Evolution and Human Behavior xxx (xxxx) xxx

Contents lists available at ScienceDirect

Evolution and Human Behavior

journal homepage: www.elsevier.com/locate/ens

Re-evaluating the relationship between pathogen avoidance and preferences for facial symmetry and sexual dimorphism: A registered report

Joshua M. Tybur [a,b,*], Lei Fan [a,b], Benedict C. Jones [c], Iris J. Holzleitner [d], Anthony J. Lee [e], Lisa M. DeBruine [f]

[a] Vrije Universiteit Amsterdam, Department of Experimental and Applied Psychology, Van der Boechorststraat 7, 1081 BT Amsterdam, the Netherlands
[b] Institute of Brain and Behavior Amsterdam, Amsterdam, The Netherlands
[c] University of Strathclyde, School of Psychological Sciences and Health, Scotland, UK
[d] University of the West of England, Department of Social Sciences, Bristol, UK
[e] University of Stirling, Division of Psychology, Scotland, UK
[f] University of Glasgow, School of Psychology & Neuroscience, Scotland, UK

ARTICLE INFO

Keywords:
Disgust
Health
Masculinity
Symmetry
Mate preferences
Behavioral immune system

ABSTRACT

Over the past decade, a small literature has tested how trait-level pathogen-avoidance motives (e.g., disgust sensitivity) and exposure to pathogen cues relate to preferences for facial symmetry and sexual dimorphism. Results have largely been interpreted as suggesting that the behavioral immune system influences preferences for these features in potential mates. However, findings are limited by small sample sizes among studies reporting supportive evidence, the use of small stimulus sets to assess preferences for symmetry and dimorphism, and design features that render implications for theory ambiguous (namely, largely only investigating women's preferences for male faces). Using a sample of 954 White young adult UK participants and a pool of 100 White young adult stimuli, the current registered report applied a standard two-alternative forced-choice approach to evaluate both men's and women's preferences for both facial symmetry and dimorphism in both same- and opposite-sex targets. Participants were randomly assigned to either a pathogen prime or a control prime, and they completed instruments assessing individual differences in pathogen avoidance (disgust sensitivity and contamination sensitivity). Results revealed overall preferences for both facial symmetry and dimorphism. However, they did not reveal a relation between these preferences and disgust sensitivity or contamination sensitivity, nor did they reveal differences in these preferences across control and pathogen prime conditions. Null results of pathogen-avoidance variables were consistent across participant sex, target sex, and interactions between participant sex and target sex. Overall, findings cast doubt on the hypothesis that pathogen-avoidance motives influence preferences for facial symmetry or dimorphism.

1. Introduction

Social living, while obligate for humans to (among other things) reproduce, obtain calories when individual yields are meager, and fend off physical threats from predators and rival coalitions, leaves us vulnerable to socially-transmitted pathogens (Kurzban & Leary, 2001; Neuberg, Kenrick, & Schaller, 2011). This vulnerability can be mitigated by limiting interactions with those who are more likely than others to be infectious. But how can humans detect microbes that are no larger than the head of a pin? Although pathogens are indeed too small to be observed directly, they often produce visible cues in their hosts. Vivid examples include the lesions that accompany smallpox, the inflamed lymph nodes resulting from the bubonic plague, the swelling and sores that accompany leprosy, and the pallor that accompanies tuberculosis. Indeed, 23 of the 25 infectious diseases estimated as causing the highest mortality in humans appear to produce changes to facial color or texture (Oaten, Stevenson, & Case, 2011). If skin color and texture correlated with infectiousness in our ancestral social environments, then pathogen-avoidance adaptations might have evolved to treat these features as indicative of infectiousness. Consistent with this proposition, individuals with such features are stigmatized across cultures (see Oaten et al., 2011, for a review). Experimental lab work similarly finds that

* Corresponding author.
E-mail address: j.m.tybur@vu.nl (J.M. Tybur).

https://doi.org/10.1016/j.evolhumbehav.2022.01.003
Received 4 February 2020; Received in revised form 28 December 2021; Accepted 29 January 2022

people avoid contact with a towel handled by a person with a port wine stain birthmark on the face as much as they avoid contact with a towel handled by a person with symptoms of influenza (Ryan, Oaten, Stevenson, & Case, 2012). Such avoidance – and its tendency to produce false-alarms (i.e., avoidance when a target is not actually infectious) – has been highlighted as one of the key features of the behavioral immune system (Ackerman, Hill, & Murray, 2018; Murray & Schaller, 2016; Schaller & Park, 2011; Tybur, Lieberman, Kurzban, & DeScioli, 2013).

A handful of recent studies suggests that the behavioral immune system shapes preferences for more stable aspects of facial morphology – namely, bilateral symmetry and sexual dimorphism (i.e., a more masculine face shape for men and a more feminine face shape for women). These studies have proposed that preferences for symmetric and dimorphic faces vary across (1) individual differences in motivations to avoid pathogens, and (2) situations in which infectious disease threats are salient. Supporting evidence has been gathered using paradigms in which participants are asked to indicate their preferences for more versus less symmetric or more versus less dimorphic versions of target faces. Studies using these approaches have either examined covariations between symmetry or dimorphism preferences and individual differences in disgust sensitivity (DeBruine, Jones, Crawford, Welling, & Little, 2010; Jones et al., 2012; Young, Sacco, & Hugenberg, 2011), which is widely interpreted as reflecting motivations to avoid pathogens (Tybur, Frankenhuis, & Pollet, 2014), or they have examined how preferences for symmetry or dimorphism differ across participants exposed to pathogen cues versus participants in control conditions (Ainsworth & Maner, 2019; Jones et al., 2012; Little, DeBruine, & Jones, 2010; Watkins, DeBruine, Little, Feinberg, & Jones, 2012; Young et al., 2011). As summarized in Table 1, half of the published studies examining covariation between individual differences in pathogen disgust or contamination sensitivity and preferences for symmetry or dimorphism have reported findings consistent with this hypothesis, as have all of the studies reporting effects of experimental manipulations involving pathogen cues. However, multiple theoretical and methodological issues both raise questions regarding how to interpret this work and provide directions for further research in this area.

1.1. Considerations of theory underlying published findings

According to the logic motivating the studies described above, both facial symmetry and dimorphism provide information regarding health,

Table 1
Overview of studies examining relations between pathogen avoidance and preferences for facial symmetry or dimorphism.

Study	Manipulation	Individual differences	Sample	Stimuli	Key result	*p* value
Watkins et al., 2012	Completed PVD scale or Resource Scarcity scale	N/A	90 women	10 male face pairs manipulated on dimorphism.	Women exposed to pathogen primes show greater preferences for men's facial masculinity.	.033
Little et al., 2010	Rated disgust-eliciting images or images not eliciting disgust	N/A	124 women, 117 men	10 male and 10 female face pairs manipulated on dimorphism, five male and five femal face pairs manipulated on symmetry.	Women and men exposed to pathogen primes show a greater preference for dimorphism and symmetry in opposite-sex faces.	.0005 (women), 0.0007 (men)
Ainsworth & Maner, 2019, Study 1	Viewed a slideshow of pathogen threats versus other threats	N/A	30 women	Three male and four female face pairs manipulated on symmetry.	Women exposed to a pathogen prime show a greater preference for symmetry in men's faces.	.041
Ainsworth & Maner, 2019, Study 2	Viewed a slideshow of pathogen threats versus other threats	N/A	24 women, 26 men	10 male and 10 female face pairs manipulated on symmetry.	Women (but not men) exposed to a pathogen prime show a greater preference for symmetry in opposite-sex faces.	.043
Young et al., 2011, Study 2	Viewed a slideshow of pathogen threats versus other threats	N/A	47 women, 27 men	10 male and 10 female face pairs manipulated on symmetry.	Exposure to a pathogen prime was associated with greater symmetry preferences controlling for perceived skin health of target faces.	.049
DeBruine, Jones, Crawford, et al., 2010, Study 1	N/A	Pathogen Disgust	345 women	20 male face pairs manipulated on dimorphism.	Pathogen disgust relates to women's preferences for men's facial masculinity independent of sexual and moral disgust.	.022
DeBruine, Jones, Crawford, et al., 2010, Study 2	N/A	Pathogen Disgust	74 women	16 male face pairs (each combination matching four non-transformed feminine men and four non-transformed masculine men).	Pathogen disgust relates to women's preferences for men's facial masculinity independent of sexual and moral disgust.	.018
Jones et al., 2012, Study 2	N/A	Pathogen disgust	48 women	16 male face pairs (each possible combination matching four non-transformed feminine men and four non-transformed masculine men).	Pathogen disgust relates to women's preferences for men's facial masculinity.	.005
Young et al., 2011, Study 1	N/A	Perceived Infectability	23 women, 15 men	10 male and 10 female face pairs manipulated on symmetry.	Perceived Infectability related to symmetry preferences controlling for the perceived skin health of target faces.	.040
Zietsch, Lee, Sherlock, & Jern, 2015	N/A	Pathogen disgust	2160 women	21 male face pairs manipulated on dimorphism.	Pathogen disgust was unrelated to women's masculinity preferences.	.640
Lee & Zietsch, 2015, Study 1	N/A	Pathogen disgust	447 women	51 male face pairs manipulated on dimorphism.	Pathogen disgust was unrelated to women's masculinity preferences.	.788
Lee & Zietsch, 2015, Study 2	N/A	Pathogen disgust	395 women	51 male face pairs manipulated on dimorphism.	Pathogen disgust was unrelated to women's masculinity preferences.	.176

* We note that other studies not listed here (e.g., Brown & Sacco, 2019; Clarkson et al., 2020; Lee & Zietsch, 2015, Study 3; McIntosh et al., 2017; Zheng, Zhang, & Zheng, 2016) have tested for relations between pathogen disgust and/or pathogen primes and preferences for facial dimorphism or symmetry. These studies departed from those summarized above by, among other things, not using the two-alternative forced-choice methods, manipulating both beardedness and dimorphism, using primes different from those used in the rest of this literature (e.g., ectoparasite cues; cues to crowding), and investigating gay men's preferences for male targets.

and hence both traits should be preferred by more pathogen-avoidant individuals and under conditions in which pathogen cues are detected. Health, though, is a broad concept, and it can refer to multiple features with different consequences for social partners, including current infection status, likelihood of future infection, and condition unrelated to infection (e.g., absence of metabolic disease) (Tybur & Gangestad, 2011). While structural aspects of the face, such as symmetry and sexual dimorphism, are unlikely to fluctuate as a function of infection status in the same way that the blemishes caused by chickenpox are, such variation could relate to the ability to resist infection if symmetry and dimorphism are (1) influenced by infection during development (and if past infection relates to infection proneness) or (2) influenced by mutation load (and if mutation load relates to infection proneness). Evidence supporting relations between infection proneness and both facial symmetry and dimorphism is tenuous, though. For example, a meta-analysis of three published studies reported only a small relation (r = .09) between fluctuating asymmetry and history of infectious disease (Van Dongen & Gangestad, 2011). Similarly, evidence for a relation between sexually dimorphic aspects of face shape and susceptibility to infectious disease is mixed (Boothroyd, Scott, Gray, Coombes, & Pound, 2013; Cai et al., 2019; Rhodes, Chan, Zebrowitz, & Simmons, 2003; Thornhill & Gangestad, 2006; see Jones, Hahn, & DeBruine, 2019, and Scott, Clark, Boothroyd, & Penton-Voak, 2012, for overviews). That said, a low (or lack of) correspondence between infection proneness and symmetry or dimorphism in Western populations with relatively low parasite stress and excellent health care (i.e., those populations sampled from in this literature) does not rule out the possibility that either trait was informative of infection proneness in environments in which human pathogen-avoidance psychology evolved (Thornhill & Gangestad, 1999). Hence, while not lending support for the hypothesis that people use symmetry or dimorphism as a cue to infectiousness, the equivocal nature of these findings is also not necessarily damning.

Studies in this literature have also suggested that more pathogen-avoidant individuals prefer more symmetric and dimorphic faces due to the indirect benefits (i.e., genes that increase offspring viability or attractiveness) putatively associated with such features (e.g., Little et al., 2010). This argument aligns with one interpretation of findings suggesting that women in nations characterized by poorer health prefer dimorphic male faces more so than women in nations characterized by better health: women who anticipate generally harsh ecological conditions in the future prioritize cues to indirect benefits that would aid offspring survival (DeBruine, Jones, Crawford, et al. (2010)). Three notable limitations apply to this line of thinking. First, more masculine men might be preferred (perhaps especially in harsh environments) due to their ability to offer protection rather than any indirect benefits they provide (Brooks et al., 2010). Second, and linking back to individual differences and experimental priming work, no evidence (that we are aware of) indicates that pathogen disgust or contamination sensitivity reflect expectations of future environmental harshness (see Tybur & Karinen, 2018, for a review). Third, a transient cue to pathogens (e.g., an infected wound on someone else's body) seemingly provides weak information regarding environmental conditions that offspring would encounter years later. Such low-validity indicators of future conditions are questionable candidates for updating mate preferences (cf. Stamps & Frankenhuis, 2016). Notably, other recent studies have reported that women from harsher (and, further, more pathogen-rich) ecologies prefer less dimorphic, rather than more dimorphic male faces (Marcinkowska et al., 2019; Scott et al., 2014). In sum, multiple considerations suggest that indirect benefits explanations be viewed with some skepticism.

Theoretical arguments aside, how could prophylactic versus indirect benefit interpretations of preferences for dimorphism and symmetry be disentangled? One approach involves examining whether pathogen avoidance relates to symmetry and dimorphism preferences equally in both same- and opposite-sex faces. If preferences for symmetric and dimorphic faces result from those features being treated as information regarding infectiousness, then pathogen avoidance should relate to such preferences for both men and women, and for both same- and opposite-sex targets. If preferences result from any indirect benefits perceived from facial symmetry or dimorphism, then they should be moderated by participant and target sex. Studies in this area have typically not been designed in a manner that can test for such sex-specific patterns. Indeed, nine of the 12 published studies on the relation between pathogen avoidance and preferences for facial symmetry or dimorphism measured only women's preferences for male faces. Two studies that have included both men and women have lent some support to the indirect benefits interpretation (Ainsworth & Maner, 2019; Little et al., 2010), with both reporting that pathogen primes affect opposite-sex – but not same sex – preferences for facial symmetry and/or dimorphism. Notably, the smaller of these two studies (Ainsworth & Maner; 24 female and 26 male participants) reported that a pathogen prime increased women's preference for male facial symmetry, but not men's preference for female facial symmetry. The larger of these two studies (Little et al.; 124 female and 117 male participants) reported that a pathogen prime increased women's preference for male facial symmetry and dimorphism (but not women's preferences for female facial symmetry and dimorphism) and men's preference for female facial symmetry and dimorphism (but not men's preferences for male facial symmetry and dimorphism). However, results from both studies should be interpreted tentatively given design limitations – limitations that characterize most studies in this literature.

1.2. Methodological considerations of published findings

Two key issues raise questions regarding whether relations between pathogen avoidance and preferences for symmetry and dimorphism exist, let alone need interpretation. The first concerns the distribution of p-values in these studies. Nine of the 12 published studies rejected the null hypothesis. At first blush, this pattern might appear to offer good support for a relation between pathogen-avoidance motives and such preferences. However, of the five published studies reporting effects of experimental manipulations, four report p-values between .03 and .05 – a range that is unlikely for studies with adequate statistical power (Simonsohn, Nelson, & Simmons, 2014). Given that the statistical power of papers within a literature is inversely related to the number of Type I errors in that literature (Button et al., 2013), these p-values suggest that the studies summarized in Table 1 offer less support than they might initially appear to. A similar issue applies to the studies using individual-difference approaches. Although more than half of the studies rejected the null – a higher number than one would expect given a false positive rate of .05 – those studies had smaller sample sizes (38, 48, 74, 345) than the studies that did not reject the null (395, 447, 2160). This is, of course, opposite to what should occur if the null is false; the studies with larger sample sizes (and higher statistical power) should have smaller p-values.

The second issue concerns the practice of estimating symmetry or dimorphism preferences by averaging across responses to a small number of stimuli. For example, Study 1 of DeBruine, Jones, Tybur, Lieberman, & Griskevicius, 2010 used 20 items to assess masculinity preferences, with each item consisting of a preference between a feminized versus masculinized version of a male face. Masculinity preferences were computed for each participant by averaging responses to the 20 items. This approach has two shortcomings. First, generalizability to a population of stimuli increases as a function of the number of stimuli, and smaller stimulus sets have lower generalizability (and, by extension, lower construct validity) than those using a larger number of stimuli (Wells & Windschitl, 1999; Yarkoni, 2020). Second, collapsing across stimuli can increase Type I error rates, sometimes drastically so (Judd, Westfall, & Kenny, 2012). All of the studies in this literature that have rejected the null hypothesis have collapsed across stimuli; two of the three that have failed to reject the null have instead treated stimulus as a random factor in mixed-effects analyses. That said, treating stimulus as a random factor can also increase Type II error rates depending on a

number of parameters, including the number of stimuli, the variance components involving the stimuli, and, of course, the magnitude of the fixed effects (Westfall, Kenny, & Judd, 2014). Those two studies that have used random effects modeling (both reported in Lee & Zietsch, 2015) have used 51 stimuli. Although 51 is by no means a trivial amount, statistical power can (though need not) be low even with this number of stimuli, depending on other parameters. Of course, the null results observed in the studies that used random effects modeling might not (and, perhaps, likely do not) reflect Type II errors, regardless of statistical power. Even so, they did not assess women's preferences for facial symmetry in either sex, men's preferences for facial symmetry in either sex, men's preferences for facial dimorphism in either sex, or women's preferences for facial dimorphism in women, nor did they use the priming methods that have only yielded positive effects in the published literature.

In sum, multiple features of the published literature cast doubt on the robustness of the reported relation between pathogen avoidance and preferences for facial symmetry and dimorphism. Given these issues – and given this research area's implications for the field's understanding of the behavioral immune system and mate preferences – the current study aims to advance the literature in four ways. First, it uses a registered report, in which publication outcome is determined before data collection. This approach removes (or, at least, severely constrains) incentives that contribute to publication bias (Nosek & Lakens, 2014). Second, it uses a sample size that is sufficiently powered to detect small effect sizes for both individual differences variables and pathogen primes. Third, it models random effects of a large number of stimuli ($N = 100$; 50 male and 50 female), an approach expected to decrease Type I and Type II errors rate relative to designs typically used in this literature. Fourth, it simultaneously assesses both men's and women's preferences for facial symmetry and dimorphism in both male and female targets. In total, this approach is intended to (1) inform whether a relation between pathogen avoidance and preferences for these facial features exists, (2) inform whether such a relation varies as a function of the sex of the perceiver and sex of the target and, consequently (3) inform whether such relations better align with pathogen-avoidance versus indirect benefits hypotheses.

2. Methods

2.1. Participants

We recruited 1050 heterosexual White UK residents between 18 and 35 years of age through Prolific, an online participant recruitment service. We recruited along these lines for multiple reasons. First, multiple studies reporting relations between preferences for facial symmetry or dimorphism have been conducted in the UK (e.g., Little et al., 2010; Watkins et al., 2012). The proposed sample is appropriate for our goal of confirming the existence of relations that have been previously inferred using White targets and largely White samples. Findings from this study could (and should) be conducted in different populations and with different targets (cf. Han et al., 2018; Jones et al., 2021). Second, many studies in this literature (including those that have reported confirmatory findings) have used online data collection platforms similar to that proposed here (e.g., DeBruine, Jones, Crawford, et al., 2010; Jones et al., 2012; Lee & Zietsch, 2015). Third, to evaluate the indirect benefits account described above, we aimed to test for differences in preferences for symmetry and dimorphism in same- versus opposite-sex faces for individuals attracted to members of the opposite sex. Fourth, some research suggests that the relation between pathogen avoidance and dimorphism preferences might be present in only younger (i.e., under age 35) adults rating younger (i.e., under age 35) faces (Lee & Zietsch, 2015). Again, our goal here is to verify a relation between pathogen avoidance and preferences for facial symmetry and dimorphism by drawing from stimulus and participant populations similar to those used in existing work.

Before data collection, we conducted a power analysis assuming a final sample of 1000 participants (500 male and 500 female) after exclusion of 5% of the sample due to failure to pass attention checks. This simulation-based power analysis, which was conducted using the *R* simr package (Green & MacLeod, 2016), used random-effect parameters (participant and stimulus intercepts) extracted from Study 1 of Lee and Zietsch (2015). Results from these power analyses indicated high power (> 90%) to detect small effect sizes (e.g., $r = .15$ for a main effect of pathogen disgust sensitivity). The simulations indicated higher power to detect interactions characterized by simple effects of $r = .15$ for male preferences for female targets and for female preferences for male targets, and simple effects of $r = .00$ for male preferences for male targets and female preferences for female targets.

After eliminating participants who did not meet our inclusion criteria (e.g., failed attention checks), we had a final sample of 954 participants (400 male, 554 female). As stated in our registration, we attempted sensitivity power analyses in simr using the full random-effect parameters observed in this study, starting with the fixed-effect parameter estimates observed in the study, and iteratively changing them until we reached approximately 80% power. Solutions failed to converge after 50+ hours. We simplified the random-effect parameters by using only participant and stimulus intercepts. These analyses indicated that we had approximately 80% power to detect fixed effects of approximately .03 for the main effect of pathogen disgust sensitivity and germ aversion on preferences for facial dimorphism or symmetry (i.e., a .03 unit change on the −3.5 to +3.5 scale for every standard deviation increase in pathogen disgust sensitivity or germ aversion). Further details regarding these power analyses – and power analyses for simple effects collapsing across stimuli – are provided in the online supplement.

2.2. Face stimuli

We used the 3DSK image set (DeBruine & Jones, 2020) to produce target images. This image set includes 100 Caucasian young adult faces ($M_{age} = 24.25$, $SD_{age} = 3.98$). We used WebMorph (DeBruine, 2018), specialist software based on algorithms developed by Tiddeman, Burt, and Perrett (2001), to create two sets of stimulus pairs (a masculinity-femininity set and a symmetry-asymmetry set) for each base face. The methods used to create these stimuli are identical to those used in previous studies assessing preferences for these facial characteristics (e.g., Jones et al., 2018) (see Fig. 1 for examples).

The masculinity-femininity image set was created by first manufacturing a female prototype (i.e., average) face by using the average of the shape, color, and texture information from 50 female Caucasian faces. A male prototype face was manufactured with the same procedure using 50 male Caucasian faces. Next, feminized and masculinized versions of each of the 100 images were created by adding or subtracting 50% of the linear (i.e., vector) differences in 2D shape between symmetrized versions of the female and male prototypes to (or from) each individual image. This process created 100 pairs of face images, with each pair consisting of a feminized and a masculinized version of an image. Similar procedures were used to create sets of 100 symmetric versus asymmetric pairs, with high- and low-symmetry versions of each original face created by adding or subtracting 50% of the linear differences in 2D shape between the original image and a perfectly symmetric version of that image. In total, we generated 200 pairs (100 male pairs and 100 female pairs) of faces: 100 of which included a masculinized and feminized version of an individual face and 100 of which included a high-symmetry and low-symmetry version of an individual face. These pairs were used to assess preferences for facial masculinity versus femininity and facial symmetry versus asymmetry.

2.3. Procedure

The study platform, which was programmed in Qualtrics, can be viewed on the Open Science Framework (https://osf.io/kaq39/).

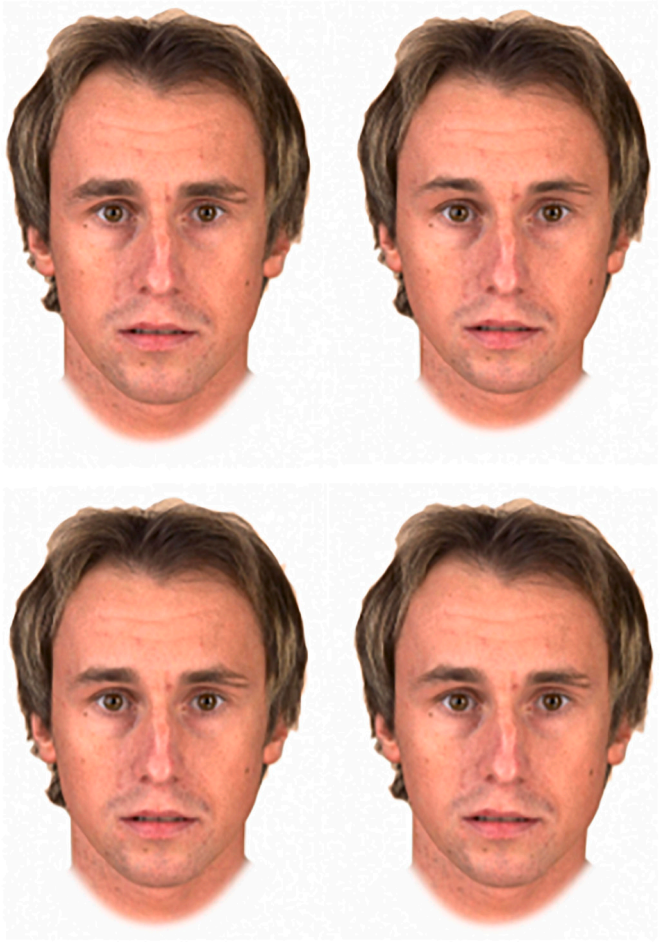

Fig. 1. Examples of masculine-feminine (top, left to right) and symmetric-asymmetric (bottom, left to right) face pairs.
Note. Each participant saw either the symmetry-manipulated pair or dimorphism-manipulated pair for each of the 100 target faces.

Participants began by completing 50 trials, each of which displayed two versions of a face. For each trial, they were asked to indicate "Which of these two faces do you find more attractive," with four options on each side labeled "slightly more attractive," "somewhat more attractive," more attractive," and "much more attractive." Face order was randomized, as was the side of the screen on which any given image in each pair was presented. This method has been used to assess preferences for experimentally manipulated face images in many previous studies (e.g., Jones et al., 2018; Zietsch et al., 2015). Participants were randomly allocated one version of each face pair (i.e., for each original face, they saw either the masculine-feminine pair or the symmetric-asymmetric pair).

After completing these 50 trials, participants were randomly assigned to a pathogen prime or a control prime. In this literature, priming procedures have involved exposing participants to visual cues to pathogens (Ainsworth & Maner, 2019; Young et al., 2011) or having participants complete an individual-differences measure that verbally describes situations with heightened pathogen risks (e.g., Watkins et al., 2012; for other examples, see Lee & Zietsch, 2011, and Navarrete & Fessler, 2006). We used these two approaches in combination. Participants assigned to the pathogen-prime condition first completed the 15-item Perceived Vulnerability to Disease scale (Duncan, Schaller, & Park, 2009) and the seven-item pathogen subscale of the Three Domain Disgust Scale (Tybur, Lieberman, & Griskevicius, 2009), and they then viewed and rated seven infectious-disease-relevant images (Curtis, Aunger, & Rabie, 2004). Participants assigned to the control-prime condition first completed the 24-item Brief HEXACO Inventory (De Vries, 2013) and then viewed and rated seven infectious-disease-irrelevant images (Curtis et al., 2004). In the image-rating tasks, participants were instructed to rate how positive or negative they found each image on a 1 (not at all negative) to 7 (very negative) scale. Ratings were made on general valence (rather than disgust) so that the term "disgust" did not appear for participants in the control condition.

After the priming procedure, participants completed the remaining 50 face-preference trials. Then, those who had previously been assigned to the pathogen-priming condition completed the Brief HEXACO Inventory and the image-rating task of infectious-disease-irrelevant images, and those who had previously been assigned to the control-priming condition completed the Perceived Vulnerability to Disease scale, the pathogen subscale of the Three Domain Disgust Scale, and the image-rating task of infectious-disease-relevant images.

On average, participation took 12 min and 42 s, and participants were paid two British Pounds. Given the nature of the stimuli, we registered the study on Prolific as requiring a desktop computer. Data collection occurred on May 14th and May 15th, 2021, during the COVID-19 pandemic. In the Discussion (Section 4.3.4), we comment on the possibility that pandemic conditions affect the generalizability of findings.

2.4. Coding responses on the face preference tests

Responses on the face preference trials were coded as in previous studies that have used this paradigm (e.g., Jones et al., 2018; Zietsch et al., 2015). For trials assessing dimorphism preferences, responses selecting the version with exaggerated sex-typical features (i.e., the masculinized male version or feminized female version) were coded as 8, with values declining by one for each of the eight response options until the strongest preference for the version with exaggerated sex-atypical features (i.e., the feminized male version or masculinized female version) had a value of 1. Responses on trials assessing symmetry preferences were coded similarly, with the strongest preference for symmetric versions of the faces coded as 8, and the strongest preference for asymmetric versions of the faces coded as 1. These values were then centered by subtracting 4.5 so that scores ranged from −3.5 to 3.5.

2.5. Data exclusions and quality checks

Two items were used to screen for inattentive responses. The first, which was presented after all face ratings, asked participants to report the number of women pictured in an image of five EU leaders (with the correct answer being one: Angela Merkel). The second was embedded in the Brief HEXACO Inventory, and asked participants to "please select 3 on this item." Participants who respond incorrectly to either of these items were excluded from analyses. Participants were also excluded if they were not between the ages of 18 and 35, if they completed fewer than 10 out of 100 ratings, if they missed responses on any single item of the pathogen disgust subscale of the Three Domain Disgust Scale or the germ aversion subscale of the Perceived Vulnerability to Disease questionnaire, if they reported being neither male nor female, or if they did not report being primarily attracted to members of the opposite sex. Scores on the pathogen disgust subscale or the germ aversion subscale that were ± 3 standard deviations from the mean were winsorised.

2.6. Analyses

Preferences were analyzed using linear mixed-effects models using the lme4 (Bates, Mächler, Bolker, & Walker, 2015) and lmerTest (Kuznetsova, Brockhoff, and Christensen (2015) packages in *R* (R Core Team, 2013). Four separate models were conducted to analyze preferences for symmetry and dimorphism. For each preference type, we tested models with fixed effects for pre- versus post-prime, priming condition, participant sex, sex of face, and either pathogen disgust sensitivity or germ

Table 2
Summary of results.

Facial characteristic	Hypothesis	Effect tested	Parameter estimate and 95% confidence interval	*p* value	Hypothesis supported?
Dimorphism	Pathogen avoidance	Main effect of pathogen disgust	0.02 [0.00, 0.05]	.075	No
		Main effect of germ aversion	−0.02 [−0.05, 0.00]	.077	No
		Interaction between prime type and pre-post prime	−0.09 [−0.16, −0.03]	.007	No*
	Indirect benefits	Interaction between pathogen disgust, target sex, and participant sex	0.04 [−0.08, 0.17]	.489	No
		Interaction between germ aversion, target sex, and participant sex	−0.04 [−0.16, 0.08]	.529	No
		Interaction between prime type, pre-post prime, target sex, and participant sex	0.07 [−0.17, 0.32]	.567	No
Symmetry	Pathogen avoidance	Main effect of pathogen disgust	0.00 [−0.02, 0.02]	.890	No
		Main effect of germ aversion	−0.02 [−0.04, 0.01]	.157	No
		Interaction between prime type and pre-post prime	−0.04 [−0.11, 0.02]	.169	No
	Indirect benefits	Interaction between pathogen disgust, target sex, and participant sex	0.02 [−0.03, 0.07]	.532	No
		Interaction between germ aversion, target sex, and participant sex	0.00 [−0.05, 0.06]	.934	No
		Interaction between prime type, pre-post prime, target sex, and participant sex	0.06 [−0.13, 0.25]	.558	No

Statistics are based on random effects models including maximally-specified random slopes and intercepts. Target and stimulus sex are coded as −.5 = female and .5 = male. Pre-post prime is coded as −.5 pre-prime and .5 as post-prime. Priming condition is coded as −.5 = control condition and .5 = pathogen prime. No inferences changed when intercept-only models were analyzed, or when data were collapsed across stimuli. * indicates that, although the interaction was non-zero, it was not in the predicted direction (see Figure 3).

aversion (i.e., possible effect of pathogen disgust and germ aversion were examined in separate models). All continuous variables were standardized, while effects of prime condition (−.5 = control-priming, .5 = pathogen-priming), whether a face-pair was assessed before or after the prime (−.5 = pre-prime, .5 = post-prime), participant sex, and stimulus sex (−.5 = female; .5 = male) were effect-coded. Interactions between participant sex, stimulus sex, and either pathogen disgust sensitivity or germ aversion, as well as between participant sex, stimulus sex, pre-prime vs post-prime, and prime condition (control or pathogen prime) were included in each model. Random intercepts were specified for participants and stimuli. Random slopes were specified maximally (Barr, 2013; Barr, Levy, Scheepers, & Tily, 2013). In our registered report proposal, we stated that we would also analyze models in which random effects were eliminated from these models based on a backward selection scheme of likelihood ratio tests (Matuschek, Kliegl, Vasishth, Baayen, & Bates, 2017). We instead examined intercept-only models in which all random slopes were eliminated. We also analyzed data averaging across stimuli, since doing so allows for effect size estimates (e.g., Pearson *r*) comparable to those used in other studies (note that this last approach was not included in our Stage 1 proposal). No conclusions differed across approaches in which all random slopes and intercepts were modeled (the approach that we registerd, and the one reported below), only random intercepts were modeled, or responses were collapsed across stimuli. We provide point estimates and 95% confidence intervals for relevant effects. The analysis script for this project and complete analysis output can be found on the Open Science Framework (https://osf.io/kaq39/).

Main effects of pathogen disgust sensitivity or germ aversion were interpreted as indicating that individual differences in pathogen avoidance relate to preferences for symmetry and/or dimorphism, and the interaction between pre-post priming manipulation and prime type informed contextual effects on these preferences. Moderation by participant and target sex informed how to interpret this relation. If the indirect benefits interpretation is correct, then we should observe moderation by both participant sex and target sex.

3. Results

Results of tests relevant to the pathogen-avoidance and indirect-benefits hypotheses are summarized in Table 2. We present tests of primes from models that included pathogen disgust sensitivity; results for models including germ aversion were effectively the same. Correlations between variables collapsing across stimuli are provided in the online supplement (Tables S1 through S3), as are mean symmetry and dimorphism preferences and standard deviations (again, collapsing across stimuli) for same- and opposite-sex faces before and after primes (Tables S4 through S9). We provide a narrative description of these results below.

3.1. Dimorphism preferences

In general, evidence was not consistent with predictions derived from the pathogen-avoidance hypothesis. We did not detect a relation between pathogen disgust sensitivity and preferences for facial dimorphism, $b = 0.02$, 95%CI [0.00, 0.05], $t(599) = 1.79$, $p = .075$ (see Figure 2). Although the direction of the effect was consistent with the pathogen-avoidance hypothesis, and the *p* value approached .05, the relation between dimorphism preferences and germ aversion – the other variable frequently interpreted as reflecting pathogen-avoidance motives – was in the opposite direction, and of a similar magnitude, $b = -0.02$, 95%CI [−0.05, 0.00], $t(951) = -1.77$, $p = .077$. Collapsing across stimuli, the bivariate correlations approached zero (.05 and − .05 for pathogen disgust sensitivity and germ aversion; see Table S1 in the online supplement). While we did detect an interaction between time of preference assessment (pre- versus post-prime) and prime condition (control versus pathogen), $b = -0.09$, 95%CI [−0.16, −0.03], $t(138) = -2.76$, $p = .007$, the effect was in the opposite direction of that predicted by the pathogen-avoidance hypothesis (a finding similar to that reported in another recent paper; Saribay, Tureček, Paluch, & Kleisner, 2021). That is, within the pathogen-prime condition, preferences for facial dimorphism were directionally lower, rather than higher, after the pathogen prime (see Fig. 3).

Evidence was also not consistent with the indirect-benefits hypothesis. The interaction between pathogen disgust sensitivity, participant sex, and target sex was non-significant, $b = 0.04$, 95%CI [−0.08, 0.17], $t(949) = 0.69$, $p = .489$, as was the interaction between germ aversion, participant sex, and target sex, $b = -0.04$, 95%CI [−0.16, 0.08], $t(771) = -0.63$, $p = .529$ (see Fig. 2). We similarly did not detect an interaction between participant sex, target sex, pre- versus post-prime, and prime condition, $b = 0.07$, 95%CI [−0.17, 0.32], $t(149) = 0.57$, $p = .567$. Collapsing across stimuli, we did not detect relations between pathogen disgust sensitivity or germ aversion and men's preferences for dimorphism in female targets (*r*'s = .05 and − .01, respectively), nor did we detect relations between these variables and women's preferences for dimorphism in male targets (*r*'s = −.01 and − .03, respectively) (see Tables S2 and S3).

Independent of pathogen-avoidance variables, the model intercept for dimorphism preferences was non-zero, meaning that, across participant sex and target sex, more dimorphic faces were preferred, $b = 0.34$, 95%CI [0.27, 0.42], $t(115) = 8.94$, $p < .001$. The main effect of stimulus

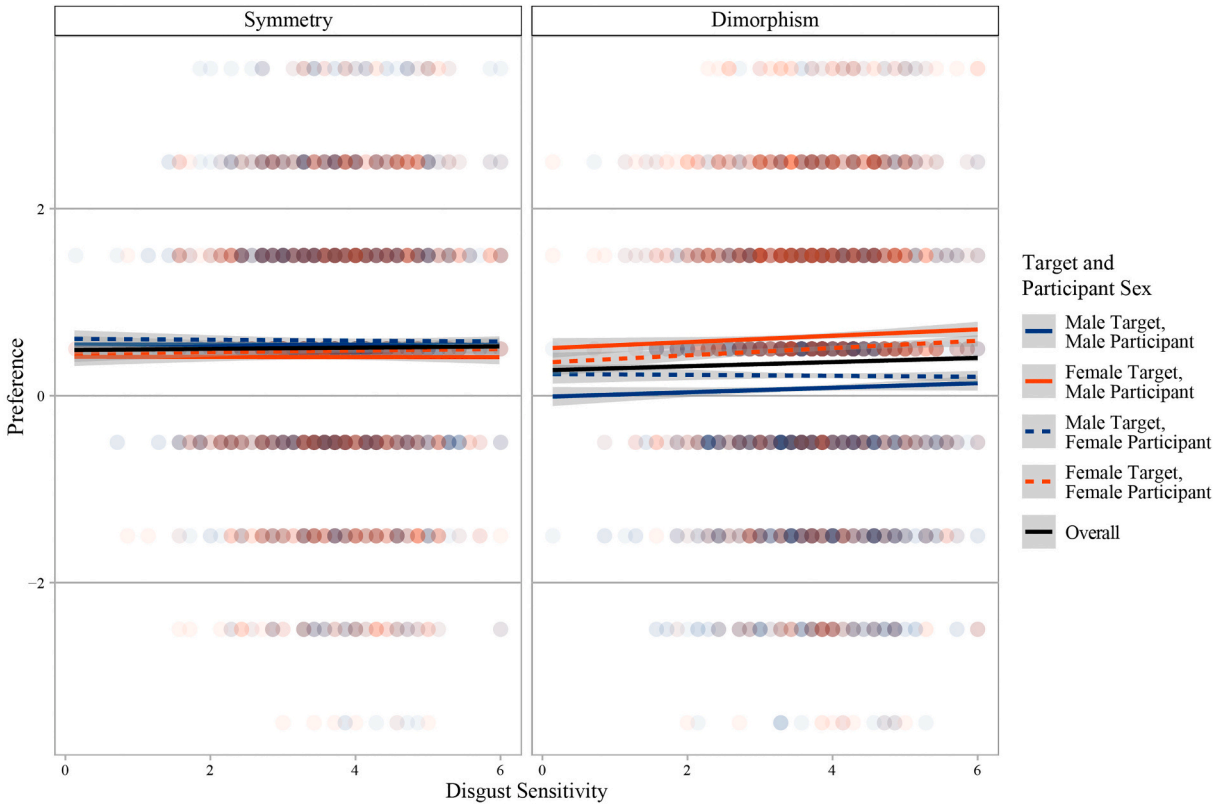

Fig. 2. Relations between pathogen disgust sensitivity and preferences for facial symmetry and sexual dimorphism.
Main effects of pathogen disgust sensitivity on preferences for facial symmetry ($b = 0.00$, $p = .890$) and sexual dimorphism ($b = 0.02$, $p = .075$).

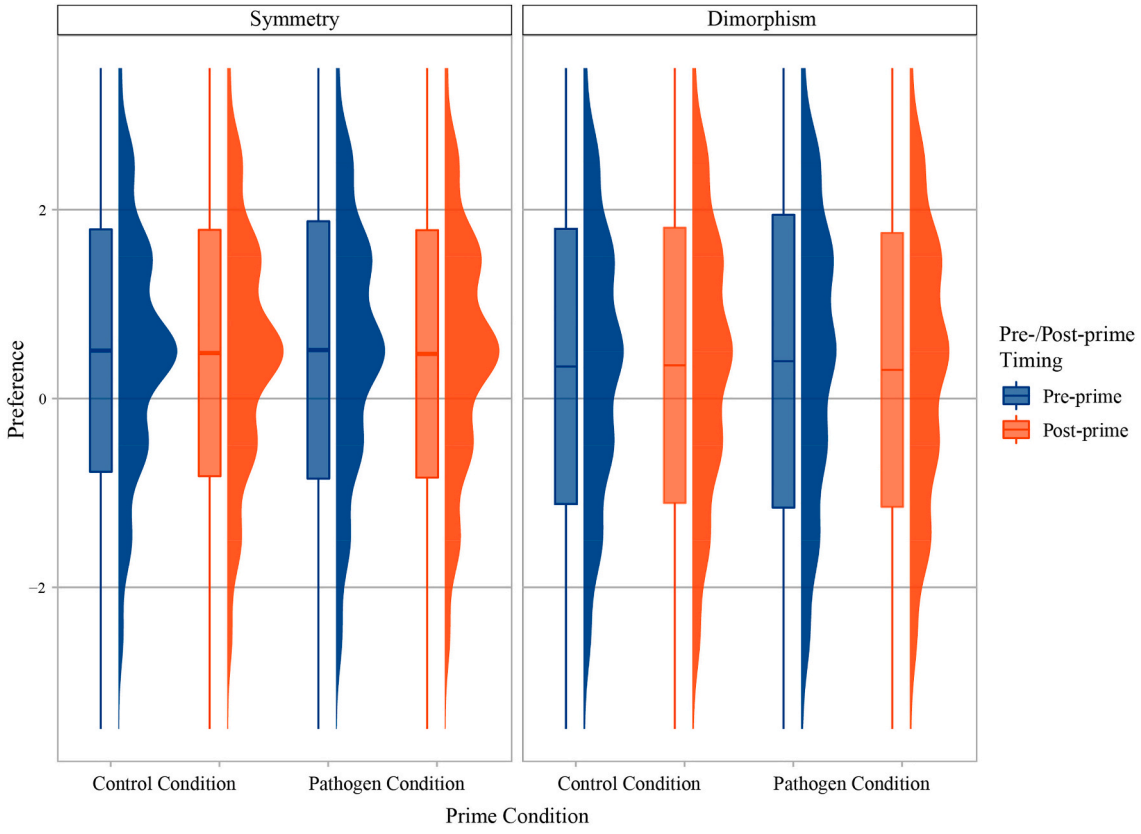

Fig. 3. Preferences for facial symmetry and sexual dimorphism before and after primes in control and pathogen prime conditions.
Box and whisker plots showing means, standard deviation intervals, and the range of the responses (whiskers), with rotated smoothed density plots on the right. Higher values on the y-axis indicate a greater preference for more symmetric versions of faces or more dimorphic versions of faces (i.e., more feminine for female targets and more masculine for male targets).

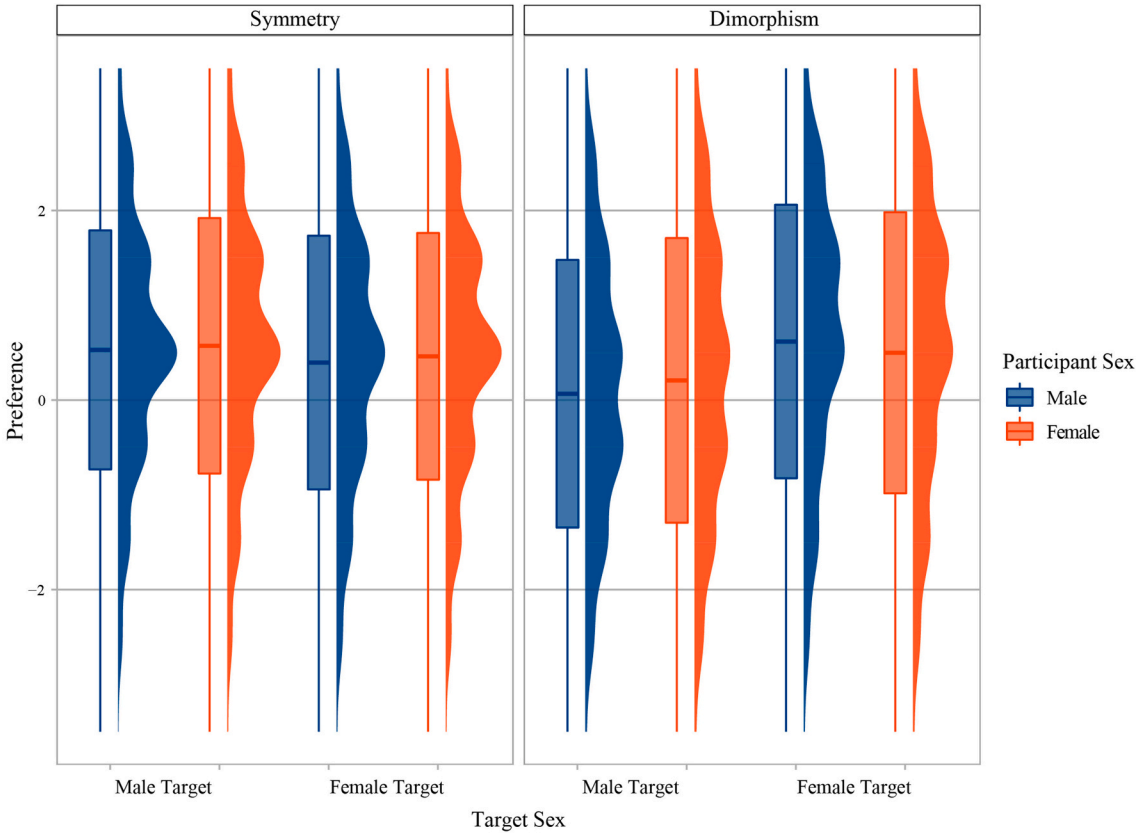

Fig. 4. Preferences for facial symmetry and sexual dimorphism in male and female targets across male and female participants.
Box and whisker plots showing means, standard deviation intervals, and the range of the responses (whiskers), with rotated smoothed density plots on the right. Higher values on the y-axis indicate a greater preference for more symmetric versions of faces or more dimorphic versions of faces (i.e., more feminine for female targets and more masculine for male targets).

sex indicated that more dimorphic facial structures were preferred more in female targets than in male targets, $b = -0.42$, 95%CI [−0.59, −0.27], $t(129) = -5.33$, $p < .001$. And this preference was further moderated by participant sex $b = -0.27$, 95%CI [−0.40, −0.14], $t(639) = -3.98$, $p < .001$, with women preferring dimorphic male targets more than men ($M = 0.20$ versus $M = 0.06$; collapsing across stimuli, $d = .24$), but preferring dimorphic female targets less than men ($M = 0.49$ versus $M = 0.62$; collapsing across stimuli, $d = .20$) (see Fig. 4).

3.2. Symmetry preferences

As with dimorphism preferences, findings were not consistent with predictions derived from the pathogen-avoidance hypothesis. We did not detect a main effect of pathogen disgust sensitivity on symmetry preferences, $b = 0.001$, 95%CI [−0.02, 0.02], $t(948) = 0.14$, $p = .890$, nor did we detect a main effect on germ aversion on symmetry preferences, $b = -0.02$ 95%CI [−0.04, 0.01], $t(621) = -1.42$, $p = .157$. Collapsing across stimuli, the bivariate correlations approached zero (.02 and − .03 for pathogen disgust sensitivity and germ aversion, respectively; see Table S1 in the online supplement). We also did not detect an interaction between time of preference assessment (pre- versus post-prime) and prime condition (control versus pathogen), $b = -0.04$, 95%CI [−0.11, 0.02], $t(472) = -1.38$, $p = .169$ (see Fig. 3).

Similarly, we did not detect relations consistent with the indirect-benefits hypothesis. The interaction between pathogen disgust sensitivity, participant sex, and target sex was non-significant, $b = 0.02$, 95% CI [−0.03, 0.07], $t(955) = 0.63$, $p = .532$, as was the interaction between priming manipulation, time or preference assessment, participant sex, and target sex, $b = 0.06$, 95%CI [−0.13, 0.25], $t(85) = 0.59$, $p = .558$. Collapsing across stimuli, we did not detect relations between pathogen disgust sensitivity or germ aversion and men's preferences for symmetry in female targets (r's = .01 and − .02, respectively), nor did we detect relations between these variables and women's preferences for symmetry in male targets (r's = −.02 and − .06, respectively) (see Tables S2 and S3).

As with dimorphism preferences, the model intercept was non-zero, meaning that more symmetric faces were preferred over less symmetric ones, $b = 0.49$, 95%CI [0.42, 0.56], $t(117) = 13.69$, $p < .001$. In contrast with preferences for dimorphism, though, preferences for symmetry did not vary across male versus female targets, $b = 0.12$, 95%CI [−0.01, 0.26], $t(99) = 1.81$, $p = .073$, nor did participant sex interact with target sex, $b = 0.01$, 95%CI [−0.04, 0.07], $t(125) = 0.53$, $p = .600$ (see Fig. 4).

4. Discussion

The current registered report evaluated the relation between pathogen-avoidance motives and preferences for facial symmetry and dimorphism. It sought to test whether any such relation applied to preferences for both same- and opposite-sex targets – a phenomenon that might result from these features being interpreted as cues to infectiousness – or only in opposite sex targets – a phenomenon that might result from these features being treated as information regarding indirect benefits (i.e., genes that increase offspring fitness). Using a set of 100 target faces and a sample of 954 participants, we did not detect evidence consistent with either perspective. That is, we did not detect a relation between individual differences measures (pathogen disgust sensitivity and germ aversion) and general preferences for facial symmetry or dimorphism, nor did we detect a difference in this relation across same- and opposite-sex faces. Similarly, we did not detect an effect of a pathogen prime (relative to a control prime) on preferences for

symmetry or dimorphism, nor did we detect differences in such preferences across same- versus opposite-sex targets. We discuss the implications of these findings for both the behavioral immune system literature and the face preferences literature below.

4.1. Implications for the behavioral immune system and face preferences

The null results observed here have some implications for how we view the functional specificity of the behavioral immune system. Current thinking conceptualizes the behavioral immune system as a suite of psychological mechanisms that monitor the environment for features that correlate with pathogen presence (i.e., cues to pathogens) and, when those features are detected, motivates behaviors that reduce the likelihood of infection (Ackerman et al., 2018; Schaller & Duncan, 2007; Lieberman & Patrick, 2014; Tybur & Lieberman, 2016). Byproducts of infection in conspecifics are some of the best candidates for such cues. And, indeed, people can distinguish between individuals experiencing an immune response from those who are not (Arshamian et al., 2021), and they avoid (and are sometimes disgusted by) individuals with rashes, ulcers, and pustules on their faces – some of the key symptoms of communicable diseases (Curtis et al., 2004; Kurzban & Leary, 2001; Oaten et al., 2011).

Following the logic presented in previous work investigating the relation between pathogen avoidance and preferences for facial symmetry and/or dimorphism, the hypotheses tested here were based on the idea that facial symmetry and dimorphism provide information regarding health, and that the behavioral immune system should motivate preferences for healthy targets (and, perhaps especially, healthy mates). However, features perceived as "healthy" need not be treated as information regarding infection threat. Health can refer to absence of infectious disease, but it can also refer to a number of other aspects of condition, including the absence of non-contagious parasites, the absence of non-contagious metabolic diseases, the absence of injury, the absence of psychopathology, etc. Just as the behavioral immune system should not be expected to influence fear of tigers or heights, both of which can be thought of as preserving some aspect of "health", it should not be expected to influence preferences for facial symmetry or dimorphism unless those features act as cues to infectiousness. Given that the structural features that give rise to variation in facial symmetry and dimorphism are fairly stable across the lifespan – and given recent findings suggesting that dimorphism and symmetry (along with multiple other aspects of facial appearance) have poor validity as cues to multiple dimensions of health that might relate to infection proneness (Foo, Simmons, & Rhodes, 2017, Cai et al., 2019; see Jones, Holzleitner, & Shiramizu, 2021) – they are unlikely candidates as infection cues. These considerations (and, naturally, the results of the current study) raise questions regarding interpretations of earlier findings that pathogen avoidance relates to preferences for facial symmetry and dimorphism.

4.2. Implications regarding preferences for facial symmetry and dimorphism

Although this investigation was designed to evaluate the relation between pathogen avoidance and preferences for facial symmetry and dimorphism, its sample size and other design features (e.g., assessment of both same- and opposite-sex preferences for both facial symmetry and dimorphism) can contribute to the field's understanding of preferences for symmetry and dimorphism, at least in the population sampled from here. Consider, for example, comparing the current results with those reported by Little, Jones, DeBruine, and Feinberg (2008), who inferred that symmetry and dimorphism provide common information based on the observation that preferences for facial dimorphism correlate with preferences for facial symmetry. The current study similarly detected a positive relation between preferences for facial symmetry and preferences for facial dimorphism (see Table S1). It also replicates other findings reported by Little et al.: that men prefer dimorphism in female faces more than women do, and that women prefer dimorphism in male faces more than men do. However, it did not replicate a third finding from the same paper: that symmetry preferences are contingent on the sex of the rater and the target. Instead, we found that symmetric faces were preferred equally in same-sex and opposite-sex targets, for both men and women. The current data might prove useful for evaluating the robustness of other findings in the face preferences literature.

4.3. Limitations and future directions

4.3.1. Statistical power and potential false negatives

Non-significant results can emerge for multiple reasons, including experimenter error or participant inattention. Multiple aspects of our findings suggest that neither of these factors explains the critical null findings observed here. The fact that we detected global preferences for facial symmetry and facial dimorphism – with the latter preference moderated by participant sex and target sex – suggests that participants were (1) able to detect these features and (2) preferred them in a manner consistent with past studies sampling from the same population. Other incidental findings discount the null results reflecting systematic errors in data collection. For example, the sex difference in pathogen disgust sensitivity observed here ($d = .41$) was virtually identical to the meta-analyzed sex difference observed in a study of 11,501 participants across 30 nations ($d = .41$) (Tybur et al., 2016).

Even without experimenter error or participant inattention, null results can still reflect Type II errors. In random effects designs such as the one employed here, the probability of making such errors is influenced by myriad factors, including (1) the magnitude of the fixed effect(s), (2) the number of participants, (3) the number of stimuli, (4) variance accounted for by participants, (5) variance accounted for by stimuli, (6) variance in the relation between participant-level individual differences (e.g., pathogen disgust sensitivity) and preferences across different stimuli, etc. We aimed to minimize the probability of making such Type II errors, even if effect sizes were small, by (1) having a large sample size ($N = 954$), (2) having a large pool of stimuli ($N = 100$), and (3) manipulating multiple factors within-participants. However, because we were unable to model all random effect components in our power analyses, results from these power analyses might be imprecise, and we cannot state with confidence the effect sizes that we had adequate power (>80%) to detect. Nevertheless, inspection of the 95% confidence intervals around effect size estimates can provide an idea of the uncertainty in our parameter estimates and the plausible upper bounds of population-level effect sizes (see Table 2). These confidence intervals are narrow and largely centered around zero. Inspection of the confidence intervals collapsing across stimuli can also be informative (see Tables S1–S3), since most prior studies in this literature have not used random effects analyses. Using this approach, the upper limit of the 95% confidence interval for the main effect of pathogen disgust sensitivity on facial dimorphism preferences was $r = .12$, and the upper limit of the 95% confidence interval for the relation between pathogen disgust sensitivity and facial symmetry preferences was $r = .08$. Given the nature of the indirect benefits hypothesis, confidence intervals around simple effects within participant sex by target sex interactions (for both symmetry and dimorphism preferences, and for both pathogen disgust and germ aversion as predictors) can also be informative, especially concerning cross-sex preferences. For men, none of the upper limits of these confidence intervals exceeded $r = .15$; for women, none exceeded $r = .07$. In total, these results suggest that any relations we failed to detect are likely to be small in magnitude. Future studies on this topic should be designed to detect effect sizes no larger than the upper limits of these confidence intervals.

4.3.2. Validity of the dependent measure and stimuli

In line with previous studies in this literature, we investigated the degree to which pathogen-avoidance motives relate to attraction to facial symmetry and sexual dimorphism. Perceptions of attractiveness

need not fully regulate the physical proximity, direct contact, or indirect contact that influences pathogen transmission, though. Recent studies in the pathogen-avoidance literature have asked participants how comfortable they would be with physical contact with a target (e.g., Van Leeuwen & Petersen, 2018), and one of these studies found only a modest relationship between target facial attractiveness and contact comfort (Tybur, Lieberman, Fan, Kupfer, & de Vries, 2020). Although the current study did not detect a relation between pathogen avoidance and attraction to facial symmetry or dimorphism, future research could better test whether people are more averse to infection-risky acts with individuals with low dimorphism or low symmetry faces (cf. Kupfer, 2018; Ryan et al., 2012).

As is standard in this literature, we used a two-alternative forced-choice response format. Recent work has suggested that this method partially assess face matching ability rather than variation in preferences (Lewis, 2020), and that it can produce results that differ from those obtained with paradigms in which individual faces are rated for attractiveness (Jones & Jaeger, 2019; Lee, De La Mare, Moore, & Umeh, 2021). Also following standard procedures in this literature, we manipulated base faces to be 50% more similar to male or female prototypes (for the dimorphism manipulation) or 50% more or less similar to a perfectly symmetric version of the base face. We cannot rule out the possibility that pathogen avoidance would relate to preferences for facial dimorphism or symmetry if transformations were more or less extreme.

4.3.3. Effects of the COVID-19 pandemic

We collected data in May 2021, after approximately 4,500,000 COVID-19 cases and 125,000 deaths had been confirmed in the UK in the 14 months since the pandemic began (Roser, 2021). Some recent work has argued that the SARS-CoV-2 outbreak has increased pathogen disgust sensitivity (Boggs, Ruisch, & Fazio, 2022; Stevenson, Saluja, & Case, 2021). Such increases, if sufficiently strong, could attenuate the relation between pathogen disgust sensitivity and preferences for facial symmetry or dimorphism. Our data give no reason to suspect that pathogen disgust sensitivity was unusually high in the population we sampled from, though. The mean observed here was virtually indistinct (and, if anything, slightly lower) from that in the sample of U.S. college students ($N = 507$) used to validate the Three-Domain Disgust Scale (Tybur et al., 2009) and that in a large ($N = 7166$) online English-speaking sample recruited shortly before the pandemic (O'Shea, DeBruine, & Jones, 2019) (see the online supplement for more details). There are also reasons to question whether, how, and why the presence of SARS-CoV-2 would affect how the behavioral immune system detects or processes cues to pathogens. Like many other respiratory pathogens, SARS-CoV-2 is largely spread via invisible respiratory droplets and aerosols expelled when (often asymptomatic or pre-symptomatic) individuals breath, talk, or sing (Greenhalgh et al., 2021). Those infected with SARS-CoV-2 typically exhibit symptoms similar to those caused by the myriad endemic respiratory pathogens that circulated widely before the COVID-19 pandemic (e.g., coughing, sneezing, headache, fatigue, fever) (Tostmann et al., 2020). And, while SARS-CoV-2 causes serious illness in some people, its appearance coincided with the virtual elimination of many other respiratory viruses from circulation (Yeoh et al., 2021). These reasons raise doubts that the pandemic conditions that began in early 2020 would affect the behavioral immune system, at least via increases in the presence of detectable transmission risks, changes in observable illness symptoms in others, or increases in encounters with pathogens oneself (Ackerman, Tybur, & Blackwell, 2021). Future work can clarify whether, how, and why the pandemic affects the behavioral immune system in other manners.

4.3.4. Generalizability to other populations

The current study sampled from a population of young adult (<35) heterosexual White individuals from the UK, and it assessed attraction toward young adult White targets. Some findings indicate that preferences for facial dimorphism – perhaps especially in male targets – varies across ecologies (DeBruine, Jones, Crawford, Welling, & Little, 2010; Marcinkowska et al., 2019; Scott et al., 2014), as do preferences for at least some other dimensions of facial appearance (e.g., coloration; Han et al., 2018). Hence, our findings might not generalize to other populations. However, most studies that have reported relations between pathogen avoidance and preferences for facial symmetry or dimorphism have sampled from similar populations and assessed attraction toward similar targets (though see Saribay et al., 2021 and Zheng et al., 2016). Future work could certainly test whether pathogen avoidance relates to such preferences in other populations, even if such a relationship does not exist in the population sampled from here.

4.3.5. Validity of priming method and concluding thoughts

Most studies in the behavioral immune system literature assess individual differences in pathogen-avoidance motives using either the Perceived Vulnerability to Disease Scale or the Three-Domain Disgust Scale (Oosterhoff, Shook, & Iyer, 2018; Tybur et al., 2014). Multiple studies have clarified the validity of these instruments (e.g., Duncan et al., 2009; Tybur et al., 2009). There is less consistency in approaches used to experimentally manipulate pathogen-avoidance motives and, relatedly, less evidence supporting the validity of these procedures. For example, studies have reported that each of the following experimental manipulations produces effects consistent with behavioral immune system hypotheses: (1) asking participants to consciously reflect upon past experiences with infection (e.g., Moran et al., 2021; Murray, Kerry, & Gervais, 2019); (2) exposing participants to olfactory cues to pathogens (e.g., Tybur, Bryan, Magnan, & Hooper, 2011); (3) having participants read essays describing pathogen-risky situations (e.g., White, Kenrick, & Neuberg, 2013); (4) having participants complete a disgust sensitivity instrument immediately before the dependent measure (e.g., Lee & Zietsch, 2011; Navarrete & Fessler, 2006; Watkins et al., 2012); and (5) exposing participants to disgust-eliciting images or slideshows showcasing pathogen risks (e.g., Faulkner, Schaller, Park, & Duncan, 2004; Hill, Prokosch, & DelPriore, 2015; Mortensen, Becker, Ackerman, Neuberg, & Kenrick, 2010; Park, Schaller, & Crandall, 2007). Using a combination of those last two approaches – methods used in studies that have reported effects of pathogen primes on preferences for facial symmetry or dimorphism (Ainsworth & Maner, 2019; Little et al., 2010; Watkins et al., 2012; Young et al., 2011) – we did not detect an effect of the priming manipulation. Other recent studies have similarly reported not detecting effects of pathogen primes on, among other things, conformity (Van Leeuwen & Petersen, 2021), political attitudes (Shook & Oosterhoff, 2020), moral sentiments (Makhanova, Plant, Monroe, & Maner, 2019), and attitudes toward immigrants (Ji, Tybur, & van Vugt, 2019). Following these null findings, the behavioral immune system literature would benefit from large-scale, registered, collaborative work using multiple priming approaches to test the same hypothesis. Such an endeavor would be valuable for multiple reasons. Like the current study, it could be used to replicate studies that used methods that, in retrospect, might not be as robust as originally assumed. It could also give an unbiased assessment of the effect sizes that researchers should expect from priming methods; such an assessment would prove valuable for future study designs. And it could indicate which of the multiple manipulations used in the literature – from images to essays to odors – give rise to the largest of such effect sizes. In sum, taking a look at the methods and results used in past behavioral immune system work can improve future developments in this area.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

This research was supported by Horizon 2020 European Research Council Grant StG-2015 680002-HBIS.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.evolhumbehav.2022.01.003.

References

Ackerman, J. M., Hill, S. E., & Murray, D. R. (2018). The behavioral immune system: Current concerns and future directions. *Social and Personality Psychology Compass, 12*, Article e12371. https://doi.org/10.1111/spc3.12371

Ackerman, J. M., Tybur, J. M., & Blackwell, A. D. (2021). What role does pathogen-avoidance psychology play in pandemics? *Trends in Cognitive Sciences, 25*(3), 177–186. https://doi.org/10.1016/j.tics.2020.11.008

Ainsworth, S. E., & Maner, J. K. (2019). Pathogen avoidance mechanisms affect women's preference for symmetrical male faces. *Evolutionary Behavioral Sciences, 13*, 265–271. https://doi.org/10.1037/ebs0000139

Arshamian, A., Sundelin, T., Wnuk, E., O'Meara, C., Burenhult, N., Rodriguez, G. G., & Majid, A. (2021). Human sickness detection is not dependent on cultural experience. *Proceedings of the Royal Society B, 288*(1954), 20210922. https://doi.org/10.1098/rspb.2021.0922

Barr, D. J. (2013). Random effects structure for testing interactions in linear mixed-effects models. *Frontiers in Psychology, 4*. https://doi.org/10.3389/fpsyg.2013.00328. Article 328.

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language, 68*(3), 255–278. https://doi.org/10.1016/j.jml.2012.11.001

Bates, D., Mächler, M., Bolker, B. M., & Walker, S. C. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*(1), 1–48.

Boggs, S. T., Ruisch, B. C., & Fazio, R. H. (2022). Concern about salient pathogen threats increases sensitivity to disgust. *Personality and Individual Differences, 186*, Article 111348. https://doi.org/10.1016/j.paid.2021.111348

Boothroyd, L. G., Scott, I., Gray, A. W., Coombes, C. I., & Pound, N. (2013). Male facial masculinity as a cue to health outcomes. *Evolutionary Psychology, 11*. https://doi.org/10.1177/147470491301100508, 147470491301100508.

Brooks, R., Scott, I. M., Maklakov, A. A., Kasumovic, M. M., Clark, A. P., & Penton-Voak, I. S. (2010). National income inequality predicts women's preferences for masculinized faces better than health does. *Proceedings of the Royal Society B, 278*, 810–812. https://doi.org/10.1098/rspb.2010.0964

Brown, M., & Sacco, D. F. (2019). How and when crowd salience activates pathogen-avoidant motives. *Evolutionary Behavioral Sciences.*. https://doi.org/10.1037/ebs0000191

Button, K. S., Ioannidis, J. P., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S., & Munafò, M. R. (2013). Power failure: Why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience, 14*, 365–376. https://doi.org/10.1038/nrn3475

Cai, Z., Hahn, A. C., Zhang, W., Holzleitner, I. J., Lee, A. J., DeBruine, L. M., & Jones, B. C. (2019). No evidence that facial attractiveness, femininity, averageness, or coloration are cues to susceptibility to infectious illnesses in a university sample of young adult women. *Evolution and Human Behavior, 40*, 156–159. https://doi.org/10.1016/j.evolhumbehav.2018.10.002

Clarkson, T. R., Sidari, M. J., Sains, R., Alexander, M., Harrison, M., Mefodeva, V., & Dixson, B. J. (2020). A multivariate analysis of women's mating strategies and sexual selection on men's facial morphology. *Royal Society Open Science, 7*, Article 191209. https://doi.org/10.1098/rsos.191209

Curtis, V., Aunger, R., & Rabie, T. (2004). Evidence that disgust evolved to protect from risk of disease. *Proceedings of the Royal Society of London. Series B: Biological Sciences, 271*, S131–S133. https://doi.org/10.1098/rsbl.2003.0144

De Vries, R. E. (2013). The 24-item brief HEXACO inventory (BHI). *Journal of Research in Personality, 47*, 871–880. https://doi.org/10.1016/j.jrp.2013.09.003

DeBruine, L. M. (2018). WebMorph (Version v0.0.0.9001). *Zenodo*. https://doi.org/10.5281/zenodo.1162670

DeBruine, L. M., & Jones, B. C. (2020). *3DSK face set with webmorph templates*. https://doi.org/10.17605/OSF.IO/A3947

DeBruine, L. M., Jones, B. C., Crawford, J. R., Welling, L. L., & Little, A. C. (2010). The health of a nation predicts their mate preferences: Cross-cultural variation in women's preferences for masculinized male faces. *Proceedings of the Royal Society B: Biological Sciences, 277*, 2405–2410. https://doi.org/10.1098/rspb.2009.2184

DeBruine, L. M., Jones, B. C., Tybur, J. M., Lieberman, D., & Griskevicius, V. (2010). Women's preferences for masculinity in male faces are predicted by pathogen disgust, but not by moral or sexual disgust. *Evolution and Human Behavior, 31*, 69–74. https://doi.org/10.1016/j.evolhumbehav.2009.09.003

Duncan, L. A., Schaller, M., & Park, J. H. (2009). Perceived vulnerability to disease: Development and validation of a 15-item self-report instrument. *Personality and Individual Differences, 47*, 541–546. https://doi.org/10.1016/j.paid.2009.05.001

Faulkner, J., Schaller, M., Park, J. H., & Duncan, L. A. (2004). Evolved disease-avoidance mechanisms and contemporary xenophobic attitudes. *Group Processes & Intergroup Relations, 7*(4), 333–353. https://doi.org/10.1177/1368430204046142

Foo, Y. Z., Simmons, L. W., & Rhodes, G. (2017). Predictors of facial attractiveness and health in humans. *Scientific Reports, 7*(1), 1–12. https://doi.org/10.1038/srep39731

Green, P., & MacLeod, C. J. (2016). SIMR: An R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution, 7*, 493–498. https://doi.org/10.1111/2041-210X.12504

Greenhalgh, T., Jimenez, J. L., Prather, K. A., Tufekci, Z., Fisman, D., & Schooley, R. (2021). Ten scientific reasons in support of airborne transmission of SARS-CoV-2. *The Lancet, 397*(10285), 1603–1605. https://doi.org/10.1016/S0140-6736(21)00869-2

Han, C., Wang, H., Hahn, A. C., Fisher, C. I., Kandrik, M., Fasolt, V., & Jones, B. C. (2018). Cultural differences in preferences for facial coloration. *Evolution and Human Behavior, 39*, 154–159. https://doi.org/10.1016/j.evolhumbehav.2017.11.005

Hill, S. E., Prokosch, M. L., & DelPriore, D. J. (2015). The impact of perceived disease threat on women's desire for novel dating and sexual partners: Is variety the best medicine? *Journal of Personality and Social Psychology, 109*(2), 244–261. https://doi.org/10.1037/pspi0000024

Ji, T., Tybur, J. M., & van Vugt, M. (2019). Generalized or origin-specific out-group prejudice?: The role of temporary and chronic pathogen-avoidance motivation in intergroup relations. *Evolutionary Psychology, 17*(1). https://doi.org/10.1177/1474704919826851, 1474704919826851.

Jones, A. L., & Jaeger, B. (2019). Biological bases of beauty revisited: The effect of symmetry, averageness, and sexual dimorphism on female facial attractiveness. *Symmetry, 11*(2), 279. https://doi.org/10.3390/sym11020279

Jones, B. C., DeBruine, L. M., Flake, J. K., Liuzza, M. T., Antfolk, J., Arinze, N. C., & Sirota, M. (2021). To which world regions does the valence–dominance model of social perception apply? *Nature Human Behaviour, 1-9*. https://doi.org/10.1038/s41562-020-01007-2

Jones, B. C., Feinberg, D. R., Watkins, C. D., Fincher, C. L., Little, A. C., & DeBruine, L. M. (2012). Pathogen disgust predicts women's preferences for masculinity in men's voices, faces, and bodies. *Behavioral Ecology, 24*, 373–379. https://doi.org/10.1093/beheco/ars173

Jones, B. C., Hahn, A. C., & DeBruine, L. M. (2019). Ovulation, sex hormones, and women's mating psychology. *Trends in Cognitive Sciences, 23*, 51–62. https://doi.org/10.1016/j.tics.2018.10.008

Jones, B. C., Hahn, A. C., Fisher, C. I., Wang, H., Kandrik, M., Han, C., & O'Shea, K. J. (2018). No compelling evidence that preferences for facial masculinity track changes in women's hormonal status. *Psychological Science, 29*, 996–1005. https://doi.org/10.1177/0956797618760197

Jones, B. C., Holzleitner, I. J., & Shiramizu, V. (2021). Does facial attractiveness really signal immunocompetence? *Trends in Cognitive Sciences.*. https://doi.org/10.1016/j.tics.2021.09.003

Judd, C. M., Westfall, J., & Kenny, D. A. (2012). Treating stimuli as a random factor in social psychology: A new and comprehensive solution to a pervasive but largely ignored problem. *Journal of Personality and Social Psychology, 103*, 54–69. https://doi.org/10.1037/a0028347

Kupfer, T. R. (2018). Why are injuries disgusting? Comparing pathogen avoidance and empathy accounts. *Emotion, 18*(7), 959–970. https://doi.org/10.1037/emo0000395

Kurzban, R., & Leary, M. R. (2001). Evolutionary origins of stigmatization: The functions of social exclusion. *Psychological Bulletin, 127*, 187–208. https://doi.org/10.1037/0033-2909.127.2.187

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2015). lmerTest: Tests for random and fixed effects for linear mixed effect models. Retrieved from https://CRAN.R-project.org/package=lmerTest.

Lee, A. J., De La Mare, J. K., Moore, H. R., & Umeh, P. C. (2021). Preference for facial symmetry depends on study design. *Symmetry, 13*(9), 1637. https://doi.org/10.3390/sym13091637

Lee, A. J., & Zietsch, B. P. (2011). Experimental evidence that wo'en's mate preferences are directly influenced by cues of pathogen prevalence and resource scarcity. *Biology Letters, 7*(6), 892–895. https://doi.org/10.1098/rsbl.2011.0454

Lee, A. J., & Zietsch, B. P. (2015). Wo'en's pathogen disgust predicting preference for facial masculinity may be specific to age and study design. *Evolution and Human Behavior, 36*, 249–255. https://doi.org/10.1016/j.evolhumbehav.2014.12.001

Lewis, M. B. (2020). Challenges to both reliability and validity of masculinity-preference measures in menstrual-cycle-effects research. *Cognition, 197*, Article 104201. https://doi.org/10.1016/j.cognition.2020.104201

Lieberman, D., & Patrick, C. (2014). Are the behavioral immune system and pathogen disgust identical? *Evolutionary Behavioral Sciences, 8*(4), 244–250. https://doi.org/10.1037/ebs0000018

Little, A. C., DeBruine, L. M., & Jones, B. C. (2010). Exposure to visual cues of pathogen contagion changes preferences for masculinity and symmetry in opposite-sex faces. *Proceedings of the Royal Society B: Biological Sciences, 278*, 2032–2039. https://doi.org/10.1098/rspb.2010.1925

Little, A. C., Jones, B. C., DeBruine, L. M., & Feinberg, D. R. (2008). Symmetry and sexual dimorphism in human faces: Interrelated preferences suggest both signal quality. *Behavioral Ecology, 19*(4), 902–908. https://doi.org/10.1093/beheco/arn049

Makhanova, A., Plant, E. A., Monroe, A. E., & Maner, J. K. (2019). Binding together to avoid illness: Pathogen avoidance and moral worldviews. *Evolutionary Behavioral Sciences, 13*(2), 182–204. https://doi.org/10.1037/ebs0000141

Marcinkowska, U. M., Rantala, M. J., Lee, A. J., Kozlov, M. V., Aavik, T., Cai, H., … Onyishi, I. E. (2019). Women's preferences for men's facial masculinity are strongest under favorable ecological conditions. *Scientific Reports, 9*, 3387. https://doi.org/10.1038/s41598-019-39350-8

Matuschek, H., Kliegl, R., Vasishth, S., Baayen, H., & Bates, D. (2017). Balancing type I error and power in linear mixed models. *Journal of Memory and Language, 94*, 307–315. https://doi.org/10.1016/j.jml.2017.01.001

McIntosh, T. L., Lee, A. J., Sidari, M. J., Stower, R. E., Sherlock, J. M., & Dixson, B. J. (2017). Microbes and masculinity: Does exposure to pathogenic cues alter women's preferences for male facial masculinity and beardedness? *PLoS One, 12*, Article e0178206. https://doi.org/10.1371/journal.pone.0178206

Moran, J. B., Kerry, N., Goh, J. X., & Murray, D. R. (2021). Parasites and promiscuity: Acute disease salience leads to more restricted sexual attitudes. *Journal of Social and Personal Relationships, 38*(11), 3333–3349. https://doi.org/10.1177/02654075211030999

Mortensen, C. R., Becker, D. V., Ackerman, J. M., Neuberg, S. L., & Kenrick, D. T. (2010). Infection breeds reticence: The effects of disease salience on self-perceptions of personality and behavioral avoidance tendencies. *Psychological Science, 21*(3), 440–447. https://doi.org/10.1177/0956797610361706

Murray, D. R., Kerry, N., & Gervais, W. M. (2019). On disease and deontology: Multiple tests of the influence of disease threat on moral vigilance. *Social Psychological and Personality Science, 10*(1), 44–52. https://doi.org/10.1177/1948550617733518

Murray, D. R., & Schaller, M. (2016). The behavioral immune system: Implications for social cognition, social interaction, and social influence. *Advances in Experimental Social Psychology, 53*, 75–129. https://doi.org/10.1016/bs.aesp.2015.09.002

Navarrete, C. D., & Fessler, D. M. (2006). Disease avoidance and ethnocentrism: The effects of disease vulnerability and disgust sensitivity on intergroup attitudes. *Evolution and Human Behavior, 27*(4), 270–282. https://doi.org/10.1016/j.evolhumbehav.2005.12.001

Neuberg, S. L., Kenrick, D. T., & Schaller, M. (2011). Human threat management systems: Self-protection and disease-avoidance. *Neuroscience & Biobehavioral Reviews, 35*, 1042–1051. https://doi.org/10.1016/j.neubiorev.2010.08.011

Nosek, B. A., & Lakens, D. (2014). Registered reports: A method to increase the credibility of published results. *Social Psychology, 45*, 137–141. https://doi.org/10.1027/1864-9335/a000192

Oaten, M., Stevenson, R. J., & Case, T. I. (2011). Disease avoidance as a functional basis for stigmatization. *Proceedings of the Royal Society of London: Series B: Biological Sciences, 366*, 3433–3452. https://doi.org/10.1098/rstb.2011.009'

Oosterhoff, B., Shook, N. J., & Iyer, R. (2018). Disease avoidance and personality: A meta-analysis. *Journal of Research in Personality, 77*, 47–56. https://doi.org/10.1016/j.jrp.2018.09.008

O'Shea, K. J., DeBruine, L. M., & Jones, B. C. (2019). Further evidence for associations between short-term mating strategy and sexual disgust. *Personality and Individual Differences, 138*, 333–335. https://doi.org/10.1016/j.paid.2018.10.019

Park, J. H., Schaller, M., & Crandall, C. S. (2007). Pathogen-avoidance mechanisms and the stigmatization of obese people. *Evolution and Human Behavior, 28*(6), 410–414. https://doi.org/10.1016/j.evolhumbehav.2007.05.008

R Core Team. (2013). *A language and environmental for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing.

Rhodes, G., Chan, J., Zebrowitz, L. A., & Simmons, L. W. (2003). Does sexual dimorphism in human faces signal health? *Proceedings of the Royal Society of London. Series B: Biological Sciences, 270*(suppl_1), S93–S95. https://doi.org/10.1098/rsbl.2003.0023

Roser, M. (2021). COVID-19 Data Explorer. Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/explorers/coronavirus-data-explorer.

Ryan, S., Oaten, M., Stevenson, R. J., & Case, T. I. (2012). Facial disfigurement is treated like an infectious disease. *Evolution and Human Behavior, 33*, 639–646. https://doi.org/10.1016/j.evolhumbehav.2012.04.001

Saribay, S. A., Tureček, P., Paluch, R., & Kleisner, K. (2021). Differential effects of resource scarcity and pathogen prevalence on heterosexual women's facial masculinity preferences. *Evolutionary Human Sciences, 3*, Article e48. https://doi.org/10.1017/ehs.2021.42

Schaller, M., & Duncan, L. A. (2007). The behavioral immune system: Its evolution and social psychological implications. In J. P. Forgas, M. G. Haselton, & W. von Hippel (Eds.), *Evolution and the social mind: Evolutionary psychology and social cognition* (pp. 293–307). New York: Psychology Press.

Schaller, M., & Park, J. H. (2011). The behavioral immune system (and why it matters). *Current Directions in Psychological Science, 20*, 99–103. https://doi.org/10.1177/0963721411402596

Scott, I. M., Clark, A. P., Boothroyd, L. G., & Penton-Voak, I. S. (2012). Do men's faces really signal heritable immunocompetence? *Behavioral Ecology, 24*, 579–589. https://doi.org/10.1093/beheco/ars092

Scott, I. M., Clark, A. P., Josephson, S. C., Boyette, A. H., Cuthill, I. C., Fried, R. L., … Honey, P. L. (2014). Human preferences for sexually dimorphic faces may be evolutionarily novel. *Proceedings of the National Academy of Sciences, 111*, 14388–14393. https://doi.org/10.1073/pnas.1409643111

Shook, N. J., & Oosterhoff, B. (2020). Testing the effects of pathogen threat and sexual strategies on political ideology. *Politics and the Life Sciences, 39*(2), 187–199. https://doi.org/10.1017/pls.2020.19

Simonsohn, U., Nelson, L. D., & Simmons, J. P. (2014). P-curve: A key to the file-drawer. *Journal of Experimental Psychology: General, 143*, 534–547. https://doi.org/10.1037/a0033242

Stamps, J. A., & Frankenhuis, W. E. (2016). Bayesian models of development. *Trends in Ecology & Evolution, 31*, 260–268. https://doi.org/10.1016/j.tree.2016.01.012

Stevenson, R. J., Saluja, S., & Case, T. I. (2021). The impact of the Covid-19 pandemic on disgust sensitivity. *Frontiers in Psychology, 11*, 3895. https://doi.org/10.3389/fpsyg.2020.600761

Thornhill, R., & Gangestad, S. W. (1999). Facial attractiveness. *Trends in Cognitive Sciences, 3*, 452–460. https://doi.org/10.1016/S1364-6613(99)01403-5

Thornhill, R., & Gangestad, S. W. (2006). Facial sexual dimorphism, developmental stability, and susceptibility to disease in men and women. *Evolution and Human Behavior, 27*, 131–144. https://doi.org/10.1016/j.evolhumbehav.2005.06.001

Tiddeman, B., Burt, M., & Perrett, D. (2001). Prototyping and transforming facial textures for perception research. *IEEE Computer Graphics and Applications, 21*, 42–50. https://doi.org/10.1109/38.946630

Tostmann, A., Bradley, J., Bousema, T., Yiek, W. K., Holwerda, M., Bleeker-Rovers, C., … Wertheim, H. (2020). Strong associations and moderate predictive value of early symptoms for SARS-CoV-2 test positivity among healthcare workers, the Netherlands, March 2020. *Eurosurveillance, 25*(16), 2000508. https://doi.org/10.2807/1560-7917.ES.2020.25.16.2000508

Tybur, J. M., Bryan, A. D., Magnan, R. E., & Hooper, A. E. C. (2011). Smells like safe sex: Olfactory pathogen primes increase intentions to use condoms. *Psychological Science, 22*(4), 478–480. https://doi.org/10.1177/0956797611400096

Tybur, J. M., Frankenhuis, W. E., & Pollet, T. V. (2014). Behavioral immune system methods: Surveying the present to shape the future. *Evolutionary Behavioral Sciences, 8*, 274–283. https://doi.org/10.1037/ebs0000017

Tybur, J. M., & Gangestad, S. W. (2011). Mate preferences and infectious disease: Theoretical considerations and evidence in humans. *Philosophical Transactions of the Royal Society B: Biological Sciences, 366*, 3375–3388. https://doi.org/10.1098/rstb.2011.0136

Tybur, J. M., Inbar, Y., Aarøe, L., Barclay, P., Barlow, F. K., De Barra, M., & Žeželj, I. (2016). Parasite stress and pathogen avoidance relate to distinct dimensions of political ideology across 30 nations. *Proceedings of the National Academy of Sciences, 113*(44), 12408–12413. https://doi.org/10.1073/pnas.1607398113

Tybur, J. M., & Karinen, A. K. (2018). Measurement and theory in disgust sensitivity. In V. Zeigler-Hill, & T. K. Shackelford (Eds.), *Handbook of Personality and Individual Differences* (pp. 159–179).

Tybur, J. M., & Lieberman, D. (2016). Human pathogen avoidance adaptations. *Current Opinion in Psychology, 7*, 6–11. https://doi.org/10.1016/j.copsyc.2015.06.005

Tybur, J. M., Lieberman, D., Fan, L., Kupfer, T. R., & de Vries, R. E. (2020). Behavioral immune trade-offs: Interpersonal value relaxes social pathogen avoidance. *Psychological Science, 31*(10), 1211–1221. https://doi.org/10.1177/0956797620960011

Tybur, J. M., Lieberman, D., & Griskevicius, V. (2009). Microbes, mating, and morality: Individual differences in three functional domains of disgust. *Journal of Personality and Social Psychology, 97*, 103–122. https://doi.org/10.1037/a0015474

Tybur, J. M., Lieberman, D., Kurzban, R., & DeScioli, P. (2013). Disgust: Evolved function and structure. *Psychological Review, 120*, 65–84. https://doi.org/10.1037/a0030778

Van Dongen, S., & Gangestad, S. W. (2011). Human fluctuating asymmetry in relation to health and quality: A meta-analysis. *Evolution and Human Behavior, 32*, 380–398. https://doi.org/10.1016/j.evolhumbehav.2011.03.002

Van Leeuwen, F., & Petersen, M. B. (2018). The behavioral immune system is designed to avoid infected individuals, not outgroups. *Evolution and Human Behavior, 39*(2), 226–234. https://doi.org/10.1016/j.evolhumbehav.2017.12.003

Van Leeuwen, F., Jaeger, B., Sleegers, W., & Petersen, M. B. (2021). Pathogen avoidance and conformity: Salient infectious disease does not increase conformity. *PsyArXiv.*. https://doi.org/10.31234/osf.io/t3bcw

Watkins, C. D., DeBruine, L. M., Little, A. C., Feinberg, D. R., & Jones, B. C. (2012). Priming concerns about pathogen threat versus resource scarcity: Dissociable effects on women's perceptions of men's attractiveness and dominance. *Behavioral Ecology and Sociobiology, 66*, 1549–1556. https://doi.org/10.1007/s00265-012-1408-2

Wells, G. L., & Windschitl, P. D. (1999). Stimulus sampling and social psychological experimentation. *Personality and Social Psychology Bulletin, 25*, 1115–1125. https://doi.org/10.1177/01461672992512005

Westfall, J., Kenny, D. A., & Judd, C. M. (2014). Statistical power and optimal design in experiments in which samples of participants respond to samples of stimuli. *Journal of Experimental Psychology: General, 143*, 2020–2045. https://doi.org/10.1037/xge0000014

White, A. E., Kenrick, D. T., & Neuberg, S. L. (2013). Beauty at the ballot box: Disease threats predict preferences for physically attractive leaders. *Psychological Science, 24*(12), 2429–2436. https://doi.org/10.1177/0956797613493642

Yarkoni, T. (2020). The generalizability crisis. *Behavioral and Brain Sciences, 1-37*. https://doi.org/10.1017/S0140525X20001685

Yeoh, D. K., Foley, D. A., Minney-Smith, C. A., Martin, A. C., Mace, A. O., Sikazwe, C. T., … Moore, H. C. (2021). Impact of coronavirus disease 2019 public health measures on detections of influenza and respiratory syncytial virus in children during the 2020 Australian winter. *Clinical Infectious Diseases, 72*(12), 2199–2202. https://doi.org/10.1093/cid/ciaa1475

Young, S. G., Sacco, D. F., & Hugenberg, K. (2011). Vulnerability to disease is associated with a domain-specific preference for symmetrical faces relative to symmetrical non-face stimuli. *European Journal of Social Psychology, 41*, 558–563. https://doi.org/10.1002/ejsp.800

Zheng, L., Zhang, J., & Zheng, Y. (2016). Relationships between pathogen disgust sensitivity and preference for male facial masculinity in gay men in China. *Personality and Individual Differences, 92*, 33–36. https://doi.org/10.1016/j.paid.2015.12.021

Zietsch, B. P., Lee, A. J., Sherlock, J. M., & Jern, P. (2015). Variation in women's preferences regarding male facial masculinity is better explained by genetic differences than by previously identified context-dependent effects. *Psychological Science, 26*, 1440–1448. https://doi.org/10.1177/0956797615591770