



The eyes do not have it after all? Attention is not automatically biased towards faces and eyes

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Abstract

It is commonly accepted that attention is spontaneously biased towards faces and eyes. However, the role of stimulus features and task settings in this finding has not yet been systematically investigated. Here, we tested if faces and facial features bias attention spontaneously when stimulus factors, task properties, response conditions, and eye movements are controlled. In three experiments, participants viewed face, house, and control scrambled face–house images in an upright and inverted orientation. The task was to discriminate a target that appeared with equal probability at the previous location of the face, house, or the control image. In all experiments, our data indicated no spontaneous biasing of attention for targets occurring at the previous location of the face. Experiment 3, which measured oculomotor biasing, suggested a reliable but infrequent saccadic bias towards the eye region of upright faces. Importantly, these results did not reflect our specific laboratory settings, as in Experiment 4, we present a full replication of a classic finding in the literature demonstrating reliable social attention bias. Together, these data suggest that attentional biasing for social information is task and context mediated, and less robust than originally thought.

Introduction

Faces are, perhaps, the most important stimuli that humans encounter in their visual environment, conveying key information for survival, emotional wellbeing, and social function. These aspects of social communication are supported both by the morphology of the human eye, which facilitates an easy reading of social signals due to the high contrast between the iris and the sclera (Campbell, 1957; Kobayashi & Kohshima, 2001), and by the specialized distributed network of brain structures (e.g., fusiform face area, superior temporal sulcus, and occipital face area) that are specifically tuned for the processing of faces, gaze information, and other socio-biological signals (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Gauthier et al., 2000; Haxby et al., 1994; Kanwisher & Yovel, 2006; Nummenmaa & Calder, 2008; Perrett, Hietanen, Oram, Benson, & Rolls, 1992; Perrett et al., 1985; Puce, Allison, Bentin, Gore, & McCarthy, 1998; Yovel, Levy, Grabowecky,

& Paller, 2003). These structures are thought to enable basic functions that lead to well-documented face-processing benefits across the lifespan, such as enhanced facial recognition abilities (Little, Jones, & DeBruine, 2011; Thomas, De Bellis, Graham, & LaBar, 2007) and upright face-processing biases (Frank, Vul, & Johnson, 2009; Simion & Giorgio, 2015), as well as to furnish the extraction of social meaning from faces to facilitate more complex social processes like theory of mind and language development (Baron-Cohen, 1995; Dunbar & Shultz, 2007; Emery, 2000; Schaller, Park, & Kenrick, 2007).

Given the importance of information conveyed by faces, it is intuitive to expect that faces and their features like eyes would lead to spontaneous biasing of attention. A number of studies that have examined both overt and covert attentional selection support this intuition. In overt tests, attentional selection is indexed by the degree of oculomotor biasing, like the proportion of fixations and/or dwell time associated with the presentation of task-irrelevant faces relative to other stimuli. Yarbus' seminal work (1967) provided one of the first demonstrations of such biasing. In his investigations, Yarbus showed that observers preferentially fixated faces and their features, like eyes, relative to other objects while freely viewing images of real-world scenes. This general finding has since been replicated by numerous studies, which

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collectively show that faces and facial features bias oculomotor behavior within the first two fixations (Birmingham, Bischof, & Kingstone, 2008a, 2008b; Cerf, Frady, & Koch, 2009; Laidlaw, Risko, & Kingstone, 2012), and elicit faster saccades relative to comparison stimuli (Crouzet, Kirchner, & Thorpe, 2010; Devue, Belopolsky, & Theeuwes, 2012). These behaviors are observed in investigations using various laboratory paradigms (e.g., inhibition of return (IOR), Theeuwes & Van der Stigchel, 2006), in tests that manipulate static and dynamic representations of social behavior (e.g., images and movies depicting social interactions, Boggia & Ristic, 2015; Riby & Hancock, 2009; Smilek, Birmingham, Cameron, Bischof, & Kingstone, 2006; Smith, 2013), as well as during real-life interactions (e.g., Hayward, Voorhies, Morris, Capozzi, & Ristic, 2017; Kuhn, Teszka, Tenaw, & Kingstone, 2016; Risko, Richardson, & Kingstone, 2016).

The results from studies that have measured covert behavior dovetail well with these findings. Here, attentional selection is indexed using manual performance within typical attentional paradigms (e.g., dot-probe, visual search, and inattention blindness tasks), with overall results, showing that task-irrelevant faces both capture and hold attention (Bindemann, Burton, Hooge, Jenkins, & DeHaan, 2005; Bindemann, Burton, Langton, Schweinberger, & Doherty, 2007). Using a variant of the dot-probe task, Bindemann and colleagues (2007) also demonstrated that presenting response targets on a task-irrelevant face resulted in faster response times for targets appearing at the previous location of the face relative to targets appearing at the previous location of the control non-social object. Similarly, the presentation of distractor faces has been found to hinder visual search (Lavie, Ro, & Russell, 2003) and target performance in an RSVP task (Ariga & Arihara, 2017a; Sato & Kawahara, 2015), but facilitate target detection in change-detection tasks when faces are the changed item. For example, Ro and colleagues (2001) reported that changing a face to a different face was detected more rapidly and accurately relative to changing an object to another object, while Devue and colleagues (2009) found higher detection rates for faces vs. objects during inattention trials in an inattention blindness paradigm.

Although this large amount of evidence suggests that the attentional system may be preferentially biased by faces and facial features, there are at least three distinct issues that arise from this past work that make it difficult to ascertain whether the intrinsic importance of faces or extraneous physical and task variables account for these results. The first relates to the observation that past work has typically not controlled for visual and conceptual differences between faces and comparison objects. Typically, faces and non-social objects have not been equated for physical size (Bindemann & Burton, 2008; Bindemann et al., 2007), position and/or distance from fixation (Birmingham, Bischof, & Kingstone, 2007; Smilek et al., 2006), the configuration

of internal features (e.g., with a consistent first-order configuration, two eyes above a nose and mouth; Guillon et al., 2016; Tomalski, Johnson, & Csibra, 2009; Vuilleumier, 2000), overall visual features like luminance (Bindemann et al., 2007; Langton, Law, Burton, & Schweinberger, 2008), valence (Crouzet et al., 2010), and/or perceived attractiveness (Bindemann et al., 2007). Importantly, each of these properties individually has been well documented to engage attention, irrespective of any bias elicited by the social nature of faces alone (size and positioning, Crouzet & Thorpe, 2011; low-level internal features, Ariga & Arihara, 2017b; Devue et al., 2012; Itier, Latinus, & Taylor, 2006; Kendall, Raffaelli, Kingstone, & Todd, 2016; Rouselet, Ince, van Rijsbergen, & Schyns, 2014; saliency, Cerf, Harel, Einhäuser, & Koch, 2008; valence and attractiveness, Nakamura & Kawabata, 2014; Silva, Macedo, Albuquerque, & Arantes, 2016; Sui & Liu, 2009; Vö, Smith, Mital, & Henderson, 2012). Furthermore, attentional effects for social and non-social cues have usually been examined in direct contrasts and not against a common comparison cue (Bindemann et al., 2007; Crouzet et al., 2010; Ro et al., 2001), the latter of which provides a way to test the magnitude of social relative to non-social attentional biasing (see Birmingham & Kingstone, 2009).

The second issue is that past work measuring manual responses has typically not accounted for the effects of eye movements, raising a question as to whether the reported biases reflected covert or overt processes (Findlay, 2003; Hunt & Kingstone, 2003b). Assessing covert attention requires measuring manual performance under conditions in which eye movements are restricted (e.g., Posner, 1980). Many well-known attentional paradigms (e.g., the dot-probe task, MacLeod, Mathews, & Tata, 1986; the cuing task, Posner, 1980) require observers to maintain fixation on a central stimulus, and index covert attention by contrasting manual performance (i.e., response time and accuracy) for targets that appear at locations previously indicated by a cue (i.e., cued locations) versus those appearing elsewhere (i.e., uncued locations). A number of past studies have relied on verbal instructions to restrict eye movements (Bindemann & Burton, 2008; Bindemann et al., 2005), while others provided no instructions to participants regarding their eye movements (Bindemann et al., 2007; Langton et al., 2008; Ro et al., 2001; Sato & Kawahara, 2015). Accounting for eye movements is especially important given that past work has overwhelmingly demonstrated that the oculomotor system is biased towards faces and facial features, particularly the eyes (Birmingham et al., 2007, 2008a; Cerf et al., 2009; Crouzet et al., 2010; Fletcher-Watson, Findlay, Leekam, & Benson, 2008; Laidlaw et al., 2012).

The third issue is that while past studies presented evidence for an attentional bias for faces as a whole, it remains unclear if any specific facial features drive this bias. That is, studies

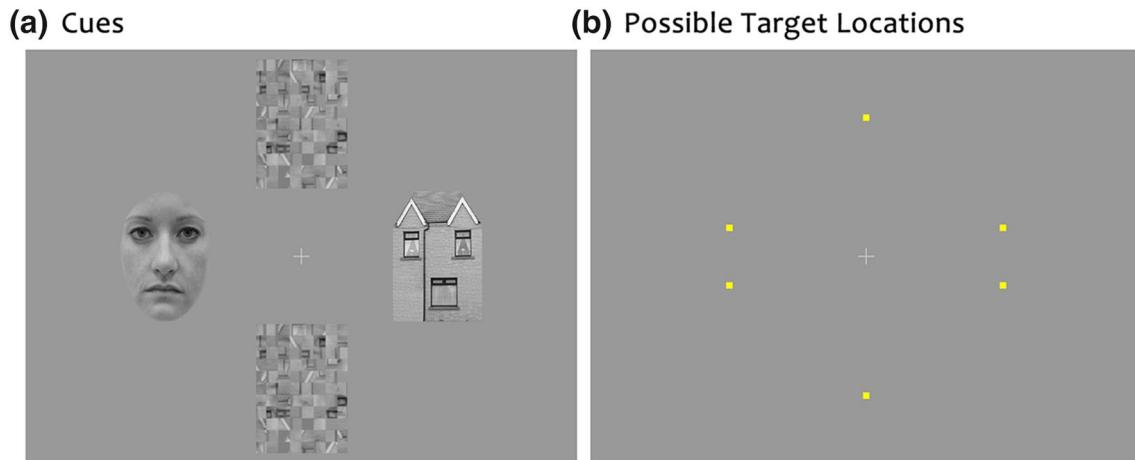


Fig. 1 **a** Cue screen for the upright condition with the face in the left visual field. **b** Target screen for square targets with all six possible locations displayed

that have measured manual performance have typically asked participants to respond to a single target appearing somewhere at the location of the face (Bindemann et al., 2007; Devue et al., 2009; Lavie et al., 2003; Ro et al., 2001). Although a bias to spontaneously attend to eyes within faces has been demonstrated using oculomotor measures (Birmingham et al., 2007, 2008a), the role of this facial feature in biasing manual performance has not yet been systematically addressed (but see Bar-Haim, Shulman, Lamy, & Reuveni, 2006). As such, there remains an open question as to whether attentional biasing reported in manual responses reflects a specific bias towards the eyes or a more general bias towards the face.

Against this backdrop, it thus remains surprisingly equivocal if faces and facial features spontaneously bias attention. To address this question, we systematically assessed attentional selection for task-irrelevant faces and their features across multiple experiments. To do so, we measured and controlled (a) stimuli and task conditions; (b) effects elicited by faces overall and their individual parts; (c) participants' eye movements. In Experiment 1, similar to past work, we measured covert attention by verbally instructing participants to maintain central fixation. In Experiment 2, we measured covert attention by restricting oculomotor behavior during the task using an eye tracker. In Experiment 3, we measured natural overt attention by examining oculomotor behavior during the task. Finally, to ensure that our findings were not due to specific settings in our laboratory, in Experiment 4, we measured covert attention using the stimuli and parameters from Bindemann and colleagues' (2007) study¹. Based on

the past literature, we expected to observe a spontaneous attentional bias for faces, with specific effects for eyes across all experiments.

Experiment 1

In Experiment 1, mirroring past work (Bindemann et al., 2007), we employed the dot-probe task (MacLeod et al., 1986), wherein participants are instructed to manually respond to targets following the presentation of task-irrelevant cues while being verbally instructed to maintain central fixation. We achieved experimental control across display and task properties in three ways.

First, the cues were equated for physical properties. The stimuli, illustrated in Fig. 1a, were gray-scale photographs of (1) a female face looking straight ahead with a neutral expression and the hairline removed, (2) a house with no contextual background, and (3) a fused overlay of the face and house photographs scrambled using 22-pixel blocks. All stimuli were presented against a uniform gray background and matched for width and height, distance from fixation (as measured from the center of the display to the center of the image), and average luminance (computed using the MATLAB SHINE toolbox; Willenbockel et al., 2010). Face and house images were matched for attractiveness² and the configuration of local features, i.e., the spatial placement of the eyes and

¹ We thank Markus Bindemann for providing us with the original stimuli.

² Twenty-eight additional naïve participants were asked to rate images of various faces and houses using a Likert scale ranging from 1- Very Unattractive to 6- Very Attractive. The Face and House images that were used here received equivalent attractiveness ratings (Face $M = 2.93$, $SD = 0.77$; House $M = 2.96$, $SD = 0.96$), which did not differ statistically, $t(27) = 0.17$, $p = 0.87$, $d_z = 0.03$.

mouth vs. the windows and door, respectively. To assess the effects of any remaining visual differences across the stimuli and to allow for examinations of upright face effects (Hochberg & Galper, 1967; Yin, 1969), we further manipulated face and house images in an upright and inverted orientation. Finally, to permit an analysis of any biases specific to social processing centers specialized in the right hemisphere of the brain (Kanwisher, McDermott, & Chun, 1997; Kanwisher & Yovel, 2006; Puce et al., 1998; Rossion, Joyce, Cottrell, & Tarr, 2003; Yovel et al., 2003), the position of the face cue was manipulated between the left and right visual fields.

Second, response targets were also controlled. Each target, with all possible locations illustrated in Fig. 1b, was presented against a uniform gray background to ensure the same local contrast between the target and background. Each target occurred with equal probability at the previous location of the eyes or mouth of the face, the top or bottom of the house, and the center of the upper or lower neutral comparison image. All targets were equidistant from fixation, ensuring that no effects were due to distance inequalities between different target positions.

Finally, the parameters of the task ensured that any attentional effects did not reflect task settings. The dot-probe task yields a measure of attentional selection by assessing the speed of target detection when targets are presented at the previous location of the cue of interest vs. the previous location of the comparison stimuli. In our experiments, all combinations of cue location and target positions occurred with equal probability, ensuring that no task relevant spatial contingencies existed between the images and the targets. Furthermore, to ensure equal processing time, cue presentation time was restricted to 250 ms, and we sampled performance at both short and long cue–target times (i.e., 250, 360, 560, and 1000 ms).

Thus, our design allowed for an assessment of attentional biasing elicited by faces and/or facial features when the stimuli were devoid of physical confounds and the task did not encourage the development of spatial attentional effects. If attention is spontaneously biased by faces and/or facial features, we expected to find response facilitation for targets occurring at the previous location of the face relative to the house and comparison stimuli when cues were presented in an upright orientation. If the selection of eyes in particular was important, we further expected to find that responses to targets located at the previous position of the eyes would be preferentially facilitated.

Methods

Participants

Thirty volunteers (24 female; age $M = 21$ years, $SD = 2$ years) with normal or corrected-to-normal vision

participated. They were recruited via a volunteer pool and received course credit for their participation. All procedures were approved by the University Research Ethics board. The sample size was selected to fall within the range reflected by an a priori power analysis (G*Power; Faul, Erdfelder, Lang, & Buchner, 2007) based on the estimated magnitude of the face selection effect from past research (Bindemann & Burton, 2008; Bindemann et al., 2007; Langton et al., 2008; Ro et al., 2001). The analysis indicated that data from 6 to 38 participants were needed to detect medium-to-large effects ranging from 0.41 to 1.36 (as estimated from Cohen's f) with the corresponding power values from 0.95 to 0.97.

Apparatus and stimuli

Stimuli were edited using Adobe Photoshop. They were presented on a 16" CRT monitor at an approximate viewing distance of 60 cm, with stimulus presentation timing and sequencing controlled by MATLAB's Psychophysics toolbox (Brainard, 1997).

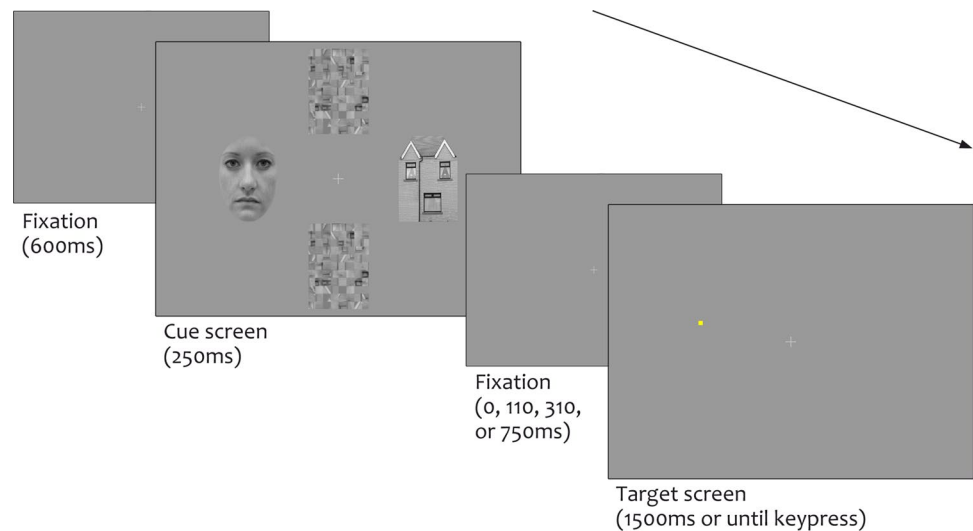
All stimuli were set on a 60% gray background. They included the central fixation cross, cue images, and target objects. The central fixation subtended $1^\circ \times 1^\circ$ of visual angle. All cue images measured $4.2^\circ \times 6^\circ$ and were positioned at a distance of 6.3° from fixation. Average gray-scale luminance (ranging from 0 to 1) was comparable across cues overall (face = 0.60, house = 0.62, and neutral = 0.61) as well as between the upper and lower halves of each cue (eyes = 0.60, mouth = 0.60, top house = 0.63, bottom house = 0.62, upper neutral = 0.61, and lower neutral = 0.62). The target was an image of a yellow circle or square measuring $0.3^\circ \times 0.3^\circ$, positioned 7.2° away from fixation. These stimulus settings are consistent with past studies, which have utilized cue sizes ranging from $2.1^\circ \times 2.1^\circ$ to $8.9^\circ \times 12.3^\circ$, target sizes ranging from $0.1^\circ \times 0.4^\circ$ to $0.6^\circ \times 0.6^\circ$, and target eccentricities ranging from 3° to 6.9° (Ariga & Arihara, 2017a; Bindemann & Burton, 2008; Bindemann et al., 2005; Bindemann et al., 2007; Lavie et al., 2003; Ro et al., 2001; Sato & Kawahara, 2015; Theeuwes & Van der Stigchel, 2006).

Design

The target discrimination task was a repeated-measures design with five factors: Cue orientation (upright, inverted), Face position (left visual field, right visual field), Target position (eyes, mouth, top house, bottom house, upper neutral image, lower neutral image), Target identity (circle, square), and Cue–target interval (250, 350, 560, 1000 ms).

Cue orientation was manipulated by presenting the face–house pair in either an upright or inverted orientation. This allowed us to examine the role of low-level properties of the stimuli in biasing attention, and to examine the face

Fig. 2 Example trial sequence. Trials started with the presentation of the fixation screen for 600 ms. The cue screen was then presented for 250 ms. After 0, 110, 310, or 750 ms, a response target demanding a discrimination response appeared in one of the six possible locations. The target remained visible for 1500 ms or until a key press was made. Note: stimuli are not drawn to scale



inversion effect. *Face position* was manipulated by varying the position of the face cue in either the left or right visual field (with the house image occurring in the opposite visual field), allowing for an assessment of the influence of right-lateralized brain centers in the processing of face cues. *Target position* manipulated the response target across one of six possible locations: at the previous location of Eyes, Mouth, Top House, Bottom House, center of the Upper Neutral image, or center of the Lower Neutral image. This enabled us to capture any performance differences between targets occurring at the location of the face overall and its specific facial features in relation to the house and comparison stimuli. *Target identity* varied between circle and square shapes to allow for speeded discrimination response and measurements of both response time (RT) and response accuracy. Half the trials received a square target and the other half received a circle target. Key response-target identity assignment was counterbalanced between participants. *Cue–target interval* varied between 250, 360, 560, and 1000 ms to assess the time course of attentional selection and to maintain consistency with the past work (Bindemann et al., 2007; Theeuwes & Van der Stigchel, 2006).

All factor combinations were equiprobable and presented equally often throughout the experimental sequence. The cues were spatially uninformative about the target location and its identity, as either target was equally likely to occur at any of the six possible locations. Conditions were intermixed and presented in a randomized order.

Procedure

Figure 2 illustrates an example stimulus presentation sequence. All trials started with a presentation of a fixation display for 600 ms. Then, the cue display was shown for 250 ms. After 0, 110, 310, or 750 ms (constituting 250,

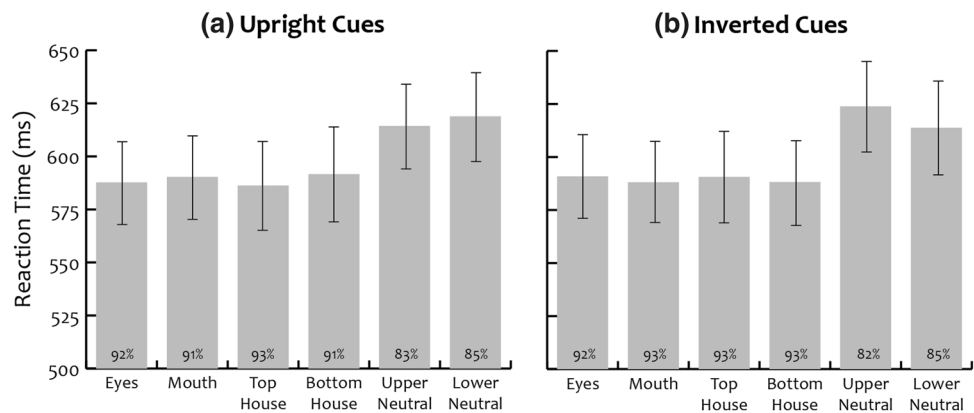
360, 560, and 1000 ms cue–target intervals), the target appeared and remained visible until participants responded or 1500 ms had elapsed. Participants were asked to respond quickly and accurately by pressing the ‘b’ or ‘h’ keys on the keyboard to identify the circle and square targets. They were informed that the target was equally likely to be a circle or a square and to appear in any of the six possible locations, and that there was no spatial relationship between target location and cue content, orientation, or placement. Participants completed 960 trials divided equally across five testing blocks, with ten practice trials run at the start. Responses were measured from target onset.

Results

Response anticipations (RTs < 100 ms; 0.2% of all trials), timeouts (RTs > 1000 ms; 3.4%), and incorrect key presses (key press other than ‘b’ or ‘h’; 0.1%) accounted for 3.7% of data, and were removed from all analyses. Overall, performance accuracy was high at 89%. Interparticipant mean correct RTs were analyzed using repeated-measures analysis of variance (ANOVAs) with paired two-tailed *t* tests used for post hoc comparisons where applicable. Multiple comparisons were corrected using the Holm–Bonferroni procedure, which controls for the Type I error while being more powerful than the Bonferroni correction (Holm, 1979). All comparisons are shown with corresponding adjusted *p* values ($\alpha_{FW} = 0.05$; Ludbrook, 2000).

We reasoned that if attention was preferentially biased by faces and/or facial features, we would find facilitated responses for targets occurring at the previous location of the face (eyes and/or mouth) relative to targets occurring at the previous location of the house and/or the neutral comparison stimuli, especially when the cue pairs were presented in an upright orientation. Contrary to this hypothesis, our

Fig. 3 Experiment 1 results. Mean interparticipant correct RTs in ms and accuracy rates in percent as a function of Target position for upright (a) and inverted (b) cues. Error bars represent 95% CIs



data illustrated in Fig. 3, depicting mean RTs and accuracy for targets following the presentation of upright (3a) and inverted (3b) cues, indicated no evidence of preferential attentional biasing for faces or any facial feature.

This observation was confirmed by an omnibus ANOVA run as a function of Cue orientation (upright, inverted), Face position (left visual field, right visual field), Target position (eyes, mouth, top house, bottom house, upper neutral, lower neutral), and Cue–target interval (250, 360, 560, 1000 ms). The ANOVA returned two reliable main effects, which confirmed the efficacy of the task. First, a main effect of *Cue–target interval* [$F(3,87)=65.32$, $p < 0.001$, $\eta_p^2 = 0.69$] indicated overall faster RTs for longer relative to shorter cue–target intervals [250 ms vs. all, $t_s > 9.88$, $p_s < 0.001$, $d_zs > 1.80$; all other $p_s > 0.17$, $d_zs < 0.37$]. This well-established finding in the literature demonstrates an increased preparation to respond with a lengthening of the time between the cue and target, with our results showing that participants performed the task with the proper degree of alertness (e.g., Bertelson, 1967; Hayward & Ristic, 2013). Second, a main effect of *Target position* [$F(5,145)=30.44$, $p < 0.001$, $\eta_p^2 = 0.51$] indicated differential performance for experimental and control stimuli, with targets appearing at the previous location of the Face and House images detected overall faster than targets appearing at the previous location of the neutral cues. While the slowest overall RTs were observed for targets that occurred at the previous location of neutral cues [upper and lower neutral vs. all others, $t_s > 5.87$, $p_s < 0.001$, $d_zs > 1.07$], responses for targets occurring at the locations of interest (Eyes, Mouth, Top House, Bottom House) did not differ from one another, all $t_s < 0.71$, $p_s > 0.99$, $d_zs < 0.07$; all 95% CIs included the zero point, ranging from -7.72 to 7.31 ms.

This was also reflected in a two-way interaction between *Cue orientation* and *Target position* [$F(5,145)=2.41$, $p = 0.039$, $\eta_p^2 = 0.08$], which indicated more slowed down RTs for targets at the previous location of the neutral cues (upper, lower) vs. all other targets for inverted [$t_s > 5.60$,

$p_s < 0.001$, $d_zs > 1.02$; all other $p_s > 0.39$, $d_zs < 0.37$] relative to upright displays [$t_s > 4.04$, $p_s < 0.001$, $d_zs > 0.74$; all other $p_s > 0.55$, $d_zs < 0.33$]. Importantly, no effects or interactions involving *Face position* and *Target position* [Face position, $F(1,29)=1.30$, $p = 0.26$, $\eta_p^2 = 0.04$; Face position \times Target position, $F(5,145)=1.51$, $p = 0.19$, $\eta_p^2 = 0.05$; Face position \times Target position \times Cue orientation, $F(15,145)=0.89$, $p = 0.49$, $\eta_p^2 = 0.03$; Face position \times Target position \times Cue–target interval, $F(15,435)=0.92$, $p = 0.54$, $\eta_p^2 = 0.03$; Face position \times Target position \times Cue–target interval \times Cue orientation, $F(15,435)=1.34$, $p = 0.17$, $\eta_p^2 = 0.04$] or any other factors, $F_s < 1.34$, $p_s > 0.27$, $\eta_p^2 < 0.04$, were found³.

To ensure that these results did not reflect the stricter statistical approach adopted here relative to past work, we have also analyzed the data using the means of median correct RTs as in Bindemann and colleagues (2007) study. A repeated-measures ANOVA compared these RTs across overall Target position (face, house) and Cue–target intervals (250, 360, 560, 1000 ms). As before, the data indicated a main effect of *Cue–target interval* [$F(3,87)=38.78$, $p < 0.001$, $\eta_p^2 = 0.57$] demonstrating the typical foreperiod effect of faster RTs for longer relative to shorter cue–target intervals [250 ms vs. all, $t_s > 7.36$, $p_s < 0.001$, $d_zs > 1.37$;

³ Confirming no speed–accuracy tradeoffs, an additional ANOVA examining mean accuracy rates with the same factors confirmed higher overall accuracy for short relative to long cue–target intervals [Cue–target interval, $F(3,87)=9.23$, $p < 0.001$, $\eta_p^2 = 0.24$; 250 ms vs. 560 ms and 1000 ms, $t_s > 3.36$, $p_s < 0.01$, $d_zs > 0.61$; 360 ms vs. 1000 ms, $t(29)=2.78$, $p = 0.036$, $d_z = 0.51$; all other $p_s > 0.07$, $d_zs < 0.44$] and overall lowest accuracy for targets appearing at the location of the neutral cues [Target position, $F(5,145)=29.74$, $p < 0.001$, $\eta_p^2 = 0.51$; upper and lower neutral vs. all, $t_s > 5.48$, $p_s < 0.001$, $d_zs > 1.00$; all other $p_s > 0.56$, $d_zs < 0.33$]. A significant interaction between *Cue orientation* and *Face position*, $F(1,29)=4.46$, $p = 0.043$, $\eta_p^2 = 0.13$, indicated lower overall accuracy when inverted faces were presented in the right visual field, $t(29)=3.29$, $p = 0.006$, $d_z = 0.60$; other $p = 0.76$, $d_z = 0.06$. No other effects involving Face position and Target position were significant, $F_s < 2.80$, $p_s > 0.11$, $\eta_p^2 < 0.08$.

other $ps > 0.20$, $d_zs < 0.24$], but no main effect of *Target position* [$F = 0.001$, $p = 0.98$, $\eta_p^2 = 0.00$] and no interaction [$F = 0.56$, $p = 0.65$, $\eta_p^2 = 0.02$]. Thus, our results do not appear to be an artifact of more conservative statistical methods.

Discussion

If attention was spontaneously biased towards faces, we expected performance to be facilitated for targets occurring at the previous location of the face and/or specific facial features. Our results did not support this prediction.

While we found that responses were overall facilitated for targets at the previous location of the face and house relative to the comparison cues, the response times for targets appearing at the location of face and house cues were equivalent. This result contrasts with past work (Bindemann et al., 2007; Ro et al., 2001), and suggests that those findings may have reflected isolated or combined contributions of attentional modulations elicited by extraneous factors like visual properties of the stimuli (e.g., size, luminance), configuration of features (e.g., spatial placement of eyes vs. other comparison areas), participants' subjective evaluations of the cues (e.g., attractiveness), and/or task settings.

Experiment 2

One potential reason for why we may not have observed an attentional bias for faces in Experiment 1 is that we did not control for participants' eye movements. That is, it is possible that a failure to observe a spontaneous attentional biasing for faces may have resulted from participants' non-compliance with task instructions to maintain central fixation. In turn, participants may have altered their focus of attention on a trial-by-trial basis by moving their eyes to inspect the cues, potentially influencing manual performance results. To test this hypothesis, in addition to controlling for visual and task factors as in Experiment 1, in Experiment 2, we further controlled for eye movements by instructing participants to maintain central fixation and by monitoring whether they complied with these instructions using an eye tracker.

Methods

Participants, apparatus, stimuli, design, and procedure

Thirty new volunteers (24 female; age $M = 20$ years, $SD = 1$ years) participated. None took part in the previous experiment and all reported normal or corrected-to-normal vision. All stimuli, design, and procedures were identical to Experiment 1, except that: (a) Participants' 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 0.05° . Although viewing was binocular, only the right eye was tracked; (b) prior to the start of the experiment, a nine-point calibration was performed, and spatial error was rechecked before every trial using a single-point calibration dot. Average spatial error was no greater than 0.5° , with maximum error not exceeding 1° .

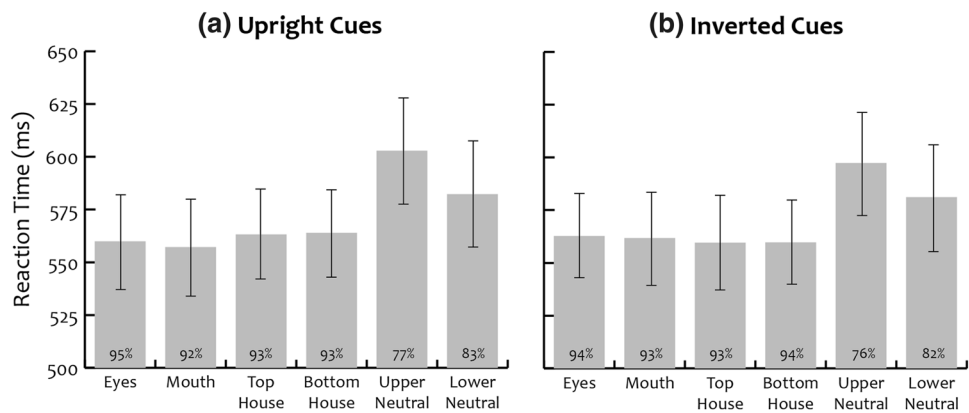
Results

Anticipations (0.1%), timeouts (3.2%), and incorrect key presses (0.1%) were removed from further analyses. To address our main hypothesis and examine covert attention biasing, all trials in which an eye movement had occurred during any part of the trial (18.9%) were also excluded from analyses. Thus, only trials in which no manual errors or eye movements occurred were analyzed. Overall response accuracy was 88%. All analyses mirrored those performed in Experiment 1.

Figure 4 depicts mean correct interparticipant RTs and accuracy for targets following Upright (4a) and Inverted (4b) cues, and shows that controlling for eye movements did not result in preferential biasing of attention to the location of the face cue. An omnibus ANOVA (Cue orientation, Face position, Target position, and Cue–target interval) supported this observation, revealing a significant main effect of *Cue–target interval*, $F(3,84) = 27.98$, $p < 0.001$, $\eta_p^2 = 0.50$, with faster RTs for longer relative to shorter cue–target intervals [250 ms vs. all, $ts > 7.00$, $ps < 0.001$, $d_zs > 1.28$; all other $ps > 0.99$, $d_zs < 0.10$], and a significant main effect of *Target position*, $F(5,140) = 26.43$, $p < 0.001$, $\eta_p^2 = 0.49$, with slowest RTs for targets that appeared in the previous location of the neutral cues [upper and lower neutral vs. all others, $ts > 3.90$, $ps < 0.008$, $d_zs > 0.71$]. Once again, responses for targets occurring at the locations of interest (eyes, mouth, top house, bottom house) did not differ from one another, all $ts < 0.82$, $ps > 0.99$, $d_zs < 0.15$, 95% CIs of all mean differences once again included the zero point, ranging from -11.23 to 9.88 ms. Of little theoretical interest, a significant main effect of *Face position*, $F(1,28) = 14.98$, $p = 0.001$, $\eta_p^2 = 0.35$, indicated that overall responses to targets, regardless of where they appeared, were faster when the face cue was presented in the left visual field compared to when it was presented in the right visual field.

Importantly, and as in Experiment 1, no effects or interactions between *Face position* and *Target position* were found [Face position \times Target position $F(5,140) = 1.15$, $p = 0.34$, $\eta_p^2 = 0.04$; Face position \times Target position \times Cue orientation, $F(15,140) = 0.45$, $p = 0.81$, $\eta_p^2 = 0.02$; Face position \times Target

Fig. 4 Experiment 2 results. Mean interparticipant correct RTs in ms and accuracy rates in percent as a function of Target position for upright (a) and inverted (b) cues. Error bars represent 95% CIs



position \times Cue–target interval, $F(15,420) = 1.46$, $p = 0.12$, $\eta_p^2 = 0.05$; Face position \times Target position \times Cue–target interval \times Cue orientation, $F(15,420) = 1.01$, $p = 0.44$, $\eta_p^2 = 0.03$; all other F s < 1.98 , p s > 0.17 , $\eta_p^2 < 0.07$]⁴.

As before, to ensure that our lack of effects were not due to stricter statistics, we calculated the means of median correct RTs and conducted a repeated-measures ANOVA across Target position (face, house) and Cue–target interval (250, 360, 560, 1000 ms). Once again, the results replicate reported data, with only a reliable main effect of Cue–target interval [$F(3,87) = 15.22$, $p < 0.001$, $\eta_p^2 = 0.34$] demonstrating faster RTs for longer relative to shorter cue–target intervals [250 ms vs. all, t s > 5.10 , p s < 0.001 , d_z s > 0.95 ; other p s > 0.43 , d_z s < 0.15], and no other effects [Target position, $F = 0.02$, $p = 0.88$, $\eta_p^2 = 0.001$; Target position \times Cue–target interval, $F = 0.78$, $p = 0.51$, $\eta_p^2 = 0.03$].

Discussion

When we controlled for participants' eye movements in addition to stimulus and task properties, we still did not find a processing advantage for targets occurring at the location of the face. Once again, our data indicated that participants performed the task well, but that their responses for targets occurring at the location of the social face and non-social house stimuli were equivalent. While we did observe that

overall RTs were faster when the face was presented in the left visual field, this effect occurred regardless of target location and was not specific to attentional selection.

Experiment 3

Here, we examined whether any oculomotor biasing was present in this task. The previous work has demonstrated that when participants are allowed and/or explicitly instructed to make eye movements, their initial fixations are reliably biased towards faces and facial features such as eyes (Birmingham et al., 2008a, 2008b; Smilek et al., 2006; Yarus, 1967). To test this notion, in Experiment 3, we did not provide participants with any instructions to maintain central fixation, but measured their spontaneous oculomotor biasing using an eye tracker while they performed the same task as in the previous two experiments.

Methods

Participants, apparatus, stimuli, design, and procedure

Thirty additional volunteers (27 female; age $M = 22$ years, $SD = 2$ years) performed the same task as in the previous experiment. The parameters remained identical except that we did not instruct participants about maintaining central fixation. This manipulation in turn preserved their natural oculomotor behavior during the task to examine if participants naturally looked at the face cue more frequently during the cue display, i.e., when all cues were available.

Results

Oculomotor data

To assess if participants spontaneously looked at the social face cue more frequently, we analyzed saccades that were launched from fixation towards one of the predefined regions

⁴ Analyses of response accuracy once again indicated no speed-accuracy trade-offs. The ANOVA returned a marginal main effect of Cue–target interval, $F(3,87) = 2.67$, $p = 0.052$, $\eta_p^2 = 0.08$, with higher accuracy for targets appearing at short relative to long cue–target intervals [250 ms vs. 1000 ms, $t(29) = 2.83$, $p = 0.048$, $d_z = 0.52$; all other p s > 0.34 , d_z s < 0.35]. A main effect of Target position, $F(5,145) = 45.18$, $p < 0.001$, $\eta_p^2 = 0.61$, once again indicated lower accuracy for targets at the previous location of both neutral cues [upper and lower neutral vs. all, t s > 5.90 , p s < 0.001 , d_z s > 1.08]. Lower accuracy was also found for targets occurring at the previous location of the mouth vs. eye cues, $t(29) = 3.11$, $p = 0.028$, $d_z = 0.57$; all other p s > 0.10 , d_z s < 0.46 . No other effects or interactions were reliable, all F s < 1.63 , p s > 0.18 , $\eta_p^2 < 0.05$.

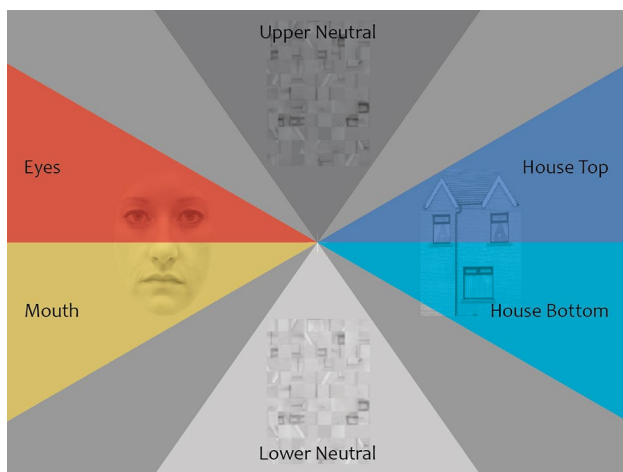


Fig. 5 Regions of interest (ROIs). ROIs were defined by a radial window, including the area of interest; red=eyes, yellow=mouth, dark blue=top house, light blue=bottom house, dark gray=upper neutral, and light gray=lower neutral. ROIs were equated for differences in the size of the visual angle

of interest (ROIs), i.e., Eyes, Mouth, Top House, Bottom House, Upper Neutral, or Lower Neutral location, during the 250 ms cue period. As illustrated in Fig. 5, each ROI was comprised of its respective cue region and spanned an average of 43° radial window. Saccades were defined as eye movements with an amplitude of at least 0.5°, an acceleration threshold of 9500°/s², and a velocity threshold of 30°/s.

For each participant, we calculated the proportion of saccades for each ROI by examining the direction of the very first saccade away from central fixation upon cue onset. For each participant, the number of saccades that were launched from fixation to each ROI were tallied across the entire experiment and then divided by the total number of first saccades that occurred during the cue period. The average number of saccades launched per trial was 0.11, with participants saccading away from fixation infrequently on 11%

of all trials. Saccades were launched towards an ROI on 83% of those trials.

A repeated-measures ANOVA examined this 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 results indicated that a greater proportion of saccades were launched towards the Eyes, particularly when the face was presented in an upright orientation and when the face was positioned in the left visual field, as illustrated in Fig. 6. There was a main effect of ROI, $F(5,145) = 8.94, p < 0.001, \eta_p^2 = 0.24$, showing an overall greater proportion of breakaways towards the Eyes compared to the Mouth and House Bottom, $t_s > 3.56, p_s < 0.011, d_zs > 0.65$. Lower proportion of breakaways also occurred towards the lower Neutral cue vs. all other cues, $t_s > 3.07, p_s < 0.045, d_zs > 0.56$ [all other $p_s > 0.73, d_zs < 0.31$].

There was also a significant interaction between Cue orientation and ROI, $F(5,145) = 4.98, p < 0.001, \eta_p^2 = 0.15$, indicating that when the cues were upright, a greater proportion of saccades were directed towards the Eyes compared to the Mouth, House Top, House Bottom, and Lower Neutral Cue, $t_s > 3.88, p_s < 0.012, d_zs > 0.71$. Lower proportions of breakaways were also directed towards the Lower Neutral vs. Upper Neutral, $t(29) = 3.44, p = 0.022, d_z = 0.63$ [all other $p_s > 0.08, d_zs < 0.52$]. In contrast, when cues were presented in an inverted orientation, the saccadic bias towards the eyes disappeared [$t_s < 2.45, p_s > 0.23, d_zs < 0.45$, all 95% CIs spanned the zero point, ranging from -0.03 to 0.06], with the only difference found between Lower Neutral having a lower proportion of breakaways as compared to Upper Neutral and House Top cues, $t_s > 4.04, p_s < 0.001, d_zs > 0.74$, [all other $p_s > 0.08, d_zs < 0.54$].

A reliable Face position and ROI interaction, $F(5,145) = 5.96, p < 0.001, \eta_p^2 = 0.17$, further suggested that the breakaway bias for Eyes was restricted to the left visual field with a larger proportion of saccades launched towards

Fig. 6 Experiment 3 oculomotor results. Mean proportion of breakaway saccades during the cue presentation period as a function of ROI for upright (a) and inverted (b) cues. Filled bars = face in the left visual field; unfilled bars = face in the right visual field. Error bars represent 95% CIs

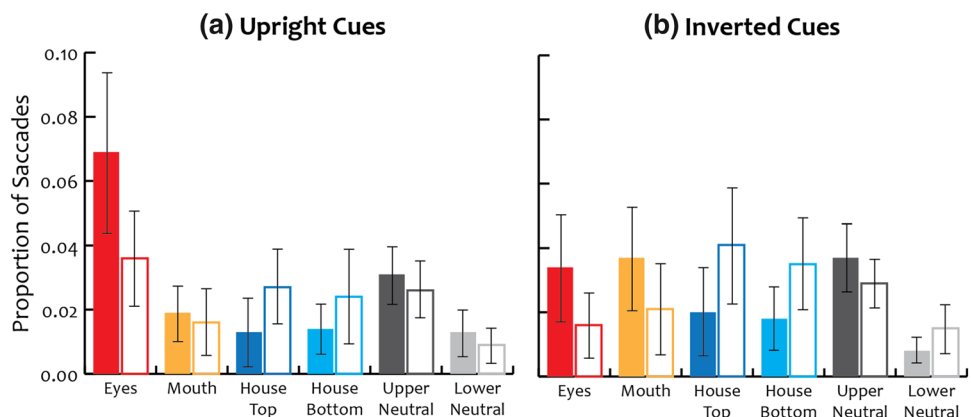
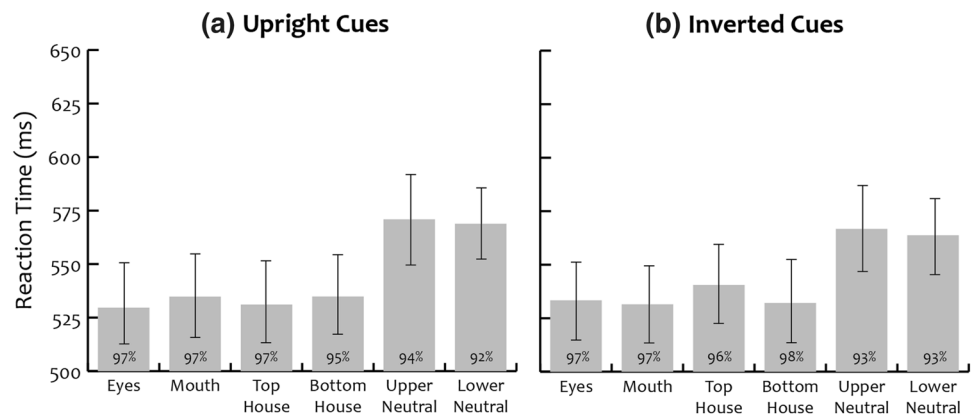


Fig. 7 Experiment 3 manual results. Mean interparticipant correct RTs in ms and accuracy rates in percent as a function of Target position for upright (a) and inverted (b) cues. Error bars represent 95% CIs



the Eyes vs. the Mouth, House Top, House Bottom, and Lower Neutral when the face was presented in the left visual field, $t_s > 3.86$, $p_s < 0.011$, $d_zs > 0.70$. Fewer saccades were also directed towards the Lower Neutral vs. the Mouth and Upper Neutral, $t_s > 3.33$, $p_s < 0.02$, $d_zs < 0.61$ [all other $p_s > 0.054$, $d_zs < 0.55$]. When the face was presented in the right visual field, however, no saccadic bias was found towards the eyes, $t_s < 2.54$, $p_s > 0.20$, $d_zs < 0.46$, all 95% CIs spanned the zero point, ranging from -0.03 to 0.02 , with fewer breakaways made toward the Lower Neutral as compared to Upper Neutral and House Top positions, $t_s > 3.18$, $p_s < 0.042$, $d_zs > 0.58$ [all other $p_s > 0.09$, $d_zs < 0.53$].

Thus, when we assessed participants' natural oculomotor behavior during the dot-probe task, we found that they spontaneously launched saccades more frequently towards the eyes of the face. This effect was also greater when the face was presented in an upright orientation and when it was presented in the left visual field.

Manual data

Anticipations (0%), timeouts (1.1%), and incorrect key presses (0.1%) were removed from analyses. Overall response accuracy was 95%. As illustrated in Fig. 7, an examination of mean correct RTs once again revealed no manual performance bias. An omnibus ANOVA with Cue orientation, Face position, Target position, and Cue–target interval once again revealed main effects of Cue–target interval, $F(3,87) = 48.41$, $p < 0.001$, $\eta_p^2 = 0.63$, and Target position, $F(5,145) = 52.89$, $p < 0.001$, $\eta_p^2 = 0.65$, driven by overall faster RTs at longer cue–target times [250 ms vs. all, $t_s > 7.93$, $p_s < 0.001$, $d_zs > 1.45$; all other $p_s > 0.99$, $d_zs < 0.15$], and slower RTs for targets that appeared in the previous location of the neutral cues [upper and lower neutral vs. all, $t_s > 7.21$, $p_s < 0.001$, $d_zs > 1.32$], respectively. RTs for targets occurring at locations of interest (Eyes, Mouth, Top House, and Bottom House) did not differ, all $t_s < 1.51$,

$p_s > 0.99$, $d_zs < 0.28$; all 95% CIs spanned the zero point, ranging from -12.57 to 8.92 ms.

An interaction between Cue orientation and Target position [$F(5,145) = 2.44$, $p = 0.037$, $\eta_p^2 = 0.08$], indicated slower RTs for targets that occurred at the previous location of both neutral cues vs. all other target locations for upright ($t_s > 7.40$, $p_s < 0.001$, $d_zs > 1.35$; all other $p_s > 0.63$, $d_zs < 0.32$) relative to inverted cues ($t_s > 4.56$, $p_s < 0.001$, $d_zs > 0.83$; all other $p_s > 0.32$, $d_zs < 0.37$). Importantly, as before, no interactions involving Face position and Target position were found [Face position \times Target position $F(5,145) = 0.75$, $p = 0.59$, $\eta_p^2 = 0.02$; Face position \times Target position \times Cue orientation, $F(15,145) = 0.52$, $p = 0.76$, $\eta_p^2 = 0.02$; Face position \times Target position \times Cue–target interval, $F(15,435) = 0.74$, $p = 0.74$, $\eta_p^2 = 0.02$; Face position \times Target position \times Cue–target interval \times Cue orientation, $F(15,435) = 0.53$, $p = 0.92$, $\eta_p^2 = 0.02$]⁵.

We also analyzed the means of median correct RTs using a repeated-measures ANOVA for Target position (face, house) and Cue–target interval (250, 360, 560, 1000 ms). As before, the results of this analysis replicated our results. There was a main effect of Cue–target interval [$F(3,87) = 34.60$, $p < 0.001$, $\eta_p^2 = 0.54$; 250 ms vs. all, $t_s > 6.41$, $p_s < 0.001$, $d_zs > 1.19$; other $p_s > 0.30$, $d_zs < 0.20$], with no main effect of Target position [$F = 0.12$, $p = 0.73$,

⁵ No speed–accuracy trade-off was evident. The same ANOVA conducted on accuracy revealed a main effect of Target position, $F(5,145) = 15.74$, $p < 0.001$, $\eta_p^2 = 0.35$, with lower accuracy for targets appearing in the previous location of the upper and lower neutral cues vs. all others [$t_s > 3.60$, $p_s < 0.008$, $d_zs > 0.66$; all other $p_s > 0.99$, $d_zs < 0.25$]. An interaction between Cue orientation and Target position, $F(5,145) = 3.42$, $p = 0.006$, $\eta_p^2 = 0.11$, indicated lower accuracy for targets that occurred at the previous location of the neutral cues (upper, lower) vs. the eyes, mouth, and house top for upright cues [$t_s > 3.60$, $p_s < 0.011$, $d_zs > 0.66$; all other $p_s > 0.24$, $d_zs < 0.43$] and lower accuracy for targets that occurred at the previous location of both neutral cues (upper, lower) vs. the eyes, mouth, and house bottom for inverted cues [$t_s > 3.57$, $p_s < 0.011$, $d_zs > 0.65$; all other $p_s > 0.30$, $d_zs < 0.40$]. No other main effects or interactions were found, all other $F_s < 2.64$, $p_s > 0.12$, $\eta_p^2 < 0.08$.

$\eta_p^2=0.004$] and no significant interaction [$F=0.22$, $p=0.89$, $\eta_p^2=0.007$].

Discussion

In Experiment 3, we investigated whether participants' eye movements were spontaneously biased toward faces overall or their facial features using a manipulation in which we monitored participants' natural oculomotor behavior, while they performed the dot-probe task. Without any specific instructions to maintain central fixation, we found that participants broke fixation and explored the cue stimuli on 11% of trials. Within those trials, an oculomotor preference for faces and specifically for eyes emerged for upright faces and when faces were presented in the left visual field. This dovetails with the existing literature that shows a preferential bias to look at the eyes of faces (Birmingham et al., 2008b; Laidlaw et al., 2012; Yarbus, 1967) and the specialized role of right-lateralized brain structures in the processing of faces (Yovel et al., 2003). However, once again, we found no manual attentional benefits, suggesting dissociations between covert and overt social attention (see also Kuhn et al., 2016 for a similar finding). We return to this point in the Discussion.

It is important to highlight here that although the oculomotor bias was statistically reliable, participants broke fixation and launched saccades towards one of the ROIs during the cue presentation on only 11% of all trials. Within those trials, they looked at the Eye region on 17% of trials. That is, oculomotor biasing toward the eyes was observed on only 1.9% of all trials. As such, although we found evidence for spontaneous oculomotor biasing towards social information in Experiment 3, this behavior occurred on a very small subset of all trials.

Experiment 4

Thus, the results so far indicated no reliable social attentional capture by faces when stimulus and task factors were systematically controlled. To ensure that this result is not an artifact of our specific laboratory settings, in Experiment 4, we conducted a direct replication of Bindemann and colleagues (2007) Experiment 1a, using their stimuli, procedures, and analyses. This study was one of the first demonstrations of spontaneous social attentional biasing while utilizing a covert attentional paradigm. However, unlike the current study, their stimuli were not matched for luminance, attractiveness, or configuration of features. If these stimulus factors are important in driving attention to faces, we expected to replicate Bindemann and colleagues' (2007) original findings demonstrating a response facilitation for

targets occurring at the previous location of the face relative to the non-social object stimuli.

Methods

Participants

Twenty new volunteers (12 female; age $M=24$ years, $SD=5$ years) with normal or corrected-to-normal vision participated. They were recruited via a volunteer pool and received compensation for their participation. None participated in the previous experiments. The sample size was selected to match Bindemann and colleagues' (2007) study. All procedures were approved by the University Research Ethics board.

Apparatus and stimuli

Original stimuli were obtained from the lead author via personal correspondence. Stimuli were presented on a 16" CRT monitor at an approximate viewing distance of 60 cm, with stimulus presentation timing and sequencing controlled by MATLAB's Psychophysics toolbox (Brainard, 1997).

The central fixation subtended $0.4^\circ \times 0.4^\circ$ of visual angle. The cue stimuli consisted of gray-scale photographs of six faces and six objects each measuring $4.2^\circ \times 4.2^\circ$ and positioned at a distance of 3.4° from fixation. The target stimuli consisted of a gray square measuring $0.6^\circ \times 0.6^\circ$, positioned 5.5° away from fixation. All displays were set on a white background.

Design

The target detection task was a repeated-measures design with six factors: Cue face (three male, three female), Cue object (train, boat, dollhouse, tap, teapot, wall clock), Face position (left visual field, right visual field), Cue-target interval (100, 500, 1000 ms), and Target position (face, object). All factor combinations were equiprobable and presented equally often throughout the experimental sequence. The cues were spatially uninformative about the target location.

Procedure

As in the Bindemann and colleagues' (2007) study, all trials began with the presentation of a fixation display for 750 ms. Then, the cue display was shown for 100, 500, or 1000 ms, after which the target appeared to the left or right of fixation and remained visible until participants responded. Participants were asked to respond quickly and accurately by pressing the '3' or '.' keys on the numpad of the keyboard to localize the target position. Participants completed 432

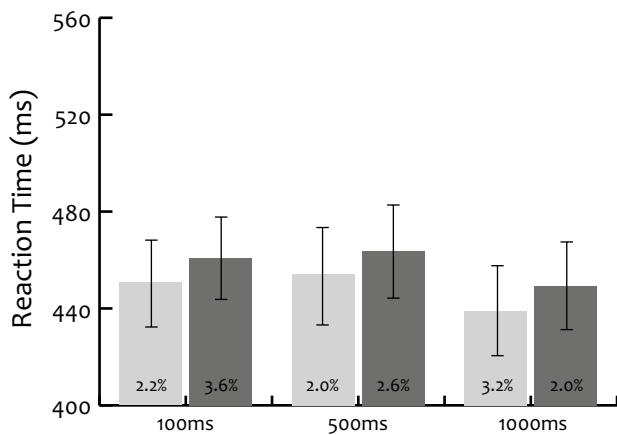


Fig. 8 Experiment 4 results. Direct replication of Bindemann and colleagues' (2007) Experiment 1a. Means of median correct RTs in ms and error rates in percent are shown as a function of Target position and Cue–target interval. Gray bars = face cue; dark gray bars = object cue. Error bars represent ± 1 SE

trials divided equally across 6 testing blocks, with 24 practice trials run at the start. Responses were measured from target onset.

Results

In the original study, the means of median correct RTs were analyzed using a repeated-measures ANOVA across Target position (face, object) and Cue–target interval (100, 500, 1000 ms). The results illustrated in Fig. 8, revealed an expected main effect of *Cue–target interval* [$F(2,38) = 4.92$, $p = 0.013$, $\eta_p^2 = 0.21$] with overall faster RTs for longer relative to shorter cue–target intervals [1000 ms vs. all, $t_s > 2.09$, $p_s < 0.05$, $d_z > 0.48$; other $p = 0.60$, $d_z = 0.12$]. More importantly, they also revealed a reliable main effect of *Target position* [$F(1,19) = 14.63$, $p = 0.001$, $\eta_p^2 = 0.44$] with targets appearing at the previous location of the face detected faster than targets appearing at the previous location of the object. No interactions were found [$F = 0.01$, $p = 0.99$, $\eta_p^2 = 0.001$].

Discussion

As predicted, when we employed uncontrolled stimuli, we fully replicated the original finding demonstrating social attentional bias towards faces. This result strengthens the findings from our previous experiments and demonstrates that the previous pattern of results does not reflect a failure to replicate but rather show a meaningful influence of stimulus and task settings on social attention.

General discussion

In the present study, while controlling for stimulus, task, and oculomotor factors, we re-examined the prevailing notion that faces and/or facial features spontaneously bias attention (Ariga & Arihara, 2017a; Bindemann et al., 2007; Langton et al., 2008; Sato & Kawahara, 2015). Using a dot-probe paradigm, we presented participants with a face–house cue pair and comparison neutral cues in upright and inverted orientations, and measured their performance in response to targets that appeared at the previous location of those cues. In Experiment 1, we instructed participants to maintain central fixation. In Experiment 2, in addition to these instructions, we ensured that they maintained central fixation via a high-speed eye tracker and excluded any trials in which eye movements had occurred. In Experiment 3, instead of controlling for eye movements, we specifically measured spontaneous oculomotor behavior. Across all three experiments, we found no preferential attentional bias in manual responses towards faces or any facial features. That is, participants' response times did not differ for targets that were presented at the previous location of the face relative to the previous location of the house. In Experiment 3, we found that when allowed to make eye movements during the task, participants looked towards the eyes of the face more frequently than to the other regions of the display, and specifically when faces were presented in an upright orientation and in the left visual field. This social oculomotor biasing however was infrequent, occurring on less than 2% of all trials. Finally, in Experiment 4, we demonstrated that we can measure typical social attention biasing when utilizing uncontrolled stimuli. Taken together, these results indicate that previously reported preferential attentional bias for faces may be more strongly affected by context, stimulus, and task factors than originally thought.

In contrast to the large body of literature demonstrating an attentional bias for social information (Bindemann et al., 2005; Bindemann et al., 2007; Devue et al., 2009; Langton et al., 2008; Ro et al., 2001; Sato & Kawahara, 2015), and in contrast to our own direct replication of Bindemann and colleagues' (2007) study, the results from our experiments surprisingly did not support the notion that faces and/or their features preferentially engage human attention. This result was particularly salient in manual responses, which consistently indicated no reliable differences between responses to targets occurring at the previous location of the face and house images. Dovetailing with existing work that has demonstrated the modulation of attention for faces through stimulus and task parameters (Crouzet & Thorpe, 2011; Itier & Taylor, 2002, 2004), our results also suggest that past reports of spontaneous social attentional bias likely reflected the influence of similar stimulus and task factors that may

have acted in isolation or in conjunction to bias attention, independently from the social features of faces. This finding highlights the strong role that stimulus and task settings play in social attention, above and beyond the perception of faces alone, and suggests that previously reported attentional effects may not be primarily due to the inherent social nature of faces but instead to their task relevance (Capozzi & Ristic, 2018). The question of which stimulus factor is the most relevant in biasing social attention remains to be addressed in future investigations geared towards directly manipulating and isolating the contribution of task, stimuli, and context to social attention, such as for example by manipulating specific low- and high-level factors, task timing, and target properties.

In contrast to manual data however, natural oculomotor behavior during the task (Experiment 3) revealed small, albeit reliable, biasing of eye movements towards the eyes. This finding held only when faces were presented in an upright orientation and in the left visual field, dovetailing well with the existing literature demonstrating preferential processing of upright faces by right-lateralized face-sensitive brain areas (McCarthy, Puce, Gore, & Allison, 1997; Rhodes, 1985; Rossion et al., 2003), and with the large volume of data showing preferential oculomotor selection of faces and eyes within the first few fixations of naturalistic free-viewing tasks (Birmingham et al., 2008a, 2008b; Smilek et al., 2006; Yarbus, 1967). However, our data revealed that preferential social oculomotor biasing occurred on a very small subset of all trials, i.e., 1.9%. Even though we were not able to examine more fine-grained saccadic measures (e.g., saccadic reaction time and initial saccade latency) due to these small number of saccadic breakaways, our results suggest that the choice of task and stimuli also modulates the strength of observed oculomotor biasing. This is consistent with the data reported by Vő and colleagues (2012) who found that fixations made to the eyes of a video protagonist were modulated by participants' goals rather than an overall preference for fixating the eyes. Thus, while preferential oculomotor biasing by faces is present across different tasks, the magnitude of this response is readily modulated by task settings and observer goals (Birmingham et al., 2008b).

From a theoretical perspective, our results highlight the notion that robust social attentional biasing may require optimal situational, stimulus, and task factors. In line with this reasoning, the recent research shows that in some social situations, the potential for social interaction decreases the frequency of social attentional behaviors like gaze following (e.g., looking at an image of a confederate vs. the person themselves; Laidlaw, Foulsham, Kuhn, & Kingstone, 2011), whereas in other settings, the same factors may lead to an increase in similar types of social behavior (e.g., eating with a friend vs. a stranger; Wu, Bischof, & Kingstone, 2013). Past results on differential and contextually situated

effects for attention to faces also support this perspective (Birmingham, Ristic, & Kingstone, 2012; Hayward et al., 2017; McPartland, Webb, Keehn, & Dawson, 2011; Vő et al., 2012), along with clinical work demonstrating little-to-no difference in attentional and oculomotor viewing patterns between individuals with autism spectrum disorder and typically developing individuals when studies utilize static, unimodal, and ecologically impoverished stimuli (Anderson, Colombo, & Shaddy, 2006; Guillon, Hadjikhani, Baduel, & Roge, 2014; McPartland et al., 2011). Thus, factors like social relevancy, context, and/or agency are important to consider when examining spontaneous social attentional biasing, with future work needed to examine the stability of the theoretically predicted social attention behaviors across different stimuli, measures, and situations.

Our results also raise important questions about the dissociation between manual (i.e., covert) and oculomotor (i.e., overt) measures of social attention. Across all experiments, we found no reliable evidence for a manual performance advantage for targets cued by faces, but nevertheless found a small but reliable oculomotor bias towards the eyes of the face cue when participants maintained natural oculomotor behavior during the task (i.e., in Experiment 3). The dissociation between manual and oculomotor data points to a potential difference in covert and overt responses when faces and eyes serve as stimuli. The relationship between covert (i.e., attention devoid of eye movements; Jonides, 1981) and overt attention (i.e., attention accompanied by oculomotor movements; Posner, 1980) has thus far been studied extensively, with most findings converging on the idea that the two modes of attention can be elicited separately as well as in conjunction (de Haan, Morgan, & Rorden, 2008; Hunt & Kingstone, 2003a; Nobre, Gitelman, Dias, & Mesulam, 2000; Peterson, Kramer, & Irwin, 2004). The examinations of these systems and their associations have typically been conducted using non-social traditional attentional stimuli, such as luminance transients or geometric shapes (Klein & Pontefract, 1994; Peterson et al., 2004; Van der Stigchel & Theeuwes, 2007). In contrast to these classic investigations, our data are consistent with a handful of recent examinations which point to important dissociations in overt and covert attentional systems within the specific domain of social attention (Kuhn et al., 2016; Laidlaw, Badiudeen, Zhu, & Kingstone, 2015; Risko et al., 2016). That is, it has recently been suggested that covert and overt attentional systems may serve different purposes in social communication. While covert social attention may primarily function to gather social information from the environment without revealing the focus of an agent's attention to others, overt social attention may aid in the communication of social cues to the other agents during social interactions (Gobel, Kim, & Richardson, 2015; Risko et al., 2016). As such, while it is possible that differential dissociated operations between

covert and overt systems may not be unique to social attention, future studies are needed to determine the individual contribution of covert and overt attentional systems to social and general attentional behaviors across different test situation complexities (e.g., Hayward et al., 2017).

To address alternate explanations for our pattern of results, it may be possible that the face–house cue image used in this study were perceptually equated to such an extent to result in a loss of information that is critical for distinguishing between face and non-face stimuli. If so, these low-level feature differences would then appear to be necessary for social attentional biasing rather than the overall presence of the face cues alone. It may also be possible that subtle differences in the task and stimulus parameters utilized here as compared to past work may have also contributed to the reduction of the social attentional bias. However, when compared to the original Bindemann and colleagues' (2007) study, these task changes were minimal. The changes included presenting three instead of two types of cues, six instead of two targets, and responses that required target identification instead of target localization. If the processes behind social attention were as spontaneous and robust as originally thought, then these minor alterations to the task and stimulus should not have such a dramatic effect on the measured effects. It was also suggested to us that participants may have spread their attention in an object-based manner, such that either the face or the house was prioritized for responding. If so, we would have expected to find an overall global effect for the face, along with no specific effects for the eyes or mouth locations; however, our results did not reveal any evidence of facilitative responses for targets occurring at the previous location of the face overall, but did demonstrate an oculomotor bias towards the eyes over the mouth. It is possible that participants may have also strategically responded to targets irrespective of the cues; however if so, this would still support our main finding indicating that social cue identity did not influence target detection.

Finally, it is important to discuss that a potential reason for why we may not have observed social attentional biasing for faces and/or facial features in this study could reflect an insensitivity of the dot-probe task to detect these effects. Although plausible, there are three reasons for why we believe this is not a likely explanation for our data. One, the dot-probe task (MacLeod et al., 1986), along with the cuing task (Posner, 1980), has been one of the most utilized attentional paradigms, and a go-to task for examining attentional biases to emotional and rewarding stimuli (Frewen, Dozois, Joanisse, & Neufeld, 2008). This popularity reflects the task's ability to elicit attentional effects on a trial-to-trial basis and to measure their behavioral modulations across different parts of the visual field (Cooper & Langton; Frewen et al., 2008; Klein & MacInnes, 1999; MacLeod et al., 1986; Navon & Margalit, 1983; but see Schmukle, 2005, for issues

with non-clinical samples). Two, existing studies that have measured and reported preferential attentional biasing by faces have often done so using the dot-probe task. For example, both Bindemann and colleagues' (2007) original study and the replication reported in the current paper showed stable attentional allocation to faces using this paradigm. Three, even though we did not find reliable differences between responses to targets preceded by faces and those preceded by houses, our data indicated that participants performed the task as instructed—they exhibited high accuracy in responses and performed the task with the expected level of temporal alertness, as demonstrated by the robust main effects of cue–target interval, which is commonly understood to reflect response preparation processes (Bertelson, 1967). Furthermore, preferential selection of faces was found when compared to control scrambled stimuli, indicating that social information was preferentially attended over and above neutral information but not over and above other stimuli of relevance. This suggests that while our procedure was able to measure differences in target processing, it did not yield theoretically predicted performance differences between targets occurring at the location of the face and house images. Although it is unlikely that our results reflect an inability of the dot-probe paradigm to reveal preferential attentional biasing by social cues, future work should address the sensitivity of this task in assessing more subtle processing differences between social and non-social cues using more temporally precise methodologies such as electroencephalography.

To conclude, in this study, we provide one of the first pieces of evidence showing the fragility of spontaneous social attentional biasing within a standard laboratory task. This finding challenges the prevailing notion that faces and facial features bias human attention spontaneously and preferentially, and highlights the need for future studies to delineate the specific contributions of stimulus, task, and situational factors to social attention.

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Compliance with ethical standards

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

Ethical approval All procedures performed in these studies involved human participants and were in accordance with the ethical standards of the institutional and/or national research committee, and with the

1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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