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General and own-species attentional face biases

Krisztina V. Jakobsen[1] · Cassidy White[1] · Elizabeth A. Simpson[2]

Abstract

Humans demonstrate enhanced processing of human faces compared with animal faces, known as own-species bias. This bias is important for identifying people who may cause harm, as well as for recognizing friends and kin. However, growing evidence also indicates a more general face bias. Faces have high evolutionary importance beyond conspecific interactions, as they aid in detecting predators and prey. Few studies have explored the interaction of these biases together. In three experiments, we explored processing of human and animal faces, compared with each other and to nonface objects, which allowed us to examine both own-species and broader face biases. We used a dot-probe paradigm to examine human adults' covert attentional biases for task-irrelevant human faces, animal faces, and objects. We replicated the own-species attentional bias for human faces relative to animal faces. We also found an attentional bias for animal faces relative to objects, consistent with the proposal that faces broadly receive privileged processing. Our findings suggest that humans may be attracted to a broad class of faces. Further, we found that while participants rapidly attended to human faces across all cue display durations, they attended to animal faces only when they had sufficient time to process them. Our findings reveal that the dot-probe paradigm is sensitive for capturing both own-species and more general face biases, and that each has a different attentional signature, possibly reflecting their unique but overlapping evolutionary importance.

Keywords Dot-probe paradigm · Visual attention · General face template · Face perception

Faces are socially and biologically relevant, with clear evolutionary importance (e.g., Öhman, 1993; Stoyanova, Pratt, & Anderson, 2007). Face perception—the ability to readily detect and interpret facial information—is one of humans' most advanced visual skills, developmentally foundational for social learning and interpersonal skills (Mondloch et al., 2013; Theeuwes & Van der Stigchel, 2006). Not surprisingly, human faces rapidly capture and hold attention even within complex and dynamic environments (Crouzet, Kirchner, & Thorpe, 2010; Fletcher-Watson, Findlay, Leekam, & Benson, 2008; Hershler, Golan, Bentin, & Hochstein, 2010; Hershler & Hochstein, 2005; Simpson, Husband, Yee, Fullerton, & Jakobsen, 2014b). Efficient human face detection occurs even when faces are task irrelevant, suggesting such processing may be automatic (Cerf, Harel, Einhäuser, & Koch, 2008; Langton, Law, Burton, & Schweinberger, 2008; Simpson, Husband, et al., 2014b). For example, when participants were asked to search for a target object (e.g., car or butterfly) among an array of objects, the presence of a task-irrelevant face slowed their reaction time to find the target objects (Simpson, Husband, et al., 2014b). An enhanced processing of conspecific (own-species) faces relative to heterospecific (other animal) faces—own-species bias (Scott & Fava, 2013)—appears to be shaped by an experience-driven developmental process in human and other primate infants (Jakobsen, Umstead, & Simpson, 2016; Scherf & Scott, 2012; Simpson et al., 2017), revealing early ontogenetic and phylogenetic roots. Together, these studies suggest that humans process human faces in a special way, perhaps qualitatively or quantitatively differently from faces of other animals.

However, there is also growing evidence for a more general face bias—a greater sensitivity to process faces or face-like stimuli relative to inanimate stimuli. According to this proposal, it may be evolutionarily beneficial for humans to preferentially attend to faces—including both humans and animals—relative to inanimate objects in their environments, given that ancestral humans had to be vigilant to both predators and other dangerous species (e.g., snakes, spiders, other humans) as well

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as attentive to prey and domestic animals (Calvillo & Hawkins, 2016; New, Cosmides, & Tooby, 2007). Consistent with this proposal, human adults quickly detect animals (including the face and whole body) in complex natural image scenes (Crouzet, Joubert, Thorpe, & Fabre-Thorpe, 2012; Guyonneau, Kirchner, & Thorpe, 2006; Kirchner & Thorpe, 2006; Thorpe, Gegenfurtner, Fabre-Thorpe, & Bulthoff, 2001), even when the animals are presented outside of conscious awareness (Zhu, Drewes, Peatfield, & Melcher, 2016). Of note is that the visibility of a head significantly increases the speed with which participants detect animals (Drewes, Trommershäuser, & Gegenfurtner, 2011). Animal heads contain faces, and face-like configurations appear to broadly attract attention (Itier, Van Roon, & Alain, 2011; Maurer, Le grand, & Mondloch, 2002).

In the present study, we explored these two well-documented biases: the own-species bias and a general face bias. We hypothesize that human faces may not be alone in receiving privileged processing relative to nonfaces; animal faces may also receive special attention compared with nonface stimuli. To our knowledge, attentional biases to animal faces compared with nonfaces objects have not previously been studied. Yet these are critical comparisons for disentangling broad biases for faces generally from biases reserved exclusively for human faces.

We used a dot-probe paradigm (MacLeod, Mathews, & Tata, 1986) to examine orienting to human faces, animal faces, and objects. In this paradigm, participants are instructed to focus on a central fixation, then two photos (cues) are simultaneously flashed briefly (e.g., 100–1,000 ms) to the left and right of the central fixation. After the cues disappear, a target probe (e.g., gray box) immediately appears in the location of one of the cues and remains on-screen. Participants press a key to indicate the target probe's location (left/right), as quickly and accurately as possible. Reaction times to the target probe indicate attention to a previously attended cue (Bindemann, Burton, Langton, Schweinberger, & Doherty, 2007). This paradigm allowed us to measure covert attentional biases to faces that occur in the absence of overt eye movements (Posner & Petersen, 1990). These attentional biases may not have been captured in previous eye-tracking studies comparing human and animal face detection, which require participants to fixate on target images (e.g., visual search tasks). In contrast, the dot-probe paradigm has uncovered subtle attentional biases for faces with different emotions (Cooper & Langton, 2006; Torrence & Troup, 2018; van Rooijen, Ploeger, & Kret, 2017), particularly for negative emotional faces (Lacreuse, Schatz, Strazzullo, King, & Ready, 2013), and especially among individuals with anxiety (Bradley, Mogg, & Millar, 2000; Mansell, Clark, Ehlers, & Chen, 1999).

We presented participants with cue displays of various duration—100 ms, 500 ms, and 1,000 ms—and examined their orienting to face and object stimuli. Previous studies report rapid attention to and processing of human faces (Bindemann, Burton, Hooge, Jenkins, & de Haan, 2005; Crouzet et al., 2010; Morrisey, Hofrichter, & Rutherford, 2019). We therefore hypothesized that participants would show attentional biases to *socially salient cues*—specifically, human faces when paired with either objects or animal faces—and would show attentional biases to *biologically salient cues*—specifically, animal faces when paired with objects—resulting in faster response times to target probes that appear in the same location as these socially or biologically salient cues.

In the current study, we used the dot-probe paradigm across three experiments to examine participants' covert attentional biases to human faces and nonface objects (Experiment 1), human faces and animal faces (Experiment 2), and animal faces and nonface objects (Experiment 3). To our knowledge, this is the first study to test for a broad face category effect, encompassing both human and animal faces, in the dot-probe paradigm.

Experiment 1

We modeled Experiment 1 after Bindemann et al.'s (2007) Experiment 1a in which participants were shown pairs of images—each pair containing one human face and one nonface object—for 100 ms, 500 ms, and 1,000 ms and indicated the location of a subsequent target probe. This design allowed us to examine orienting to human faces when in competition with objects. Consistent with Bindemann et al.'s (2007) findings, we expected participants to respond to target probes located on the side of the human face more quickly than target probes on the side of the object.

Method

Participants

Twenty-five undergraduate students (21 females) participated for course credit at a large southeastern university. A power analysis conducted in G*Power (Faul, Erdfelder, Buchner, & Lang, 2009; Faul, Erdfelder, Lang, & Buchner, 2007) indicated that $N = 18$ was the minimal desired sample for a one-way repeated-measures analysis of variance (ANOVA), given $\alpha = 0.05$, a power of 0.95, and a medium effect ($f = 0.25$). The average age was 18.44 years ($SD = 0.59$); 18 participants identified as Caucasian, one participant identified as Black, four participants identified as Asian, one participant identified as Hispanic or Latinx, and one participant identified as Caucasian and Black. Participants reported normal or corrected-to-normal vision.

Materials

Stimuli included six photographs of forward-facing human faces with neutral expressions (three females, three males) and six photographs of objects (train, boat, teapot, faucet, dollhouse, clock; same object types as those used in Bindemann et al., 2007), all grayscale (see top and bottom rows in Fig. 1); all images were obtained from Google searches. We used the SHINE Toolbox to match images on luminance (Willenbockel et al., 2010); however, when using naturalistic images, it is impossible to control for *all* low-level features (e.g., spatial frequency, complexity) while still retaining the natural image integrity. To balance these factors, we took an approach from previous studies of face processing (Hershler & Hochstein, 2005; Simpson, Buchin, Werner, Worrell, & Jakobsen, 2014a, 2014b) and reduced the contributions of low-level features by using natural, unmanipulated, heterogenous stimuli, diverse in their lighting, angles, and backgrounds. The human faces were independently rated by a separate group of participants to verify that they had neutral expressions. All faces and objects appeared with different backgrounds and were cropped to measure 4.4 × 4.4 cm (subtending 4.2° × 4.2° sitting at a distance of 60 cm). We used these 12 images to construct 72 cue displays, each containing a human face and an object. Each of the 72 cue displays was shown six times, for a total of 432 trials. Human faces and objects were spaced 5.5 cm (5.2°) apart and appeared on the left and right side of the cue display an equal number of times. The target probe consisted of a gray square sized 1.2 × 1.2 cm (1.1° × 1.1°), presented in the center of where one of the cues previously appeared, 2.75 cm (2.6°) to the left or right of the central fixation.

Procedure

Participants were asked to keep their eyes on the fixation cross in the center of the screen throughout the test session. Trials began with a central fixation cross for 750 ms followed by a cue display (a pair of images: one human and one object) for 100 ms, 500 ms, or 1,000 ms in a semirandomized order (see Fig. 2a). When the cue display disappeared, the target probe appeared in the center of one of the cue locations. Participants were instructed to indicate with a key-press response whether the target appeared on the left or the right side, by pressing the corresponding key with their index finger as quickly and accurately as possible. The target remained on the screen until the participant's key-press response. After the response, the central fixation cross appeared again for 750 ms, starting the next trial. Cues were equally predictive of the target location (i.e., the target probe was equally likely to occur on the human face and object sides). Each participant received 24 practice trials, which included pairs of nonface objects, and 432 experimental trials, presented in six blocks of 72 trials, with short breaks between each block. In total, the task took approximately 30 minutes.

Data analysis

We collapsed the data across cue locations (left, right) and analyzed the means for each cue type (human face, object) and each cue display duration (100, 500, 1,000 ms). We only included trials in which the participant responded correctly to the target probe (1.9% of trials were incorrect and therefore excluded). We also excluded trials in which participants' reaction times (RTs) were less than 200 ms—indicating an anticipatory response—and trials in which participants' average RTs for that condition were greater than 2.5 standard deviations (*SD*) above the mean for that condition—indicating the participant was off-task (e.g., Salemink, van den Hout, &

Fig. 1 Stimuli used in Experiments 1–3. *Note.* Human faces and objects were used in Experiment 1; human faces and animal faces were used in Experiment 2; and animal faces and objects were used in Experiment 3

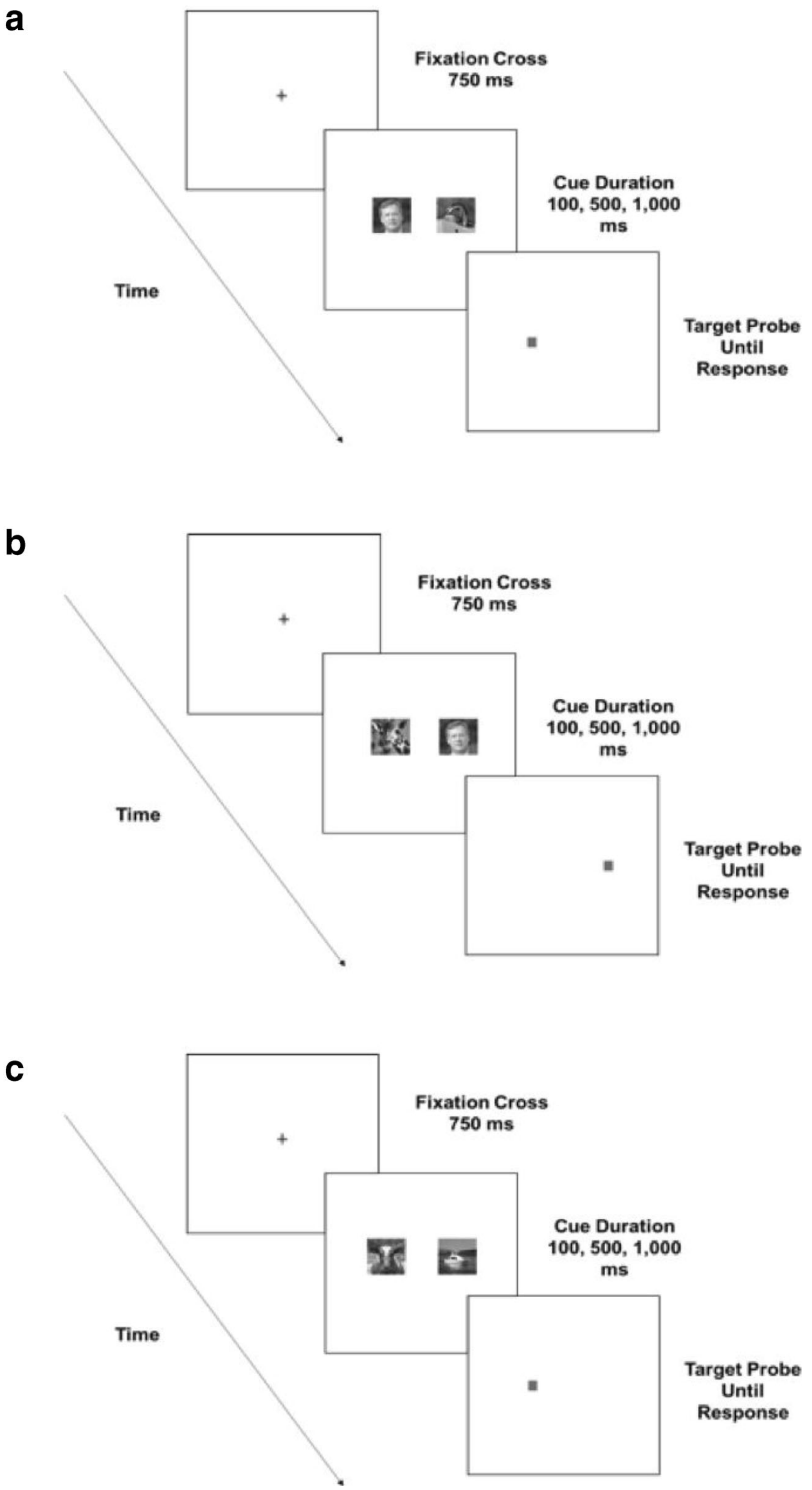

Fig. 2 Procedures. *Note*. This figure presents the procedures used in Experiments 1–3. A central fixation cross was presented for 750 ms, followed by a cue display that had either pairs of human faces and objects (Experiment 1; **a**), human faces and animal faces (Experiment 2; **b**), or animal faces and objects (Experiment 3; **c**). Cue displays were presented for 100 ms, 500 ms, or 1,000 ms. Following the cue display, a target probe was presented on either the left or right, in the location of one of the cues, until the participant responded

Kindt, 2007). This resulted in the exclusion of <.001% of trials that were less than 200 ms and 2.6% of trials that were more than 2.5 *SD* above the mean. We carried out repeated-measures ANOVAs and used Bonferroni corrections for follow-up *t* tests.

Results

We ran a 2 (cue type: human face, object) × 3 (cue display time: 100, 500, 1,000 ms) ANOVA. There was a main effect of cue type, $F(1, 24) = 35.00$, $p < .001$, $\eta_p^2 = .59$ (see Fig. 3), with participants responding faster to target probes on the side of human faces ($M = 425$ ms, $SD = 41$) than those on the side of objects ($M = 434$ ms, $SD = 45$). There was also a main effect of cue display time, $F(2, 48) = 76.29$, $p < .001$, $\eta_p^2 = .76$, with participants responding fastest to target probes in the 1,000-ms cue display ($M = 414$ ms, $SD = 49$), followed by the 500-ms cue display ($M = 425$ ms, $SD = 44$), followed by the 100-ms ($M = 452$ ms, $SD = 39$); all of the cue display times were significantly different from each other, $t(24) > 4.61$, $ps < .001$, $ds > 0.92$.

These main effects were qualified by a Cue Type × Cue Display Time interaction, $F(2, 48) = 6.67$, $p = .003$, $\eta_p^2 = .22$. To explore the interaction, we first examined cue type at each of the cue display times. At the 100-ms stimulus presentation duration, participants were faster to respond to target probes on the side of human faces ($M = 446$ ms, $SD = 46$) than those on the side of objects ($M = 457$ ms, $SD = 52$), $t(24) = 3.72$, $p = .001$, $d = 0.74$. At the 1,000-ms stimulus presentation duration, participants were also faster to respond to target probes on the side of human faces ($M = 407$ ms, $SD = 37$) than those on the side of objects ($M = 420$ ms, $SD = 42$), $t(24) = 5.49$, $p < .001$, $d = 1.09$. However, at the intermediate 500-ms stimulus presentation duration, there was no statistically significant difference in RT to target probes between human faces ($M = 424$ ms, $SD = 44$) and objects ($M = 426$ ms, $SD = 43$), $t(24) = .81$, $p = .43$, $d = .16$, signifying that there may be something special about this cue display duration.

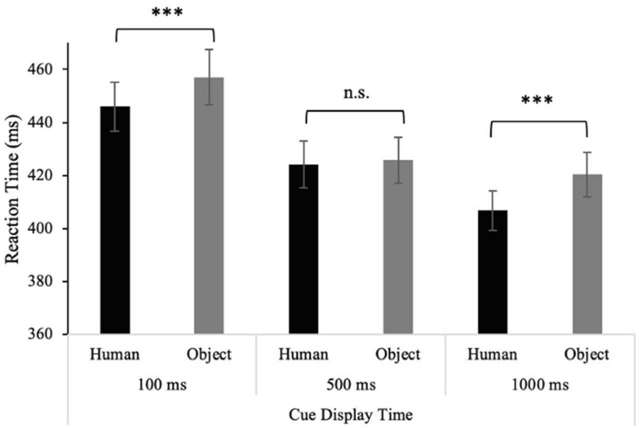

Fig. 3 Reaction times to detect target probes in the location of human faces and objects (Experiment 1). *Note.* Participants responded more quickly to target probes appearing in the location of human faces (black bars) compared with targets probes appearing in the location of objects (gray bars) in the 100-ms and 10,00-ms cue display durations (left and right), but not the 500-ms cue display duration (middle). Participants were fastest to respond to targets probes in the 1,000-ms cue display duration, followed by the 500-ms cue display duration, and slowest in the 100-ms cue display duration. Error bars reflect standard error of the mean. ****ps* ≤ .001

Next, we followed up the Cue Type × Cue Display Time interaction by examining participants' responses to target probes on the side of human faces at each of the cue display times, and by examining participants' responses to target probes on the side of the objects at each of the cue display times. Paired-samples *t* tests revealed that longer cue display times were associated with faster response times for both human faces and objects ($ps < .001$, $ds > 1.14$), except for target probes in the location of the object, whereas there was no statistically significant difference in response speed at the 1,000-ms and the 500-ms presentation durations, $p = .09$, $d = 0.34$.

Discussion

Our results are consistent with previous studies that report that participants are faster to attend target probes on the side of previously presented human face cues compared with target probes on the side of previously presented object cues (Bindemann et al., 2007; Ro, Russell, & Lavie, 2001). Interestingly, this was the case for only the 100-ms and 1,000-ms cue displays. We did not find an attentional bias at the 500-ms cue displays, which is also consistent with previous studies, particularly for individuals with no or low-level anxiety (Chen, Ehlers, Clark, & Mansell, 2002; Cooper & Langton, 2006; Koster, Verschuere, Crombez, & Van Damme, 2005; Lubman, Peters, Mogg, Bradley & Deakin, 2000; Mansell et al., 1999) and suggests that there are different attentional patterns across cue display durations (Cooper & Langton, 2006).

The results of Experiment 1 are in line with the larger literature demonstrating that human faces receive biased attentional processing compared with objects in various paradigms (Cerf et al., 2008; Crouzet et al., 2010; Hershler et al., 2010; Hershler & Hochstein, 2005; Langton et al., 2008; Simpson, Buchin, et al., 2014a; Theeuwes & Van der Stigchel, 2006), congruent with the proposal that there is a general face bias (Itier et al., 2011; Morton & Johnson, 1991; Palmer & Clifford, 2020; Reid et al., 2017; Shibata et al., 2002). Consistent with previous literature, participants were fastest to respond to the longest cue displays and slowest to respond to the shortest cue displays (e.g., Bindemann et al., 2007), which may be because participants had enough time to disengage their attention from the stimulus at the long cue displays, but not the short cue displays (Seya & Mori, 2012). Interestingly, these main effects were qualified by an interaction effect in which the different cue display durations appeared to differently impact response speed as a function of whether the target was on the side with the human face or object. The intermediate cue display duration, in particular, revealed no difference in response speeds between human face and object cues. One possible interpretation is that participants were covertly shifting their attention back and forth between the human and object cues, with their first covert shift of attention likely to the human face, thereby showing the human-face-advantage at the shortest cue duration. At the intermediate cue time, participants had the opportunity to covertly shift their attention back and forth a few times, resulting in some participants focusing their attention at that time at the human face, while others focused on the object, leading to (on average) no effect. At the longest cue time, participants' covert attention may have either shifted back to the human face, or their initial attention may have been held longer by the human faces than the objects, revealing, again, a human face advantage (e.g., Bindemann et al., 2005).

Experiment 2

Experiment 1 revealed an attentional bias to human faces compared with objects. This human face advantage is not surprising, given that human faces are important socially and biologically (e.g., Stoyanova et al., 2007). In Experiment 2, we paired human faces with animal faces to determine whether they elicit attention differently when pitted directly against each other. To our knowledge, human and animal faces have not been presented together as pairs to examine attentional biases in the dot-probe paradigm (for a review, see van Rooijen et al., 2017). While previous studies have demonstrated an own-species bias from early in infancy using measures of preference (e.g., longer looking to human compared with animal faces: Di Giorgio, Leo, Pascalis, & Simion, 2012; Heron-Delaney, Wirth, & Pascalis, 2011), discrimination (e.g., superior face recognition for human compared with animal faces; Dufour, Pascalis, & Petit, 2006; Pascalis, de Haan, & Nelson, 2002; Simpson, Varga, Frick, & Fragaszy, 2011), and detection (e.g., faster and more likely to look at human compared with animal faces in a visual search task; Hershler & Hochstein, 2005; Jakobsen et al., 2016; Simpson, Maylott, Mitsven, Zeng, & Jakobsen, 2019b), studies have not directly examined how human and animal faces cue attention. Based on previous reports of an own-species bias, we hypothesized that we would likewise detect attentional biases for human faces compared with animal faces.

Method

Participants

Twenty-five undergraduate students (16 females), who did not participate in Experiment 1, participated for course credit. The average age was 18.72 years (*SD* = 0.74); 20 participants identified as Caucasian, one participant identified as Black, two participants identified as Hispanic/Latinx and Caucasian, and one participant identified as Asian and Caucasian. Participants reported normal or corrected-to-normal vision.

Materials

We used the human faces from Experiment 1 and grayscale photographs of six neutral, forward-facing animal faces—sheep, giraffe, otter, chimpanzee, cow, chipmunk (see the second row in Fig. 1). We chose these species because we wanted a variety of nonthreatening mammals (not predators), which were not typically pets (and therefore, are not too familiar), and yet were recognizable species. Animal photos were enlarged and cropped around the faces, cutting out the rest of the body. These animal face images were independently rated by a separate group of participants to confirm they were neutral (nonthreatening) in their expressions.

Procedure

The procedure in Experiment 2 was the same as that in Experiment 1, except participants were presented with human and animal face cue pairs.

Data analysis

We analyzed the data in the same way as in Experiment 1. As in Experiment 1, we excluded trials with incorrect responses (1.3%), and responses that were too fast (<200 ms; <.001%) or too slow (>2.5 *SD* above the mean; <0.3%).

Results

We analyzed RTs with a 2 (cue type: human face, animal face) × 3 (cue display time: 100, 500, 1,000 ms) repeated-measures ANOVA. There was a main effect of cue type, $F(1, 24) = 11.02$, $p = .003$, $\eta_p^2 = .32$ (top graph in Fig. 4), with faster RT to target probes on the side of human faces ($M = 418$ ms, $SD = 36$) than those on the side of animal faces ($M = 422$ ms, $SD = 37$). There was also a main effect of Cue display time, $F(2, 48) = 88.23$, $p < .001$, $\eta_p^2 = .78$, with the fastest RT to target probes preceded by a 1,000-ms cue display ($M = 400$ ms, SD=40), followed by slower RTs to the 500-ms cue display ($M = 421$ ms, $SD = 38$), and the slowest RTs to the 100-ms cue display ($M = 432$ ms, $SD = 41$); all of the cue display times were significantly different from each other, $t(24) > 6.22$, $ps < .001$, $ds > 1.24$ (see bottom graph in Fig. 4). We detected no statistically significant Cue Type × Cue Display Time interaction, $F(2, 48) = 2.30$, $p = .111$.

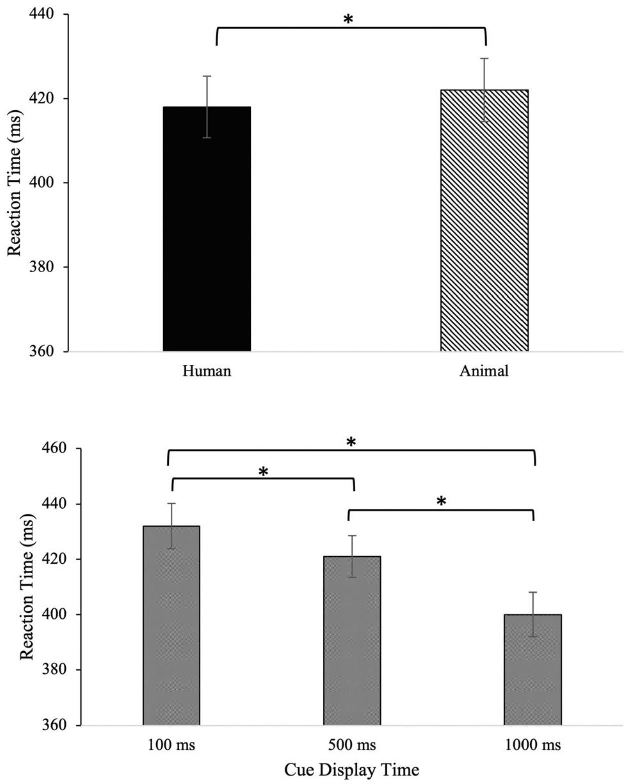

Fig. 4 Reaction times to detect target probes in the location of human faces and animals. *Note.* Top panel: Participants responded more quickly to target probes appearing in the location of human faces (black bars) compared with target probes appearing in the location of animal faces (striped bars). Bottom panel: Participants were fastest to respond to targets probes in the 1,000-ms cue display duration, followed by the 500-ms cue display duration, and slowest in the 100-ms cue display duration. Error bars reflect standard error of the mean. **p* = .003

Discussion

These results support the hypothesis that there is an own-species attentional bias (Hershler & Hochstein, 2005; Jakobsen et al., 2016), and show, for the first time, that it can be detected with the dot-probe paradigm. Our findings suggest that covert orienting—which enables the selection of visual information without eye movements and which accelerates visual information processing (Carrasco & McElree, 2001)—may play a role in the enhanced processing of conspecific relative to heterospecific faces. In fact, we found an own-species bias in task-irrelevant covert attention, consistent with findings in visual search tasks (Simpson, Buchin, et al., 2014a; Simpson, Husband, et al., 2014b). Together, our findings in Experiments 1 and 2 demonstrate a robust human face advantage in attentional processing.

Experiment 3

In addition to the purported own-species face bias, might humans also have a broad face processing bias, which enables rapid detection and processing of faces, in general? While much of the face processing literature focuses on the ways in which people process human faces, few studies have examined whether other animal faces receive similar specialized processing. Such studies are important for revealing the extent to which other types of stimuli—besides human faces—may receive privileged attention. In dot-probe studies, emotionally relevant images receive heightened attention relative to other images. For example, people addicted to opiates are faster to respond to target probes in the location of drug-related compared with neutral pictures (Lubman et al., 2000). Similarly, adults who drink heavily show greater attentional biases for alcohol-related compared with neutral stimuli (Miller & Fillmore, 2010). In addition, people who smoke nicotine demonstrate greater attentional biases for cigarettes compared with neutral stimuli, relative to nonsmokers (Ehrman et al., 2002). Together, these findings suggest that attentional biases may extend to other categories of emotional relevance beyond faces.

Given their evolutionary importance, we hypothesize that animal faces may likewise receive prioritized attention. Directly comparing animal faces and nonfaces in the dot-probe task will help us to understand faces as a broader category that may receive privileged attention (Itier et al., 2011; Morton & Johnson, 1991; Shibata et al., 2002). As we saw in Experiment 1, there is an attentional bias to human faces when paired with neutral objects, a finding that is not surprising given the biological and social importance of human faces. It remains untested, however, whether animal faces—which are, arguably, also of high biological importance (Leopold & Rhodes, 2010)—may also receive greater attention compared with nonface objects, similar to human faces.

In Experiment 3, we, therefore, examined whether animal faces receive specialized processing compared with objects. Although limited, there is some evidence that animal faces are processed similarly to human faces (e.g., categorization using a go/no-go task; Rousselet, Macé, & Fabre-Thorpe, 2004). We therefore predicted that there would be attentional biases for animal faces relative to objects. Further, given that animal faces may be processed more slowly than human faces (e.g., Carmel & Bentin, 2002), we predicted that we would not see as much of an attentional bias at shorter cue durations.

Method

Participants

Twenty-five undergraduate students (18 females), who did not participate in either Experiments 1 or 2, participated for course credit. The average age was 18.64 years (*SD* = 0.86); 18 participants identified as Caucasian, one participant identified as Black and Caucasian, one participant identified as Hispanic/Latinx and Caucasian, one participant identified as Pacific Islander and Asian, one participant identified as Pacific

Islander and Caucasian, one participant identified as Alaska Native/American Indian and Caucasian, one participant identified as Black and Asian, and one participant did not disclose their race/ethnicity. Participants reported normal to corrected-to-normal vision.

Materials

We used the object photos from Experiment 1 and the animal face photos from Experiment 2 to present animal–object face cue pairings.

Procedure

The procedure was the same as that in Experiments 1 and 2, except participants observed animal faces and objects paired together.

Data analysis

We analyzed the data in the same way as in Experiments 1 and 2. As in Experiments 1 and 2, we excluded trials with incorrect responses (1.3%), and responses that were too fast (<200 ms; <.001%) or too slow (>2.5 *SD* above the mean; <3.2%).

Results

We ran a 2 (cue type: animal face, object) × 3 (cue display time: 100, 500, 1,000 ms) repeated-measures ANOVA. We detected no statistically significant main effect of cue type, $F(1, 24) = .39$, $p = .539$ (see Fig. 5). There was a main effect of cue display time, $F(2, 48) = 28.39$, $p < .001$, $\eta_p^2 = .52$, with participants responding fastest to target probes at the 1,000-ms cue display ($M = 401$ ms, $SD = 40$), followed by the 500-ms cue display ($M = 415$ ms, $SD = 40$), followed by the 100-ms cue display ($M = 430$ ms, $SD = 51$); all of the cue display times were significantly different from each other, $t(24) > 3.85$, $ps \leq .001$, $ds > 0.77$.

This main effect was qualified by a Cue Type × Cue Display Time interaction, $F(2, 48) = 4.63$, $p = .014$, $\eta_p^2 = .16$. To explore this interaction, we first examined cue type at each of the cue display times, but this revealed only an effect at the longest cue display time: RT were faster to targets presented on the animal side ($M = 398$ ms, $SD = 42$) compared with the object side ($M = 404$ ms, $SD = 38$) only in the 1,000-ms cue display time, $t(24) = 3.08$, $p = .005$, $d = .62$. There were no differences for the 500-ms cue display (target probes on the animal side, $M = 416$ ms, $SD = 42$; target probes on the object side, $M = 414$ ms, $SD = 40$), $t(24) = 1.10$, $p = .281$, or the 100-ms cue display (target probes on the animal side, $M = 431$ ms, $SD = 54$; target probes on the object side, $M = 429$ ms, $SD = 48$), $t(24) = .43$, $p = .671$.

Next, we followed up the Cue Type × Cue Display Time interaction by examining participants' responses to target probes on the side of animal faces at each of the cue display times, and by examining participants' responses to target probes on the side of the objects at each of the cue display times. Paired-samples *t* tests revealed that longer cue display times were associated with faster response times for both animal faces and objects ($ps \leq .005$, $ds \geq .61$).

Discussion

Our results provide support for the proposal that there is a general face bias, beyond just an own-species face bias. We found that participants attend more quickly to target probes on the side of the animal faces compared with those on the side of the objects. These results are in line with previous studies that largely focused on the attention capture of entire animal bodies—including faces, although typically smaller and oriented to be facing away from the camera—in complex naturalistic images. For example, participants quickly detect animals in complex natural image scenes (Crouzet et al., 2012; Guyonneau et al., 2006; Kirchner & Thorpe, 2006; Thorpe et al., 2001), particularly when the head is visible (Drewes et al., 2011). Our findings are also consistent with the proposal that there is a general and broad category for "face-ness" (Itier et al., 2011; Morton & Johnson, 1991; Shibata et al., 2002). Interestingly, this animal face bias effect was driven by the longest cue display, suggesting that participants needed sufficient time to process the animal faces, unlike the more rapid (100-ms cue display) attentional bias we found for human faces in Experiment 1. These behavioral findings that animal faces may be processed more slowly than human faces are consistent with reports of slower brain activation for animal faces compared with human faces (Carmel & Bentin, 2002). Our results provide additional evidence that although animal faces receive some privileged processing compared with objects, animal faces may not receive the same degree of attentional bias as human faces.

General discussion

Our findings reveal that the dot-probe paradigm is sensitive for capturing both own-species and more general face biases. Our results suggest the presence of a general face template, which may be driven by features of the face, including the eyes and mouth (Itier et al., 2011; Omer, Sapir, Hatuka, & Yovel, 2019; Shibata et al., 2002) and first-order relations, which include the configuration of faces (e.g., eyes above the nose and the nose above the mouth; Maurer et al., 2002; Paukner, Bower, Simpson, & Suomi, 2013). Additional support for a general face template comes from studies of newborn infants who prefer top-heavy face-like stimuli with little

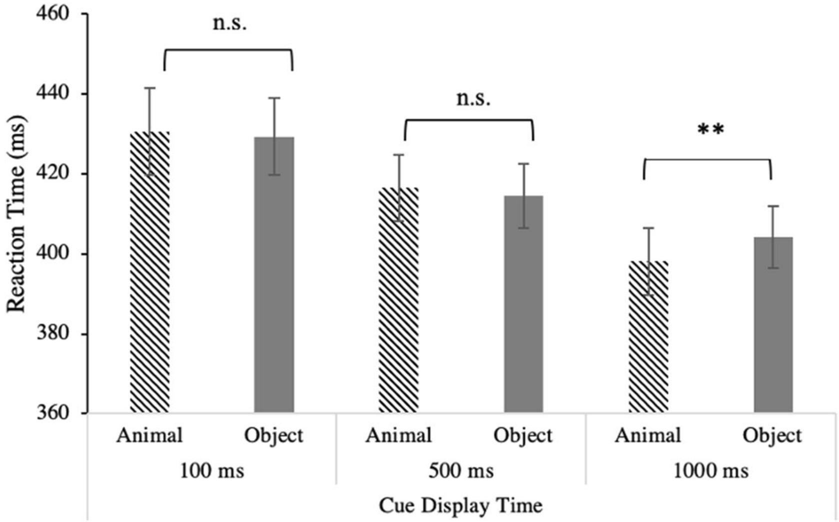

Fig. 5 Reaction times to detect target probes in the location of animal faces and objects (Experiment 3). *Note.* Participants responded more quickly to target probes appearing in the location of animal faces (striped bars) compared with target probes appearing in the location of objects (gray bars) in the 1,000-ms cue display duration (right; $**p = .005$), but not the 100-ms (left) and 500-ms (middle) cue display durations, $ps > .10$. Participants were fastest to respond to targets probes in the 1,000-ms cue display duration, followed by the 500-ms cue display duration, and slowest in the 100-ms cue display duration, $ps < .001$. Error bars reflect standard error of the mean

or no experience with faces (Goren, Sarty, & Wu, 1975; Morton & Johnson, 1991; Reid et al., 2017). Recent studies show that even nonface objects—when perceived to have face-like characteristics (i.e., pareidolic objects that look like faces, such as a cloud or rock that appear to have facial features)—can convey information similar to faces, providing further evidence for a general face template. For example, adults who perceive faces in objects are likely to follow the eye gaze of pareidolic objects (Takahashi & Watanabe, 2013) and show activation in the right fusiform face area, similar to when they view human faces (Liu et al., 2014).

Limitations and future directions

The current study does not resolve the debate about what information dot-probe tasks provide about attentional mechanisms (Bantin, Stevens, Gerlach, & Hermann, 2016; Cooper & Langton, 2006). Rather, the present study provides evidence for an own-species face bias and a more general face bias, whatever the attentional mechanisms may be (Cooper & Langton, 2006). Future studies are needed to examine whether human and animal faces elicit differences in attention capture and/or attention holding (Al-Janabi, MacLeod, & Rhodes, 2012; Salemink et al., 2007), as well as whether orienting to faces in the dot-probe paradigm is the result of exogenous—automatic, stimulus-driven—or endogenous—voluntary, goal-driven—orienting (Posner, 1980). These mechanisms could be explored by using event-related potentials to measure the timing and location of cortical activity (Torrence & Troup, 2018) or by using tasks that require overt eye movements along with eye tracking to track gaze fixations (Petrova, Wentura, & Bermeitinger, 2013). Such studies could provide more information about when and where participants allocate their attention prior to and during the presentation of the target probes.

Another limitation of our study is that some low-level features of our stimuli may have influenced participants' attention. While some of these features were controlled (e.g., luminance, color, valence), others (e.g., spatial frequency) may have unintentionally varied across our stimulus categories. While we think such factors, alone, are unlikely to account for the face biases we observed, we think these are important considerations for future research. For example, future studies may consider controlling for or experimentally manipulating visual complexity (Székely & Bates, 2000) or orientation (Simpson, Maylott, Leonard, Lazo, & Jakobsen, 2019a) of faces and objects. Given that inversion selectively disrupts some aspects of face, but not object processing, upside-down stimuli are an excellent control condition (Farah, Tanaka, & Drain, 1995; Pallett & MacLeod, 2011), for future studies in the dot-probe paradigm.

Additionally, we recognize that our results were based on primarily White, Educated, Industrialized, Rich, and Democratic (WEIRD) samples, using White faces and primarily White participants, which have limited generalizability to humans more broadly (Henrich, Heine, & Norenzayan, 2010). For example, individuals demonstrate superior discrimination and recognition for individuals with whom they have regular contact and experience, often referred to as the own-race bias (Chiroro, Tredoux, Radaelli, & Meissner, 2008; Meissner & Brigham, 2001; Wright, Boyd, & Tredoux, 2003). Further studies should test whether our findings are generalizable with more diverse samples and stimuli, across other ethnicities and cultures.

The extent to which attentional biases exist for stimuli varying in their "faceness" is another area of interest. While there is growing evidence for a greater sensitivity to process animate relative to inanimate stimuli—for example, biological relative to nonbiological motion (Mather & West, 1993; Simion, Regolin, & Bulf, 2008), and animate relative to inanimate words (Bugaiska et al., 2019; Leding, 2019)—to our knowledge, the animate monitoring hypothesis has yet to be tested in the dot-probe paradigm. For example, it may be interesting to examine participants' attentional biases to pareidolic objects (i.e., objects that look like faces) in dot-probe tasks, to test whether attention to these objects are similar to real faces. Even infants recognize robots as interactive partners by 17 months of age, although they are more likely to ascribe agency to, and follow gaze behaviors of, human partners than robot partners (Manzi et al., 2020). Examining morphed faces (Campbell, Pascalis, Coleman, Wallace, & Benson, 1997), which gradually morph from an object into a real human or animal face, or robots with face-like features (Manzi et al., 2020), in dot-probe tasks will provide a better understanding about the line between human and animal face processing and the line between animate and inanimate processing.

Conclusions

There appear to be covert attentional biases for both human and animal faces when presented in competition with objects. There also appears to be a robust own-species bias in which human faces received privileged attention relative to animal faces. The dot-probe paradigm is a promising tool to measure own-species and broad face biases, each revealing unique but overlapping attentional signatures, shaped over the course of human evolution.

The data and materials are available from the corresponding author on reasonable request; this study was not preregistered.

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