

Visual Attention Is Not Attuned to Non-Human Animal Targets' Pathogenicity: An Evolutionary Mismatch Perspective

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Abstract

A considerable amount of research has revealed that there exists an evolutionary mismatch between ancestral environments and conditions following the rise of agriculture regarding the contact between humans and animal reservoirs of infectious diseases. Based on this evolutionary mismatch framework, we examined whether visual attention exhibits adaptive attunement toward animal targets' pathogenicity. Consistent with our predictions, faces bearing heuristic infection cues held attention to a greater extent than did animal vectors of zoonotic infectious diseases. Moreover, the results indicated that attention showed a specialized vigilance toward processing facial cues connoting the presence of infectious diseases, whereas it was allocated comparably between animal disease vectors and disease-irrelevant animals. On the other hand, the pathogen salience manipulation employed to amplify the participants' contextual-level anti-pathogen motives did not moderate the selective allocation of attentional resources. The fact that visual attention seems poorly equipped to detect and encode animals' zoonotic transmission risk supports the idea that our evolved disease avoidance mechanisms might have limited effectiveness in combating global outbreaks originating from zoonotic emerging infectious diseases.

Introduction

On March 11, 2020, the World Health Organization (WHO) declared the novel coronavirus (SARS-CoV-2) outbreak a global pandemic. As of yet, approximately 7 million deaths worldwide have been reported to the WHO (WHO, n.d.). Leaving aside the catastrophic social, economic, and public health consequences, it is indispensable to take cognizance of the pandemic starting point where the initial infections burst out: Huanan Seafood Wholesale Market in Wuhan, China (Guo et al., 2020; Lu et al., 2020). Moreover, it has been estimated that approximately three-quarters of all major human infectious diseases have zoonotic roots, namely they are caused by pathogens originating from wild and domestic animals (Dharmarajan et al., 2022; Jones et al., 2008).

Considering these, the interface between humans and animals seems to constitute a prominent risk factor for emerging infectious diseases and global outbreaks (Pike et al., 2010). From this viewpoint, integrating an evolutionary psychological perspective into global health and epidemiological studies is crucial to elucidate the ultimate causes of why contact with animal infectious disease vectors has led to such devastating outcomes in recent human evolutionary history and what role the evolved mind has played herein. Accordingly, at first, a specific set of psychological mechanisms motivating defenses against the threat of infectious diseases will be introduced. Then, the evolutionary mismatch hypothesis will be propounded as an ultimate explanation for why these psychological mechanisms seem insensitive to the pathogenicity of animal disease vectors.

The Behavioral Immune System and the Evolutionary Mismatch Hypothesis

As with many other animals, disease-causing pathogenic agents (e.g., viruses, helminths, and bacteria) have constituted prominent selection pressures on reproductive fitness throughout the

evolutionary history of humans. Indeed, infectious diseases are estimated to have a greater impact on human mortality than all other causes put together (Gurven et al., 2007). Thus, evolutionary psychologists theorized a proactive motivational system comprised of a repertoire of psychological mechanisms, collectively known as the behavioral immune system, that detect cues connoting the existence of pathogens in the immediate environment, activate emotional and cognitive anti-pathogen responses, and enable behavioral prophylaxis of pathogen infection (Schaller, 2016; Schaller & Park, 2011). Relatedly, the extant literature has linked the behavioral immune system with a wide range of psychological phenomena, including disgust, selective attention, prejudice, and sexual behaviors (Ackerman et al., 2018; Murray & Schaller, 2016).

On the other hand, the behavioral immune system appears to have various shortcomings and may offer rather restricted protection against particular disease threats (Schaller et al., 2022). One of the most notable among these shortcomings is the fact that a great majority of infectious diseases that human populations have now suffered from emerged following the rise of the agricultural revolution (Wolfe et al., 2007). At this point, the evolutionary mismatch hypothesis (Li et al., 2018) offers a viable theoretical framework to illuminate why our evolved disease avoidance psychology has limited effectiveness in combating those diseases. The term “evolutionary mismatch” refers to the adaptive lag that arises when a given mechanism’s environment changes more quickly than it takes for the mechanism to adapt to that change (Tooby & Cosmides, 1990). Accordingly, disease avoidance mechanisms can continue to function effectively to the extent that modern ecologies resemble ancestral conditions (Ackerman et al., 2021). However, numerous characteristics of modern environments regarding the spread of infectious diseases are profoundly different from the recurrent ancestral conditions that formed the evolution of the behavioral immune system (Schaller et al., 2022).

One of the most dramatic of these differences is the frequency of contact with animal reservoirs of infectious diseases. Following the development of agriculture (i.e., approximately 11,000 years ago), humans have begun to live side by side with herd animals, butcher and eat their flesh, care for their young and sick, and share their shelter (Crawford, 2007, p. 60). Unsurprisingly, the likelihood of zoonotic disease transmission substantially rises as these practices and many more (e.g., trading of animal foods, wet markets, bushmeat consumption, and domestication of exotic pets) increase (Pike et al., 2010). In sharp contrast, before the adoption of farming, zoonotic transmission was characterized by incidental infections from hunting or other small numbers of animal encounters rather than prolonged close contact with animals (Wolfe et al., 2007). In light of this information, it is quite evident that there exists an evolutionary mismatch between ancestral and post-agricultural conditions concerning human-animal contact. Therefore, anti-pathogen defense mechanisms designed in response to preindustrial, hunter-gatherer selection pressures might be ill-prepared to detect the pathogenicity of animal disease vectors and combat the threat of zoonotic disease transmission (Ackerman et al., 2021).

The Behavioral Immune System and Attentional Mechanisms

The initial stages of successful threat management involve detecting and encoding threats in one's immediate environment (Neuberg et al., 2011). Thus, the selective allocation of attentional resources (i.e., attentional bias) to evolutionarily threatening stimuli over neutral stimuli has a significant survival value for organisms since perception is finite in its representational capacity (Tooby & Cosmides, 1990). In this direction, one line of research has reported that visual attention is adaptively tuned to enable automatic and rapid encoding of disgust-eliciting stimuli (e.g., body products, rotten foods) connoting the presence of pathogens (e.g., Ciesielski et al., 2010; Fančovičová et al., 2022; van Hooff et al., 2013). For instance, Perone et al. (2021) showed that disgust-eliciting visual stimuli elicited a greater attentional blink than both neutral stimuli and fear-eliciting stimuli at certain lags. Furthermore, Ackerman et al. (2009) indicated that, as compared to normal faces, participants took longer to disengage visual attention from disfigured faces (i.e., heuristic cues to the presence of disease). The findings of this study also revealed that this attentional bias was even more pronounced when the threat posed by pathogens was contextually salient. In other studies, however, neither the experimental manipulations to make the pathogen threat contextually salient nor the individual differences measures of trait pathogen avoidance moderated attentional bias toward disgust-eliciting stimuli (e.g., Perone et al., 2021; van Hooff et al., 2014; Vogt et al., 2011). Hence, the pattern of findings continues to be controversial, even though it is plausible to expect that contextually heightened anti-pathogen motives would produce an attentional bias toward pathogen-related stimuli.

The Current Study

Taken together, the current study was designed to elucidate whether selective attention is adaptively tuned to facilitate automatic and rapid encoding of animal targets' pathogenicity. Moreover, if there exists an attentional bias toward animal disease vectors, it was aimed to clarify the extent of this sensitivity compared to that for human targets signaling the presence of pathogens (i.e., disfigured faces). Thus, to the best of our knowledge, this is the first study investigating the effects of both human and non-human animal targets' on disease avoidance psychology. Although several studies (e.g., Prokop & Fančovičová, 2010; Prokop et al., 2010a; Prokop et al., 2010b) have found some associations between the ratings of disgust, fear, and danger with disease-relevant animals (e.g., macroparasites), they only rely on self-reported measurements. Therefore, these studies appear to lack experimental methodology, which precludes the possibility of making causal inferences about the effects of pathogen-related stimuli. For this purpose, we employed an experimental manipulation to heighten the participants' contextual-level anti-pathogen motives.

Based upon the suggestion that anti-pathogen defenses designed in ancestral environments might be poorly equipped to combat the threat of zoonotic disease transmission (Ackerman et al., 2021), our primary expectation was that disfigured faces would capture more visual attention than animal disease vectors. Relatedly, we expected that attention would exhibit specialized attunement to humans implying increased infection risk over normal human targets (see Ackerman et al., 2009), whereas it would be indiscriminately allocated between animal disease vectors and disease-irrelevant animals. Last but not

least, we predicted that these expectations would be especially pronounced under conditions in which the cues connoting the presence of pathogens in the immediate environment were contextually salient.

Method

Participants

We calculated the required sample size a priori via G*Power 3.1.9.7 software (Faul et al., 2007). Given an $\alpha = 0.05$ and a power $(1-\beta) = 0.95$, the sample size needed to detect a medium effect size ($\eta^2 = 0.06$) was 75 participants. We recruited 80 participants to compensate for a potential participant loss. Two participants were excluded because they did not complete all phases of the study. A total of 78 undergraduate and graduate students ($n_{\text{females}} = 39$, $n_{\text{males}} = 39$; $M_{\text{age}} = 21.74$, $SD_{\text{age}} = 5.64$) from Ege University participated in exchange for extra course credit. They were randomly assigned to one of the two experimental conditions. Forty ($n_{\text{females}} = 21$, $n_{\text{males}} = 19$) participated in the pathogen salient condition, whereas thirty-eight ($n_{\text{females}} = 18$, $n_{\text{males}} = 20$) participated in the control condition.

Materials

Pathogen Salience Manipulation. We took advantage of the standardized Disgust-Related-Images (DIRTI) photograph set (Haberkamp et al., 2017) to amplify the threat posed by pathogens contextually. This set was chosen because it contains a category that includes animal photographs, which renders it possible to present human-contaminant and animal-contaminant photographs equally. In six different categories (food, animals, body products, injuries/infections, death, and hygiene), the set includes 240 disgust-eliciting photographs. Based on the norming study, 10 disgust-related photographs from these categories (e.g., rotten food, festering wounds, and roundworms) and 10 neutral photographs that were matched within the same categories (e.g., fresh fruit, unharmed body parts, and honeybees) were selected (see the Supplemental Material). Our selection criterion was that disgust ratings for disgust-related photographs were as high as possible compared to neutral photographs on a scale from 1 to 9. The normative ratings indicated that disgust-related photographs ($M = 5.28$, $SD = 0.86$) were assessed as significantly more disgusting than neutral photographs [$M = 1.32$, $SD = 0.07$, $t(9) = 15.550$, $p < .001$, $r = .96$].

Facial Photographs. To manipulate the heuristic cues to the presence of infectious diseases, high-resolution facial photographs of Turkish undergraduate students were obtained from the Bogazici Face Database (Saribay et al., 2018). Initially, photographs containing any emotional expression or other confounding factors (e.g., make-up, piercings, hijab, eyeglasses, or beard) were excluded. Then, we aimed to determine the photographs that were rated to have average values on various critical facial characteristics. Following the norming study, eight female and eight male photographs that were rated as average on the features of facial width-to-height ratio, attractiveness, dominance, maleness, and femaleness were selected. Following this procedure, in half of these photographs, several disfigurements were added to a random area of the face (e.g., rashes around the mouth and eye) using photoshop software. Which faces had these disfigurements and which did not was counterbalanced between

participants. Lastly, all targets were dressed in gray t-shirts to standardize the clothing of the photographs (see the Supplemental Material).

Animal Photographs. To manipulate the pathogenicity of animal targets, we used photographs of animal vectors of zoonotic infectious diseases. To determine which animals to use, we utilized the World Health Organization's list of vector-borne diseases (WHO, 2020) as well as the list of disease-relevant animal species presented in the related studies (e.g., Prokop & Fančovičová, 2010; Prokop et al., 2010a; Prokop, 2018). Thus, 8 disease vectors and 8 disease-neutral animals have been identified, with both categories consisting of 5 invertebrate and 3 vertebrate species. The list of disease vector animals was as follows: common Bent-wing bat (*Miniopterus schreibersii*), common rat (*Rattus norvegicus*), dengue mosquito (*Aedes aegypti*), German cockroach (*Blatella germanica*), house mouse (*Mus musculus*), kissing bug (*Triatoma infestans*), sandfly (*Phlebotomus papatasi*), and tse-tse fly (*Glossina palpalis*). The list of disease-neutral animals was as follows: damselfly (*Calopteryx splendens*), Emperor dragonfly (*Anax imperator*), European mantis (*Mantis religiosa*), European rabbit (*Oryctolagus cuniculus*), Eurasian red squirrel (*Sciurus vulgaris*), European roe deer (*Capreolus capreolus*), ladybird beetle (*Coccinella septempunctata*), and swallowtail (*Papilio machaon*). Having identified which animals to use, open-access resources on the Internet were scanned, and high-resolution photographs of these species were obtained. Afterward, some retouching was applied to the photographs to minimize the possibility of confounding the attentional processes. Firstly, the backgrounds of photographs were erased, as in facial photographs. Then, it was ensured that animal and facial photographs had equal size (693 x 860 pixels). Finally, the automatic brightness and contrast adjustments of the photographs were also made (see the Supplemental Material).

Dot-Probe Task. A version of the visual dot probe procedure (e.g., MacLeod et al., 1986) was used to assess attentional disengagement (i.e., how quickly participants were able to shift their attention away from a given stimulus; see Fox et al., 2001). Each trial began with a blank screen for 2000 ms, then a central fixation symbol (+) appeared for 1000 ms. Following this, a target stimulus (disfigured face, normal face, disease vector animal, or disease-neutral animal) was presented for 500 ms in one quadrant of the computer screen. Right after the disappearance of the target stimulus, a categorization object (a triangle or circle) was displayed in either the same quadrant as the target stimulus ("filler trials": %25 of the total) or in a different quadrant ("attentional disengagement trials": %75 of the total). The purpose of the filler trials was to reinforce participants to focus their attention on the target stimulus until it disappeared. When the categorization object was displayed, participants' task was to identify the object as a triangle or circle by using the "A" or "K" keys on the keyboard. The key to the correct response for the given object was counterbalanced between participants. A reaction time measure of the speed with which participants disengaged attention from the target stimulus (i.e., attentional adhesion) was provided by the response latency between the presentation of the categorization object and the participants' response (Maner et al., 2008). That is to say, greater response latencies show that it took participants longer to divert their attention from the location of the target stimulus. Both trial type (filler or attentional disengagement) and target stimuli were randomly presented within participants (for a sample trial from the dot-probe task, see Fig. 1).

Procedure

Upon arriving at the Ege University Evolutionary Social Psychology Laboratory, participants read and filled out an informed consent form. Then, each participant was seated in front of a standard desktop computer in a private laboratory cubicle. After the participant indicated their gender and age, the experimenter emphasized the importance of reading the instructions carefully and then left the cubicle. Participants were randomly assigned to a pathogen salient or control condition and completed the subsequent phases individually. Before the first phase of the study, participants were given a cover story stating that they would first evaluate some photographs being created to be used in other studies. Subsequently, either 10 pathogen-signaling or 10 neutral photographs were randomly presented for 7 seconds. After viewing the photographs, participants responded to some filler questions (e.g., “How would you rate the brightness of the photographs you have seen?”, “How many photographs did you see?”). Additionally, a measure of state disgust (“How much disgust do you experience at the moment?”, rated on a scale from 1 = “No disgust at all” to 7 = “Very much disgust”), was included as a manipulation check to assess the effectiveness of the pathogen salience manipulation (see van Leeuwen et al., 2023).

Next, participants received instructions for the dot-probe task and were told that the study investigated cognitive abilities. They were also instructed to look at both the central fixation symbol (+) and the photographs when they appeared and to identify the geometric shapes as quickly and accurately as they could. Before the experimental trials, participants completed 8 practice trials in which photographs of household furniture were presented as the target stimuli. The practice trials had two objectives: to familiarize the participant with the task procedure and to disguise the connection between the pathogen salience manipulation and the dot-probe task. At each practice trial, participants were given feedback on the accuracy of their responses. Besides, a warning message (“Your response time is slow; please try to be quicker”) was displayed when the response latency exceeded 2000 ms. Experimental trials were started upon the completion of the practice trials. In this phase, each target stimulus (8 disfigured faces, 8 normal faces, 8 disease vector animals, and 8 disease-neutral animals) was viewed twice, for a total of 64 trials. After finishing all trials, all participants were carefully probed for suspicion to assure that they did not realize the link between the pathogen salience manipulation and the dependent variables. None of the participants reported that they realized this link or the purpose of the dot-probe task. The study was completed by debriefing and thanking the participants.

Results

Manipulation Check

Participants in the pathogen salient condition ($M = 4.20$, $SD = 2.04$) reported greater levels of state disgust compared to those in the control condition [$M = 1.39$, $SD = 1.01$, $t(76) = 7.644$, $p < .001$, $r = .66$]. Given that disgust represents the emotional manifestation of disease avoidance psychology, higher levels of state disgust observed in the pathogen salient condition revealed that the experimental manipulation worked as intended.

Reaction Time Data Preprocessing

The reaction time on attentional disengagement trials served as the dependent variable. Averaging reaction times within each target category produced separate indices of attentional adhesion for disfigured faces, normal faces, disease vector animals, and disease-neutral animals. Following standard data preprocessing procedures for dot-probe tasks (e.g., Jakobsen et al., 2020; Maner et al., 2007), trials in which the participants inaccurately identified the categorization object were excluded from the analysis. Additionally, we removed trials in which participants' reaction times were under 200 ms (0.18% of all trials), indicating an anticipatory response, and were greater than 3.0 standard deviations above the mean for each target category and experimental condition (1.30% of all trials). These rates were approximate to those obtained in different dot-probe studies (e.g., Ackerman et al., 2009; Koster et al., 2004; Waechter et al., 2014).

Attentional Adhesion Effects

A 2 (Pathogen Salience Manipulation: Pathogen Salient - Control) x 2 (Target Type: Faces - Animals) x 2 (Disease Signal: Disease Relevant - Disease Irrelevant) mixed-design ANOVA was conducted to assess the attentional adhesion effects. Mean reaction times by target category and pathogen salience manipulation are provided in Table 1. The results revealed a significant main effect of target type [$F(1, 76) = 7.859, p = .006, \eta_p^2 = .094$], such that faces ($M = 560.81, SD = 138.02$) captured attention longer than animals ($M = 545.65, SD = 129.69$). Furthermore, a significant main effect of disease signal was also observed [$F(1, 76) = 4.354, p = .040, \eta_p^2 = .054$], indicating that disease-relevant targets ($M = 558.43, SD = 136.36$) held attention longer than disease-irrelevant targets ($M = 548.03, SD = 130.10$).

Table 1
Mean reaction times (in ms) by target category and pathogen salience manipulation

	Target Category			
	Disfigured Faces	Normal Faces	Disease Vector Animals	Disease-Neutral Animals
Pathogen Salient Condition	581.53 (164.42)	542.49 (130.05)	536.91 (120.16)	548.72 (149.14)
Control Condition	572.65 (147.44)	546.58 (132.26)	524.64 (131.85)	554.34 (137.19)
<i>Note</i> Standard deviations appear in parentheses				

However, these main effects were qualified by a Target Type X Disease Signal interaction, $F(1, 76) = 15.408, p < .001, \eta_p^2 = .169$. Bonferroni-adjusted pairwise comparisons were performed to explore the source of the interaction between these factors. Results showed that disfigured faces ($M = 577.09, SD = 154.42$) captured attention to a greater extent than did disease vector animals ($M = 539.77, SD = 124.40$),

$p < .001$. In contrast, attention was held equally by normal faces ($M = 544.53$, $SD = 129.48$) and disease-neutral animals ($M = 551.53$, $SD = 141.64$), $p = .392$. Additionally, disfigured faces captured attention longer than normal faces, $p < .001$. However, attention was allocated comparably between disease vector animals and disease-neutral animals, $p = .100$ (see Fig. 2.).

Nonetheless, neither a main effect of pathogen salience manipulation [$F(1, 76) = .008$, $p = .957$], nor a Target Type X Pathogen Salience Manipulation interaction [$F(1, 76) = .556$, $p = .458$] nor a Disease Signal X Pathogen Salience Manipulation interaction [$F(1, 76) = .416$, $p = .521$] was found. Besides, a three-way interaction of Target Type X Disease Signal X Pathogen Salience Manipulation was not detected, $F(1, 76) = .335$, $p = .564$.

Discussion

Detecting and encoding evolutionarily threatening stimuli in one's immediate environment constitutes the initial stages of efficient threat management (Neuberg et al., 2011). Accordingly, the present study was designed to illuminate whether visual attention shows adaptive attunement toward animal targets' pathogenicity. Consistent with our primary expectation, faces possessing cues heuristically associated with disease held visual attention to a greater extent than did animal vectors of zoonotic infectious diseases. Furthermore, the results revealed that while attention showed a specialized sensitivity toward processing potential disease cues on faces, it was indiscriminately captured by animal disease vectors and disease-irrelevant animals. Contrary to our expectation, however, the pathogen salience manipulation employed to heighten the participants' perceptions of disease risk did not moderate the attentional adhesion effects.

The evolutionary mismatch hypothesis provides the ultimate explanation for why attentional mechanisms seem insensitive to the pathogenicity of animal disease vectors. This hypothesis accentuates that key features of any evolved psychological mechanism may no longer be maintained to operate effectively to the degree that modern environments diverge from those in which they evolved (Li et al., 2018). Undoubtedly, a great majority of current evolutionary mismatches are rooted in the agricultural revolution, when human societies started living in conditions that were considerably different from those of their hunter-gatherer ancestors (Tooby & Cosmides, 1990). The frequent and multifarious contact between humans and animal reservoirs of infectious diseases following the development of agriculture corresponds to one of the most conspicuous among these evolutionary mismatches (Ackerman et al., 2021; Crawford, 2007, p. 60). As a consequence of this divergence, attentional mechanisms might have encountered an adaptive lag that inhibits their capability of detecting and encoding animal disease vectors' pathogenicity. Unlike disease vector animals, on the other hand, it is reasonable to assume that perceivers have been inferring the infection risk from visible facial abnormalities not only in present-day environments but also in ancestral ecologies. Indeed, Oaten et al. (2011) revealed that almost all of the major human infectious diseases are directly displayed through the face (e.g., rashes, runny noses, and sores). In this direction, it is not surprising that the cues of morphological deviations on faces prompt a cluster of anti-pathogen responses, including attentional

adhesion (Ackerman et al., 2009), social categorization (Petersen, 2017), willingness to contact (Kouznetsova et al., 2017), and stigmatization (Duncan, 2005).

Notwithstanding that these results were in line with our expectations and the evolutionary mismatch framework, the allocation of visual attention did not vary as a function of the pathogen salience manipulation, despite our predictions. To put it more specifically, we predicted that disfigured faces would hold attentional resources even more compared to animal disease vectors when the threat posed by pathogens was contextually amplified. Likewise, under the pathogen salience manipulation, we predicted that selective attention would exhibit greater sensitivity to faces displaying physical abnormalities than normal faces, yet it would remain insensitive to the disease transmission potential of the animal targets.

Although some previous studies indicated that both chronic concerns about disgust (Cisler et al., 2009) and disease-sensitivity manipulation (Ackerman et al., 2009) elicited difficulty in disengaging visual attention from pathogen-related stimuli, our results suggest that the allocation of attentional resources toward disease-relevant targets was invariant across contextual anti-pathogen motives (i.e., experimental conditions). In a similar vein, some studies showed that participants' attention was deployed to the disgust-eliciting stimuli independently of trait-level and contextual-level pathogen avoidance (Perone et al., 2021; van Hooff et al., 2014; Vogt et al., 2011). Taken together with these, our results contribute to the possibility that the initial stages of the attentional processing of pathogen-related cues remain active in the majority of individuals, regardless of their chronic proneness to experience disgust or the immediate environment in which those cues are encountered (van Hooff et al., 2014). In light of the negligibly low cost and high potential benefit of deploying early attentional resources to detect pathogen cues, these lower-order mechanisms might have been designed to function regardless of whether or not pathogen-related cues exist in the context. Nonetheless, the costs of prompting higher-order responses to pathogen threats (e.g., behavioral prophylaxis) might be adequate to differ between individuals and contextual settings (Perone et al., 2021).

Limitations and Future Directions

The current study's limitations may offer some helpful directions for future research. One limitation pertains to the lack of trait-level measures of pathogen avoidance. Although we employed a pathogen salience manipulation to activate the participants' pathogen-related concerns, it remains unanswered whether individuals' chronic proneness to experience disgust or perceived vulnerability to infectious diseases moderate the selective allocation of attentional resources to disease-relevant targets. Thus, future research may utilize individual differences measures of trait-level pathogen avoidance to shed some light on this point, such as the Perceived Vulnerability to Disease Scale (Duncan et al., 2009) and the Three Domain Disgust Scale (Tybur et al., 2009).

Another possible limitation involves the selection of material to manipulate pathogen-avoidance concerns. Whereas the higher levels of state disgust detected in the pathogen salient condition indicated that the manipulation was successful, the deployment of visual attention did not alter as a function of

this manipulation. Given that the extant literature has used a wide range of other manipulation techniques, including priming participants with olfactory cues to pathogens and having participants read vignettes about the transmission of infectious diseases (see Tybur et al., 2014), these alternative methods could also be considered in future work.

A third limitation of the current study relates to the specific perceptual phenomenon we chose to investigate (i.e., attentional disengagement) and the paradigm we used to assess it (i.e., the dot-probe task). To increase the generalizability of our findings, future studies would benefit from using different paradigms to test attentional biases (e.g., the attentional blink task), as well as examining other cognitive processes such as categorization and memory.

Conclusion

To the best of our knowledge, this is the first study examining how our evolved disease avoidance psychology is affected by both human and non-human animal targets' disease transmission risk. Overall, our findings point out that visual attention did not appear to be as vigilant to the pathogenicity of animal targets as it was to the heuristic infection cues on faces. Considering the fact that human-animal interaction was identified as of paramount importance in the disease emergence process and global outbreaks (Dharmarajan et al., 2022; Pike et al., 2010), our findings have crucial implications for global health and epidemiological studies. Since attentional mechanisms are inefficient in detecting and encoding animals' risk of zoonotic transmission, the implementation of culturally learned disease avoidance strategies may compensate for this critical shortcoming and reduce reliance on evolved anti-pathogen responses.

Most particularly, Hagen et al. (2023) argued that increased exposure to zoonotic spillovers has paved the way for cultural transmission of ethnomedical knowledge (e.g., traditional use of pharmacological plants) and medical specialization within ancestral human groups. Additionally, Wormley and Varnum (2023) revealed that individuals with greater knowledge of germ theory (sample items include "Diseases like malaria and dengue fever are transmitted by mosquitoes" and "Infectious diseases may spread by different vectors like the air or animals") showed less engagement of several behavioral immune system elements. Taking into account all of these, the upshot is that effective utilization of socially transmitted anti-pathogen defenses regarding the dynamics of zoonotic disease transmission (e.g., public health education) will play a supplemental role in the prevention of future zoonotic emerging infectious diseases and global pandemics.

Declarations

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Supplemental Material. The data associated with this research and additional supporting information are available and can be found at the OSF project site: <https://osf.io/6g4rf/>

Author Contributions. SR—Conceptualization, writing, and compilation of manuscript, established methodology and research design, data collection, and analysis. MT—Conceptualization, supervision, and assistance with methodology and research design, interpretation of results, and edition of the manuscript.

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Competing Interests. The authors have no competing interests to declare that are relevant to the content of this article.

Ethical Approval. This study was performed in accordance with the principles of the Declaration of Helsinki. Approval was granted by the Social and Human Sciences Research and Publication Ethics Committee of Ege University (30-03-2021/41).

Informed Consent. Informed consent was obtained from all individual participants included in the study, who all signed informed consent regarding the publication of their data.

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Figures

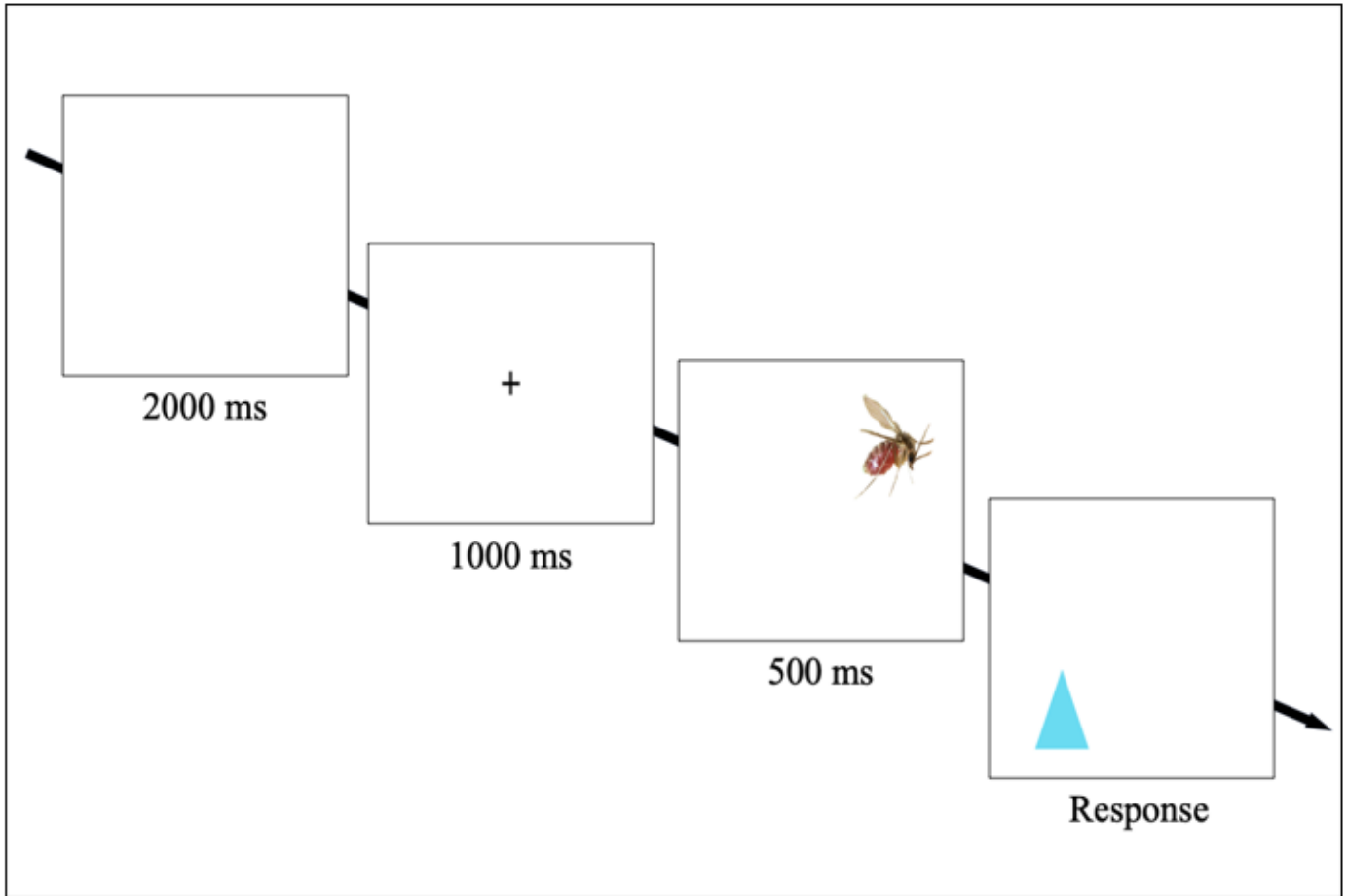


Figure 1

A single attentional disengagement trial in the dot-probe task

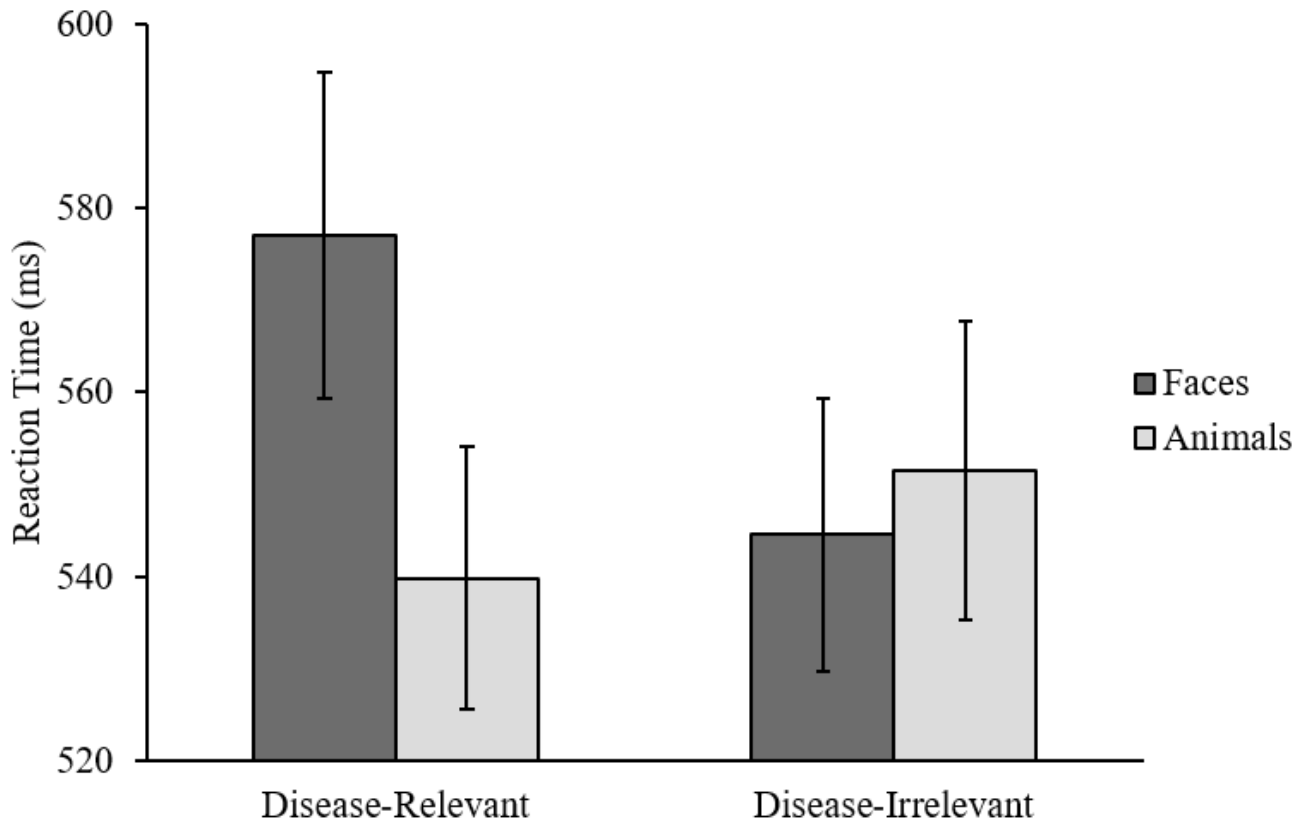


Figure 2

Selective allocation of visual attention as a function of target type and disease signal. Whereas a greater attentional adhesion to disfigured faces than disease vector animals was found, normal faces and disease-neutral animals captured attention equally. Moreover, while disfigured faces held attention to a greater extent than did normal faces, attention was allocated comparably between disease vector animals and disease-neutral animals. Error bars indicate standard errors