The control of attention to faces

Markus Bindemann Department of Psychology, University of Glasgow, Glasgow, UK

A. Mike Burton Department of Psychology, University of Glasgow, Glasgow, UK

Stephen R. H. Langton Department of Psychology, University of Stirling, Stirling, UK

Stefan R. Schweinberger Department of Psychology, University of Jena, Jena, Germany

Martin J. Doherty Department of Psychology, University of Stirling, Stirling, UK

Humans attend to faces. This study examines the extent to which attention biases to faces are under top-down control. In a visual cueing paradigm, observers responded faster to a target probe appearing in the location of a face cue than of a competing object cue (Experiments 1a and 2a). This effect could be reversed when faces were negatively predictive of the likely target location, making it beneficial to attend to the object cues (Experiments 1b and 2b). It was easier still to strategically shift attention to predictive face cues (Experiment 2c), indicating that the endogenous allocation of attention was augmented here by an additional effect. However, faces merely delayed the voluntary deployment of attention to object cues, but they could not prevent it, even at short cue–target intervals. This finding suggests that attention biases for faces can be rapidly countered by an observer's endogenous control.

Keywords: attention, faces, endogenous control

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Introduction

Attention is frequently deployed to faces, to the detriment of other visual stimuli (Bindemann, Burton, Hooge, & Jenkins, 2005; Mack, Pappas, Silverman, & Gay, 2002; Ro, Russell, & Lavie, 2001; Shelley-Tremblay & Mack, 1999; Theeuwes & Van der Stigchel, 2006; Vuilleumier, 2000). This phenomenon, often referred to as attention capture, implies that much of what we see depends on whether a face is present or not in a visual array. However, there are many circumstances when a face is not the intended object of a person's attention. This study examines the extent to which observers can exert control over an attention bias to faces under these conditions.

It is well established that visual attention can be shifted by two orienting mechanisms (e.g., Jonides, 1981). Endogenous attention shifts are under a person's own control and enable voluntary goal-directed behavior. Exogenous shifts are triggered by external demands, so that attention is reflexively drawn to some stimuli, even when this is counter to a person's intentions. These involuntary shifts are often referred to as attention capture (e.g., Yantis, 1996) and are usually driven by low-level visual attributes, such as abrupt visual onsets (e.g., Remington, Johnston, & Yantis, 1992) or salient singletons in a display (e.g., Theeuwes, 1991). Recently, however, similar tests have been applied to more complex stimuli, such as faces, with intriguing results. Schematic faces, for example, appear resistant to metacontrast masking in comparison with their inverted and scrambled counterparts (Shelley-Tremblay & Mack, 1999) and are detected in a visual stream when tree shapes and inverted faces are frequently missed (Mack et al., 2002). Patients with visual neglect also report line-drawn faces more often in the impaired hemifield than scrambled faces and shapes (Vuilleumier, 2000). Thus, it appears that the mere onset of a face stimulus may be sufficient to obtain a person's attention.

A face advantage is also found when a distinction is required between concurrent stimuli. Thus, nonface stimuli are extinguished more often in visual neglect patients when they are presented alongside faces (Vuilleumier, 2000), faces receive more attention than nonface stimuli in change detection tasks (Ro et al., 2001), and faces give rise to inhibition of return alongside a concurrent nonface object (Theeuwes & Van der Stigchel, 2006). Therefore, it seems that faces also draw attention when they are in competition with other stimuli.

At present, however, the extent to which these attention biases can be controlled endogenously remains unresolved, although this is crucial for a complete understanding of how face processing and attention interact. In the related scenario of eye-gaze perception from faces, for example, visual attention is shifted in the direction of a seen gaze even when it is counter to an observer's intention to do so (Driver et al., 1999; Langton & Bruce, 1999). For the specific case of eye-gaze, at least, this implies that the allocation of attention is immune to endogenous control. If the same applies to attention biases toward faces, then this leads to the strong prediction that an observer cannot control the allocation of attention within the visual field when a face is present.

To explore this question, the experiments reported here use a spatial cueing task, in which a face and an object cue were presented simultaneously, one on either side of fixation. After stimulus onset asynchrony (SOA) of 100, 500, or 1,000 ms, a target probe followed in one of these locations. Participants made speeded responses according to the target position, with response times (RTs) indicating attention to a cue. The advantage of this task is that it is simple to manipulate the predictiveness of the cues. In our first experiment, faces and objects were initially equally predictive of the target to demonstrate that viewers attend to faces when there is no strategic reason to do so (Experiment 1a). In Experiment 1b, we made faces negatively predictive by making them valid target location cues on only 25% of trials. Note that the interest here, in contrast to previous studies (e.g., Ro et al., 2001), was not to test whether faces generally draw attention more than nonface objects by comparing faces with a broad range of comparisons. Rather, the aim was to examine the extent to which an existing attention bias (as elicited in Experiment 1a) can be overturned by endogenous control (Experiment 1b).

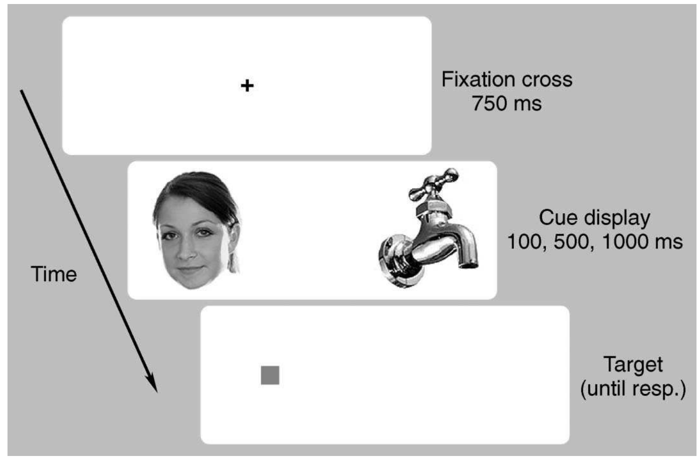

Figure 1. Task sequence for Experiment 1. In Experiment 1a, faces and objects were equally predictive of the target. Observers were asked to monitor the screen for the target and to respond to its on-screen location as quickly as possible (i.e., left vs. right). In Experiment 1b, object cues predicted the likely target location on 75% of trials. Observers exploited these probabilities to locate the targets as quickly as possible by shifting attention endogenously to the object locations.

Experiment 1

Methods

Experiment 1a

Twenty students participated for a small fee. Photographs of six unfamiliar faces (three male) and six objects (a train, a boat, a dollhouse, a watertap, a teapot, and a wall clock) served as stimuli (for an example, see Figure 1). All images were converted to grayscale and cropped to remove extraneous background and measured maximally 4.4 × 4.4 cm (subtending 4.2° × 4.2° of visual angle at a distance of 60 cm). These 12 images were used to construct 72 cue displays containing a face and an object image. Face and object cues were equally likely to appear left or right of fixation, with the nearest cue contours at least 3.6 cm (3.4° of VA) apart. The target consisted of a gray square with a width of 0.6 cm (0.6° of VA).

Trials began with a fixation cross for 750 ms, followed by a cue display. After SOAs of 100, 500, or 1,000 ms, the cues disappeared and the target appeared in one of the cue locations. The target, which was equally likely to occur left or right of fixation, remained on-screen until response. Participants responded to the target's location by pressing one of two keys ("3" and ".") on the number pad of a computer keyboard. All cues were equally predictive of the target location, so that the target probe occurred in a face location on 50% of trials. Subjects were asked to respond as quickly and as accurately as possible. Each participant received 24 practice trials, and 72 trials for each cue combination (face–object, object–face) and SOA (100, 500, 1,000 ms), giving a total of 432 experimental trials. Conditions were randomized in blocks of 72 trials, and participants took short breaks between blocks.

Experiment 1b

Twenty new students participated in this experiment. Stimuli and procedure were identical to Experiment 1a, except that targets were now three times more likely to appear in the location of an object than of a face. Participants were informed of this probability and were instructed to concentrate on object cues to complete the experiment as quickly as possible. Subjects performed 24 practice and 576 experimental trials.

Results

Experiment 1a

To simplify analysis, we collapsed the data across the cue locations and calculated the means of the median correct RTs and percentage errors for all conditions (Figure 2, 50:50). A 2 (face, object cue) × 3 (100, 500, and 1,000 ms SOA) ANOVA showed a main effect of SOA, $F(2, 38) = 17.79$, $p < .01$, reflecting faster RTs with increasing SOA, and a main effect of cue, $F(1, 19) = 35.08$, $p < .01$, due to faster RTs to face-cued targets. The SOA × Cue interaction was not significant, $F(2, 38) < 1.1$. In addition, error rates were generally lower for face-cued targets (Figure 2), but these differences were not reliable (all Fs < 1).

Experiment 1b

ANOVA revealed a main effect of SOA, $F(2, 38) = 22.40$, $p < .01$, due to faster responses with increasing SOA, and a main effect of cue, $F(1, 19) = 20.12$, $p < .01$. In contrast to Experiment 1a, this reflected faster RTs to object-cued targets (see Figure 2, 25:75). The SOA × Cue interaction was not significant, $F(2, 38) < 1.2$. Consistent with the RT data, more errors were made to face-cued targets. ANOVA showed a main effect of cue, $F(1, 19) = 5.90$, $p < .05$, but not of SOA, $F(2, 38) < 1$, and no interaction, $F(2, 38) < 1$.

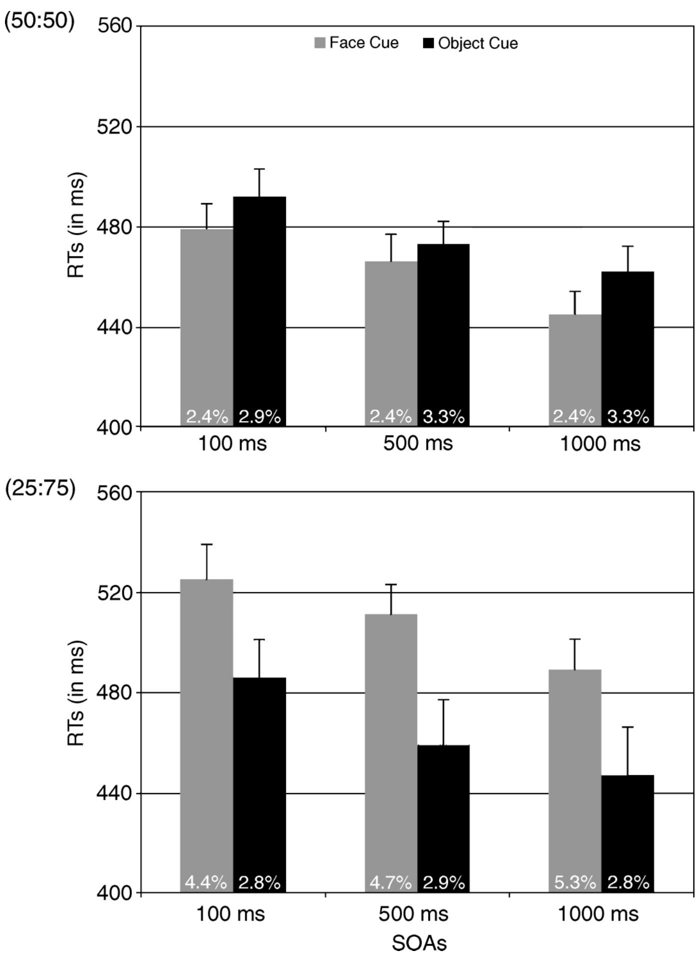

Figure 2. Mean reaction times and percentage errors (in white) as a function of cue and SOA in Experiment 1. In Experiment 1a, face and object cues were equally predictive of the target (50:50). In Experiment 1b, face cues were less predictive than object cues (25:75). Vertical bars represent standard errors.

Discussion

Consistent with previous studies, faces engaged attention more than object cues at all SOAs in Experiment 1a (e.g., Ro et al., 2001; Theeuwes & Van der Stigchel, 2006; Vuilleumier, 2000). However, Experiment 1b shows that this effect can be reversed by the simple manipulation of cue predictiveness. It is striking that this is present with the shortest cue–target SOA. Attention capture peaks within 200 ms of stimulus onset, whereas endogenous orienting develops more gradually and requires 300–400 ms to reach its maximum (e.g., Müller & Findlay, 1988; Müller & Rabbitt, 1989). Therefore, one might have expected a face bias at least at the 100 ms SOA (see, e.g., Müller & Rabbitt, 1989). The absence of a face advantage in Experiment 1b therefore initially appears to contradict previous claims of attention capture by faces (e.g., Theeuwes & Van der Stigchel, 2006; Vuilleumier, 2000). However, this experiment has two shortcomings as it only assessed endogenous orienting toward object cues, in a between-subject design. Consequently, it is possible that the results of Experiment 1b represent an additive effect: a capture effect for faces, similar to the face bias in Experiment 1a, and a larger endogenous effect toward objects. This is examined in Experiment 2.

Experiment 2

There is evidence that attention cueing effects are additive when attention is endogenously shifted to one location and is simultaneously drawn exogenously to another, so that voluntary attention shifts directly compound involuntary attention effects (e.g., Berger, Henik, & Rafal, 2005; Berlucchi, Chelazzi, & Tassinari, 2000; Lupiáñez et al., 2004; see also Berlucchi, 2006). This experiment therefore examines whether the object advantage in Experiment 1b reflects a pure endogenous effect or a combined effect reflecting both the voluntary deployment of attention to the object cues and a smaller involuntary face bias. In Experiment 2a, faces and objects are initially equally predictive of the target. Cue predictiveness is then manipulated, so that the target is three times more likely to appear in the location of an object in

Experiment 2b and three times more likely to appear in the location of a face in Experiment 2c. Experiment 2a was always completed first, but the order of Experiments 2b and 2c was counterbalanced across subjects. We predicted a face bias for Experiment 2a, which should persist when attention is directed endogenously to the nonface cue. This should be evident from an advantage for predictive face cues (Experiment 2c), reflecting additive effects of endogenous orienting and face capture, in comparison with the purely endogenous orienting effects for predictive nonface cues (Experiment 2b).

Two further changes were made for Experiment 2. The localization task of Experiment 1 was replaced with an identification task to avoid the possibility of an "opposite-side" response strategy (i.e., pressing "left" when viewers are drawn to a right-sided cue that is not followed by a right-sided target). Consequently, participants now responded to the orientation of a line target, which was equally likely to appear in either cue location. To extend the range of object comparisons, faces were now compared with a homogeneous set of houses.

Method

Thirty new student subjects participated in this experiment. Pictures of six houses were edited in the same way as the six face stimuli from Experiment 1. Faces and houses were histogram-equalized to have the same average gray levels and standard deviation and were used to construct 72 cue displays in the same manner as in Experiment 1. The target probe consisted of a gray line measuring 1.1 × 0.1 cm, which was equally likely to appear in a horizontal or vertical orientation. The target was followed by a screen mask, consisting of two "+" signs with a line width of 1.1 × 0.1 cm, with one each appearing in the two possible target locations.

A trial began with a fixation cross (750 ms), followed by a cue display (100, 500, or 1,000 ms), then a target in one of the cue locations (200 ms), and then the mask (100 ms). Participants responded to the target's orientation (i.e., vertical vs. horizontal) by pressing one of two keys ("3" and ".") on a computer keyboard. In Experiment 2a, all cues were equally predictive, so that the target probe appeared in the location of a face on 50% of trials. Each participant received 48 practice trials and 216 experimental trials (36 trials for each combination of cue and SOA). In Experiment 2b, the targets were then three times as likely to appear in the location of an object than a face cue. As in Experiment 1b, participants were informed of these probabilities and were instructed to concentrate on the object cues to respond to the target as quickly as possible. All participants completed 24 practice and 432 experimental trials. Experiment 2c consisted of the same number of trials, but in this task the faces were predictive of the target by the same ratio of 3:1. The order of Experiments 2b and 2c was counterbalanced across subjects.

Results

Experiment 2a

RTs and errors were analyzed as in Experiment 1 and are shown in Figure 3 (50:50). ANOVA showed a main effect of cue, $F(1, 29) = 32.85$, $p < .01$, but no interaction between cue and SOA, $F(2, 58) < 1.4$. The main effect of SOA was marginally significant, $F(2, 58) = 3.03$, $p = .06$, with faster responses at 500 versus 100 ms SOA, Tukey HSD, $p < .05$. Percentage errors were lower for face-cued targets but ANOVA showed no effect of cue, $F(1, 29) < 2.3$, SOA, $F(2, 58) < 1$, and no interaction, $F(2, 58) < 1$.

Experiments 2b and 2c

A 2 × 3 × 2 ANOVA of experiment (Experiment 2b vs. Experiment 2c), cue (face vs. object), and SOA (100, 500, 1,000) showed a three-way interaction, $F(2, 58) = 10.92$, $p < .01$ (cf. Figure 3, 25:75 and 72:25). To facilitate the interpretation of this interaction, we carried out two separate ANOVAs of cue and SOA for these experiments.

For Experiment 2b, a main effect of SOA was found, $F(2, 58) = 29.96$, $p < .01$, due to faster RTs with increasing SOA (Tukey HSD, 100 vs. 500 and 100 vs. 1,000, $p < .01$; 500 vs. 1,000, *ns*) and a main effect of cue, $F(1, 29) = 39.63$, $p < .01$, with faster responses to object-cued targets. The Cue × SOA interaction was not significant, $F(2, 58) < 2.1$. Error rates complemented the RT data, with an effect of SOA, $F(2, 58) = 5.71$, $p < .01$, and cue, $F(1, 29) = 7.91$, $p < .01$, but no interaction, $F(2, 58) < 1.1$ (see Figure 3, 25:75).

Experiment 2c showed an effect of SOA, $F(2, 58) = 6.78$, $p < .01$ (Tukey HSD, 100 vs. 500, $p < .05$; 100 vs. 1,000, $p < .01$; 500 vs. 1,000, *ns*), a main effect of cue, $F(1, 29) = 74.56$, $p < .01$, and a Cue × SOA interaction, $F(2, 58) = 23.27$, $p < .01$. Simple main effect analysis showed robust cueing effects at each SOA, 100, $F(1, 29) = 12.02$, $p < .01$; 500, $F(1, 29) = 26.30$, $p < .01$; 1,000, $F(1, 29) = 40.45$, $p < .01$, and an effect of SOA for face-cued targets, $F(2, 58) = 17.11$, $p < .01$ (Tukey HSD, 100 vs. 500 and 100 vs. 1,000, $p < .01$; 500 vs. 1,000, *ns*), but not for object-cued targets, $F(2, 58) < 1$ (see Figure 3, 75:25). Analogous analysis of percentage errors showed a main effect of cue, $F(1, 29) = 29.47$, $p < .01$, but no effect of SOA, $F(2, 58) < 1.3$, and no interaction, $F(2, 58) < 1$.

Voluntary versus involuntary effects

To examine the contribution of endogenous and exogenous effects, we conducted two further 3 × 2 ANOVAs. The first ANOVA compared responses to predictive cues (i.e., the 75% predictive objects from Experiment 2b vs. the 75% predictive faces from Experiment 2c) to determine whether endogenous attention shifts are facilitated toward face cues in comparison to object cues (see Figure 4, 75:75). Consistent with this notion, the

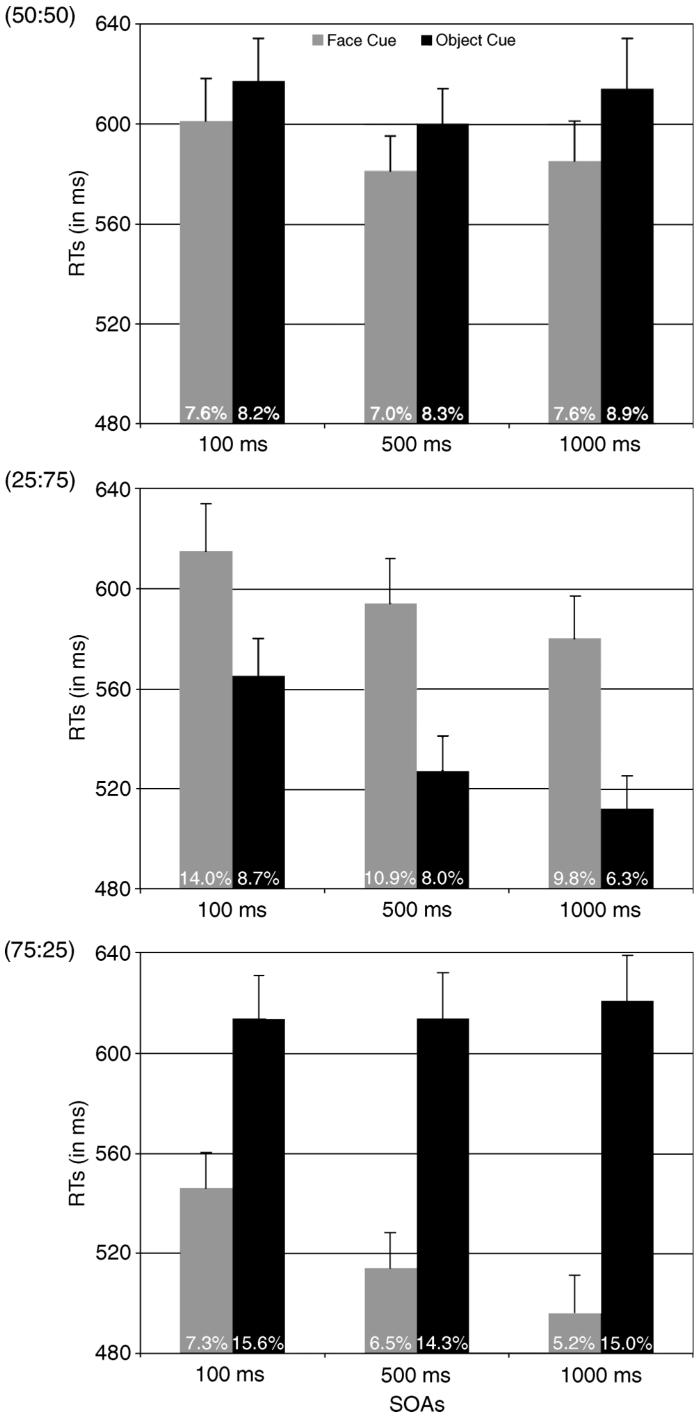

Figure 3. Mean reaction times and percentage errors (in white) as a function of cue and SOA in Experiment 2. In Experiment 2a, face and object cues were equally predictive of the target (50:50). In Experiment 2b, face cues were less predictive than object cues (25:75). In Experiment 2c, face cues were more predictive than object cues (75:25). Vertical bars represent standard errors.

main effect of SOA, $F(2, 58) = 42.90$, $p < .01$, was supplemented by an effect of cue, $F(1, 29) = 5.39$, $p < .05$, demonstrating overall faster responses to face cues. The Cue × SOA interaction was not significant, $F(2, 58) < 1$.

The second ANOVA compared the unpredictive cues (i.e., the 25% predictive faces from Experiment 2b vs. the 25% predictive objects from Experiment 2c). For these conditions, the main effects of SOA, $F(2, 58) = 1.71$, and cue, $F(1, 29) = 3.15$, $p = .09$, were not significant, but an interaction was found, $F(2, 58) = 12.16$, $p < .01$. Simple main effect analysis showed an effect of SOA for face cues, $F(2, 58) = 4.90$, $p < .05$, but not for object cues, $F(2, 58) < 1$, and an effect of cue at the 1,000 ms SOA, $F(1, 29) = 4.23$, $p < .05$, due to faster responses to face-cued targets. These effects were not significant at the 100 and 500 ms SOA, both $Fs < 1.1$ (see Figure 4, 25:25).

Discussion

Experiment 2 examined whether endogenous and involuntary attention mechanisms exert concurrent effects in this task (see, e.g., Berger et al., 2005; Berlucchi,

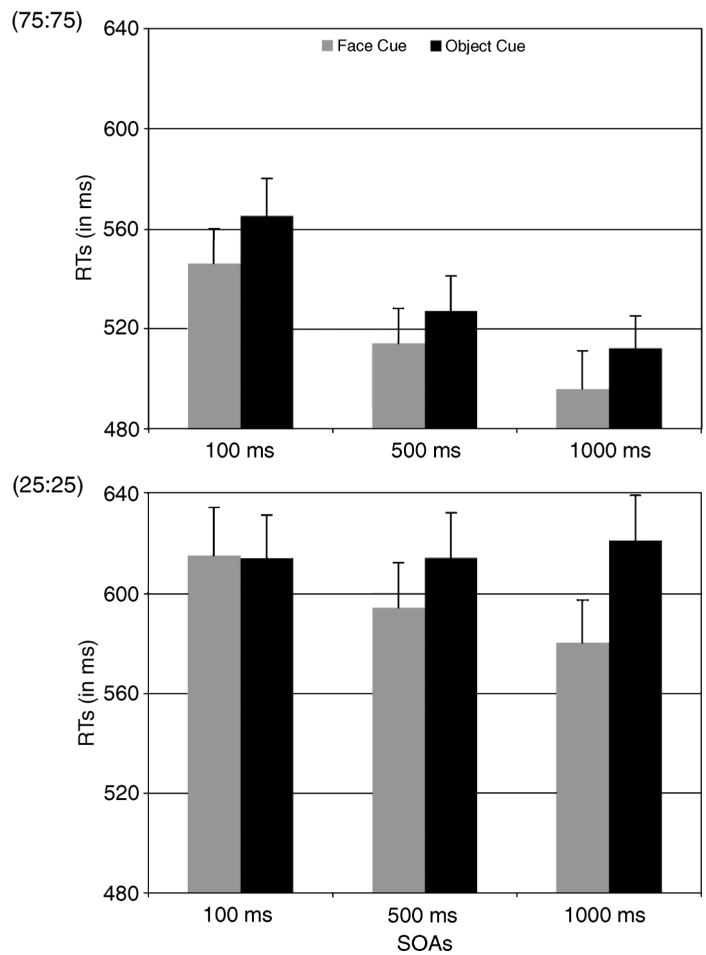

Figure 4. A comparison of the predictive object cues from Experiment 2b and the predictive face cues from Experiment 2c (75:75), and a comparison of the unpredictive face cues from Experiment 2b and the unpredictive object cues from Experiment 2c (25:25).

2006). Consistent with this notion, the face advantage of Experiment 2a, in which faces and nonface objects were equally predictive, was still present across Experiments 2b and 2c, where attention was endogenously allocated to the different cue types. Thus, responses to predictive face cues were significantly faster than to predictive object cues, indicating an additive or a “net” effect from both endogenous and reflexive mechanisms for face cues (see Figure 4, 75:75). In addition, responses were slower to targets cued by unpredictive objects in Experiment 2c than to targets cued by unpredictive faces in Experiment 2b (see Figure 4, 25:25). These differences provide further support that attention was allocated more readily to faces, although this effect was only reliable at the longest SOA. Despite this, however, an overall endogenous cueing effect was present for predictive faces and predictive objects even at the shortest cue–target SOA.

General discussion

This study examined the extent to which attention biases to faces are under an observer’s control. We assessed first whether observers can overturn a face bias endogenously in a cueing task (Experiment 1). We then pitted endogenous orienting toward and away from faces against each other (Experiment 2). In both experiments, observers were able to switch attention away from faces and to a concurrent object when it was beneficial to do so. It is striking that these endogenous effects were present with a very short cue–target SOA of 100 ms, as exogenous mechanisms are most influential at such short SOAs, in comparison to endogenous mechanisms (see, e.g., Cheal & Lyon, 1991; Müller & Findlay, 1988; Müller & Rabbitt, 1989; Shepherd & Müller, 1989). This clearly demonstrates that attention biases for faces are to a large extent under a viewer’s control.

Despite this, these endogenous effects were still underpinned by a persistent face bias. Thus, it was easier to shift attention to predictive face cues than to predictive object cues, indicating that the endogenous allocation of attention to faces was augmented here by an additional effect (see Figure 4, 75:75). Similarly, responses were reliably slower to unpredictive objects than to unpredictive faces, albeit only at the 1,000 ms SOA, which suggests that faces were also drawing attention while observers were looking at the object cues (see Figure 4, 25:25). These differences suggest that complete endogenous selectivity was not possible in the presence of a face image. In this respect, the results resemble previous claims of attention capture by faces. Indeed, the early onset and longevity of the face advantage here perhaps suggest a faster and a more persistent face bias than previous evidence indicates (e.g., Ro et al., 2001; Theeuwes & Van der Stigchel, 2006; Vuilleumier, 2000). Importantly, however, faces merely delayed the voluntary deployment of attention to the object cues, but they could not prevent it. In contrast, voluntary control processes could override attention biases to faces even at the shortest SOA.

One possibility, of course, is that these face biases (Experiments 1a and 2a) and their reversal (Experiments 1b and 2b) simply reflect the object comparisons, which, unlike faces, did not represent stimuli of particular social or biological importance and which also differed from faces in many physical dimensions. Thus, there may be better-matched nonface stimuli, which might pose stronger competitors for visual attention, such as objects reflecting individuals’ addictions or particular visual expertise (e.g., Jones, Jones, Smith, & Copley, 2003; Waters, Shiffman, Bradley, & Mogg, 2003). It is also possible that a face bias in the current task, particularly at the middle and long SOA, does not reflect attention capture but attention retention (see, e.g., Bindemann et al., 2005). With respect to both of these issues, it is important to reiterate that the aim of the present research was not to examine the general existence of a face bias by comparing faces with a broad range of objects or by contrasting attention capture and retention. Rather, the uniqueness of this research lies in examining the endogenous control of an existing attention bias for faces. If anything, however, it should certainly be less demanding to endogenously shift attention toward nonface objects that are stronger competitors for visual attention than the nonface cues of the current task. This underlines the influence of voluntary control processes in this task, which could override attention biases to faces even at the shortest SOA.

In some sense, of course, this behavior seems entirely predictable. If endogenous mechanisms can shift attention voluntarily, then one might expect that attention can also be shifted from faces by these mechanisms. However, it is important to stress that some types of facial information, such as the eyes, do not interact with endogenous attention mechanisms in this “predictive” manner but resist voluntary control and induce automatic attention shifts in the direction of a seen eye-gaze (see, e.g., Driver et al., 1999; Langton & Bruce, 1999). In this sense, a face bias may also differ from attention capture effects that are driven by low-level stimuli, such as salient color singletons, and which cannot be overridden by top-down control (see, e.g., Theeuwes, 2004; Theeuwes, de Vries, & Godijn, 2003). Similarly to these instances with eye-gaze and low-level stimuli, much has been made of faces’ ability to capture visual attention, as has been observed in many different situations (e.g., Ro et al., 2001; Theeuwes & Van der Stigchel, 2006; Vuilleumier, 2000). However, the current study suggests that the effect that these attention biases for faces exert on human behavior is limited by endogenous control. This is clearly adaptive, as one often needs to concentrate on one task without constant interruption by external stimulation. For example, even seemingly simple tasks such as maneuvering a car through traffic might become arduous if attention is uncontrollably drawn to pedestrians. Our results imply that endogenous mechanisms can override a face bias under such circumstances, when it is necessary to do so.

It is worth speculating about the neural mechanism underlying these effects. The prefrontal cortex (PFC) receives input from all sensory systems and is implicated in top-down attention biasing (for a review, see Miller & Cohen, 2001). Such top-down behavior depends on the ability to associate different types of information, for instance, such as cue type (face vs. object) and cue predictiveness (75% vs. 25% predictive) in the current task. PFC neurons code associations (e.g., Asaad, Rainer, & Miller, 1998), including, as in the present task, information about spatial locations and stimulus identity (e.g., Kostopoulos & Petrides, 2003; White & Wise, 1999). Therefore, the PFC may also be involved in enabling endogenous attention shifts toward and away from faces. From this view, it is noteworthy that PFC activation is enhanced when endogenous mechanisms are competing with automatic processes (e.g., Cohen, Dunbar, & McClelland, 1990). If faces capture attention automatically, PFC activation during endogenous attention shifts should therefore increase in the presence of a face distractor in comparison to a nonface object. This might be an interesting topic for future research.

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Corresponding author: Markus Bindemann.
E-mail: markus@psy.gla.ac.uk.
Address: Department of Psychology, University of Glasgow, Glasgow, G12 8QQ, UK.

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