and 2), imbalance of featural configuration (Experiments 3 and 4), and higher attractiveness (Experiments 5 and 6) affected the resulting social attentional bias. When measuring manual RT under instruction to maintain eye fixation (Experiments 1, 3, and 5), we found no evidence of attentional biasing toward upright faces across all experiments. This result was supported by both null hypothesis testing and Bayesian methods. However, when measuring oculomotor biasing in conditions when eye movements were not restricted (Experiments 2, 4, and 6), when the face cue was perceived as more attractive than the nonsocial cue, we found a reliable indication of a social attention bias that was specific to upright faces and specific to the eyes of faces as well. Taken together, the results of these experiments show that global luminance and internal configuration of features likely contribute little to social attentional biasing, but that perceived attractiveness potentially plays a critical role in social attentional biasing. These results raise several points for further discussion.

Perceived Facial Attractiveness Is an Important Factor in Oculomotor Social Attentional Biasing

First, when examining the effect of perceived facial attractiveness on social attention when eye movements were not restricted in Experiment 6, we found evidence for social attentional biasing in both manual and oculomotor data. In manual effects, there was an overall bias to detect targets occurring at the location of the face that was not specific to upright faces or any facial feature. It is possible that this finding may indicate a nonspecific manual bias for targets occurring at the location of the face, as recent data has shown that attractiveness may survive face inversion and potentially even enhance it as a result of the loss of distinctive facial characteristics with inversion effects (Leder et al., 2017); however, more studies are needed to investigate whether this nonspecific effect reflects social attentional biasing. In oculomotor data, our findings indicated a saccadic bias toward the eyes of the face, which was specific to upright faces and when faces were presented in the left visual field. This finding furthers behavioral studies that suggest that assessing facial attractiveness occurs automatically (Olson & Marshuetz, 2005; Willis & Todorov, 2006) and is difficult to inhibit (Sui & Liu, 2009), and dovetails with past work showing a general preference for upright faces and a processing advantage for faces presented in the left visual field (Frank et al., 2009; Kanwisher et al., 1997; Kanwisher & Yovel, 2006; Puce et al., 1998; Rossion et al., 2003; Simion & Giorgio, 2015; Yin, 1969; Yovel et al., 2003). Of note here is that nonspecific effects were found for both upright and inverted faces within manual measures, whereas specific effects were found for upright faces within oculomotor measures. This suggests that comparing upright and inverted stimuli without controlling for and isolating specific visual and/or categorical variables may not be sufficient to capture potential differences across all extraneous factors, highlighting the need to specifically account for stimulus content variables when studying social attention, above and beyond inversion effects. As such, the findings from Experiment 6 provide evidence for social attentional biasing that may be reflected across both manual and oculomotor data.

Thus, perceived facial attractiveness may be an important factor in social attention. This point is particularly revealing given that oculomotor effects occurred even though saccadic breakaways from fixation occurred rarely (i.e., on 9% of trials). This suggests that even with a low proportion of eye movements, perceived attractiveness instantiated statistically robust oculomotor biasing toward the eyes of the face. Furthermore, our findings also show that the attractive face used in the current study and the controlled face used in previous work (Pereira et al., 2020) both resulted in similar percentage of trials with saccadic breakaways, but that the attractive face resulted in numerically greater proportion of saccades directed toward the eyes (i.e., 3.4% in the current study vs. 1.9% in Pereira et al., 2020). Although these comparisons represent numerical differences alone, they suggest that perceived attractiveness may regulate the degree of oculomotor social biasing for faces and eyes rather than acting to enhance overall eye movements. Low proportions of saccadic breakaways within the current study prevented more complex analyses from being conducted to examine whether trials on which saccadic breakaways to faces and eyes occurred also resulted in faster manual RTs for targets appearing in these locations. Future studies can utilize similar manipulations of perceived attractiveness while making eye movements relevant to the task to uncover possible combinatory effects of oculomotor and manual performance when examining attentional biasing toward attractive faces.

An additional point worth noting is that the eyes of attractive faces were the specific feature that biased eye movements, above and beyond any oculomotor effects for the mouth. This finding dovetails with past work demonstrating that the eye region plays a central role in social attentional effects (Birmingham et al., 2007; Capozzi & Ristic, 2018; Laidlaw et al., 2012; Langton et al., 2000). For example, it is well-established that information contained within the eyes (i.e., eye gaze) is capable of orienting attention even when this information runs counter to task instructions and settings (Friesen & Kingstone, 2003; Itier et al., 2007; Mansfield et al., 2003). Our results further extend these findings by showing that this oculomotor effect was not driven by any specific global luminance or featural configuration differences within this region since these factors were equated between our cue stimuli for Experiment 6. However, the present study did utilize a different task paradigm (i.e., dot-probe vs. gaze cuing) and different gaze stimuli (i.e., direct vs. averted gaze) compared with this prior work, and more comparisons will be needed to assess whether differences in stimulus content factors also affect attentional orienting when elicited by eye gaze. Past work has also found that perception of direct and averted gaze is subserved by different brain mechanisms (Bayliss et al., 2011; Frischen et al., 2007; George & Conty, 2008) and serves different communicative purposes (i.e., communicative intent vs. attentional orienting). Thus, it is possible that the mechanisms invoked by the perception of gaze may not be the same as those invoked by attentional orienting in response to gaze direction. This question remains for further research.

Another key question from our findings is the degree to which social attentional biasing can be modulated by subjective ratings of attractiveness. That is, in the current study, we utilized faces that were aggregately rated as more attractive by an independent group of participants. However, it may be possible for oculomotor effects to be heightened if faces are perceived as more or less attractive on an individual level. Future studies could employ a similar task design while utilizing face stimuli of high and low attractiveness or nonsocial stimuli that may be more personally-relevant or socially-equivalent to faces (e.g., avatars, pareidolic faces; Henschel et al., 2021; Liu et al., 2014; Takahashi & Watanabe, 2013) as a within-subject factor to clarify the role of this stimulus content factor in oculomotor biasing effects toward the eyes.

Together, the current results suggest that past studies that have shown robust social attentional biasing in oculomotor measures (Birmingham et al., 2008a, 2008b; Laidlaw et al., 2012; Langton et al., 2008; Theeuwes & Van der Stigchel, 2006; Yarbus, 1967) may have also captured the influence of perceived facial attractiveness due to its ability to quickly engage social attention.

No Social Attentional Biasing Across Stimulus Content Factors in Manual Measures

Second, and in contrast to oculomotor data from Experiment 6, other manipulations of stimulus content factors did not result in reliable social attentional biases in manual responses when participants' eye movements were controlled. This finding is consistent with recent work showing that controlling stimulus content, visual context, and task settings abolishes social attentional biasing in manual performance (Pereira et al., 2019, 2020, 2022), and adds to the growing body of literature demonstrating null or conditional social attentional biasing effects (Besner et al., 2021a, 2021b; Burra et al., 2018; McCrackin et al., 2021; McCrackin & Itier, 2018, 2021; Ricciardelli et al., 2013; Võ et al., 2012).

One possibility for these emergent null effects is the notion that spontaneous social attentional biasing may depend on a combination of stimulus content and visual context factors rather than being specific to a single extraneous variable. For example, it may be possible that a combination of factors that have resulted in attentional biasing in previous and current work (e.g., background context and perceived attractiveness) may be necessary for manual effects to occur. It is also possible that social biasing toward faces and eyes may be dependent on task settings, or that social attentional biasing occurs purposefully based on internal and external demands. Some evidence supports this notion. For example, Võ et al. (2012) have demonstrated that attentional selection of faces and facial features can be differentially elicited based on established priorities from the task (e.g., see also Smilek et al., 2006). More recently, Burra et al. (2018) demonstrated that both behavioral and neural measures of social attentional biasing are influenced by task relevancy by showing modulations in gaze processing depending on whether the face was relevant to the task. The present results dovetail with these findings and highlight the need for future investigations geared toward understanding how components of stimulus content, visual context, and task factors lead to robust social attentional biasing.

Another possibility is that our study design or stimulus manipulations contributed to the lesser social attentional biasing effects. From a theoretical perspective, preferential spontaneous effects for faces should be resilient to these relatively simple manipulations of task factors; however, it is possible that having such a tightly controlled design with specific binary stimulus content manipulations may have biased the experiment against finding potential subtle differences between conditions. For example, it is possible that utilizing a simplified study design with different levels of stimulus content factors manipulated as within-subjects variables may reveal that these factors play a role in the magnitude of attentional biasing for faces. Similarly, utilizing a study design that increases the global luminance of the house cue or rearranges the internal featural configuration of the face cue may reveal whether similar behavior and oculomotor effects exist for social and nonsocial information. In addition, it is also possible that the study design may have resulted in participants responding strategically to most frequent target locations, owing to the higher proportion of targets appearing in the middle region as compared with the upper and lower regions of the screen. Although future study designs with fully balanced target locations can be beneficial in examining whether upper, middle, and lower regions of the screen can impact reaction times, it is worth noting that within the current studies, the number of targets appearing at the locations of the face and the house cues were equal, and as such, this design feature should not have affected the primary question of interest about potential attentional biases invoked by faces.

Although studies of this nature can shed light on the threshold that needs to be met for stimulus content factors to moderate attentional biasing, a truer test of social attention necessitates a direct contrast of social versus nonsocial information (Birmingham & Kingstone, 2009). Although this may at times present nonequivalent and dissimilar contrasts (e.g., by comparing stimuli such as faces and houses), this key manipulation is critical in determining whether faces contain fundamental social properties that result in spontaneous and robust attentional biasing. If this were the case, then contrasting two highly dissimilar stimuli like faces and houses should result in exponentially greater social attentional biasing owing to the heightened social relevance of the face compared with the lesser relevance of the house; however, if instances of controlling for simple extraneous factors between stimuli is able to rob faces of their attentional relevance, resulting in null effects, this speaks to the factors that may have driven the originally reported effects. In this manner, the current set of studies are compelling specifically because of their ability to reveal modulations of social attentional biasing or the lack thereof in these carefully designed contrasts.

Dissociations in Data Across Manual and Oculomotor Measures

Third, the differential results found when eye movements were restricted versus when eye movements were allowed to occur highlight recent results showing dissociations of covert and overt measures of social attention, respectively (Gobel et al., 2015; Kuhn et al., 2016; Laidlaw et al., 2015; Risko et al., 2016). Namely, these studies suggest that covert and overt social attention may diverge based on the utilization of gaze cues in real life to either signal social information or reciprocate that information back. In this manner, covert and overt social attention may serve different purposes, as covert social attention can be used to gather information surreptitiously (i.e., by shifting the mind's eye toward a location of interest), whereas overt social attention can be used to directly communicate social cues (i.e., by shifting the eyes to a location of interest). In addition to providing evidence in favor of this distinction, the present set of studies also point to factors that may give rise to covert-overt dissociations in a spontaneous manner. Specifically, facial attractiveness was the only stimulus content factor that resulted in differential covert and overt effects, such that no manual biases were found when participants were instructed to maintain central fixation (Experiment 5), and a nonspecific manual bias toward faces and a specific oculomotor bias toward the eyes was found when participants were allowed to freely move their eyes (Experiment 6). As such, this factor may provide a particularly illuminating real-world example of the necessity for separate investigations of the factors that may drive covert and overt social attention, further pointing to the utility of reconceptualizing attentional control as an integrative system that can be influenced by stimulus factors, task information, internal preferences, and personal experiences (Awh et al., 2012; Ristic & Enns, 2015).

An important caveat to note however is that the manipulations contained within the current set of studies do not fully overlap with typical conceptualizations of covert and overt attention. Specifically, Experiments 1, 3, and 5 did not provide a pure measure of covert attention since participants were verbally instructed to maintain fixation without fixation monitoring. Conversely, Experiments 2, 4, and 6 did not provide a typical measure of overt attention because eye movements were not task-relevant, as in typical free-viewing oculomotor tasks. However, despite these differences, there is evidence to suggest convergence across our effects and available covert/overt data given that past work confirms that verbal instructions result in participants' compliance with fixation (Friesen et al., 2004; Pereira et al., 2020; Posner, 1980) and that eye movements occurred spontaneously within the short period of cue presentation (i.e., 250 ms). As such, the present manipulations provided generally consistent results within each measure and replicated the effects of previous work. This finding lends parallel evidence to the notion that humans may use covert and overt attentional processes differently in various environments, such as in situations where we use covert attention to discreetly gather information around us without revealing our immediate intentions to others or when we need overt attention to explicitly convey our own internal thoughts and emotions to others.

Bridging Social Attention Within a Generalized Framework

Finally, the current set of results appear to lend support for social attention being subsumed at least partly by generalized attentional mechanisms in which faces do not hold a special status, but instead bias attentional mechanisms by virtue of their stimulus or task characteristics. However, our results also provided patterns that are indicative of typical perceptual processing for faces, such as a general preference for upright faces and a processing advantage for faces presented in the left visual field. We also found that some stimulus content factors, like global luminance and featural configuration, produced generalized biasing effects, independent of face orientation. As such, our results suggest that the links between perceptual and attentional mechanisms for faces may be more nuanced than originally thought. One potential neural structure which could play an important role in this interaction is the right temporoparietal junction (TPJ), which is typically activated when attention is engaged in a spontaneous manner (Corbetta & Shulman, 2002). The TPJ is also known to be important for attentionally orienting toward behaviorally relevant stimuli (Geng & Vossel, 2013; Joseph et al., 2015; Kincade et al., 2005; Ristic & Giesbrecht, 2009; Serences et al., 2005) and for higher level sociocognitive processing, such as theory of mind (Corbetta et al., 2008; Decety & Lamm, 2007; Mars et al., 2013). Recent work from Capozzi and Ristic (2018) has proposed that connections between the TPJ and adjacent face processing regions may be critical in understanding how attentional systems are linked with visual processing hubs for social information at a neural level. Although more research is needed to determine the specific gating mechanisms between social attention and face perception, the current set of studies suggest that nonsocial generalized mechanisms may play a strong role in modulating these links.

Conclusions

In summary, the present set of studies investigated how stimulus content factors, namely global luminance, internal configuration of features, and perceived attractiveness, influenced social attentional biasing. Although the data showed no robust effects of social attentional biasing across any of the stimulus content factors when eye movements were restricted, they indicated that perceived facial attractiveness elicited social attentional biasing when eye movements were allowed to occur. As such, these data point to perceived attractiveness as an important factor in social attentional biasing and further highlights the need for future work to delineate the contributions of other generalized factors of content, context, and task factors to social attention.

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