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Are people more averse to microbe-sharing contact with ethnic outgroup members? A registered report

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ABSTRACT

Intergroup biases are widespread across cultures and time. The current study tests an existing hypothesis that has been proposed to explain such biases: the mind has evolved to interpret outgroup membership as a cue to pathogen threat. In this registered report, we test a core feature of this hypothesis. Adapting methods from earlier work, we examine (1) whether people are less comfortable with microbe-sharing contact with an ethnic outgroup member than an ethnic ingroup member, and (2) whether this difference is exacerbated by additional visual cues to a target's infectiousness. Using Chinese ($N = 1533$) and British ($N = 1371$) samples recruited from the online platforms WJX and Prolific, we assessed contact comfort with targets who were either East Asian or White and who were either modified to have symptoms of infection or unmodified (or, for exploratory purposes, modified to wear facemasks). Contact comfort was lower for targets modified to have symptoms of infection. However, we detected no differences in contact comfort with ethnic-ingroup targets versus ethnic-outgroup targets. These results do not support the hypothesis that people interpret ethnic outgroup membership alone as a cue to infection risk.

1. Introduction

Intergroup biases are ubiquitous across cultures and times (e.g., Ashburn-Nardo, Voils, & Monteith, 2001; Hewstone, Rubin, & Willis, 2002; Schlueter, Schmidt, & Wagner, 2008). Researchers have proposed that such biases are motivated by needs to maintain self-esteem and a positive view of the ingroup (e.g., Martiny & Rubin, 2016; Rubin & Hewstone, 1998), to cope with the stress caused by intergroup threats (e.g., Riek, Mania, & Gaertner, 2006), to manage conflicting goals and competition over limited resources (e.g., Brief et al., 2005; Levin, Federico, Sidanius, & Rabinowitz, 2002), or to fend off a fear of death (e.g., Greenberg & Kosloff, 2008). Putting aside such phenomenological functions, evolutionarily-oriented researchers have instead aimed to understand these biases by focusing on the fitness threats and opportunities inherent to intergroup interactions. One such proposal suggests that intergroup biases partially function to neutralize pathogen threats (e.g., Faulkner, Schaller, Park, & Duncan, 2004; Fincher, Thornhill, Murray, & Schaller, 2008; McGovern & Vanman, 2021; Navarrete & Fessler, 2006).

1.1. Outgroup membership as a pathogen cue

Infectious diseases are costly. They redirect metabolic resources from other important functions, and they can lead to long-term disability or death. Even if an individual emerges from an infection unscathed, he or she can transmit infection to a friend or family member, who might not be so lucky. The pathogens and parasites that cause infectious disease are not randomly distributed across the ecology. Instead, they tend to be in some locations more than others – they are more likely to be in saliva than in snow, in meat than in moss, and in pus than on plants. Given both the non-random distribution of pathogens and the costs of infectious disease, humans (like many other animals) have evolved some ability to detect and avoid pathogens – that is, we have a behavioral immune system (BIS; for reviews, see Ackerman, Hill, & Murray, 2018; Murray & Schaller, 2016; Tybur & Lieberman, 2016). Drawing from BIS theory, researchers have suggested that intergroup biases partially result from localized pathogen-host coevolution, which leads to different groups developing immunity to different pathogens (Fincher & Thornhill, 2012). According to this perspective, the average outgroup member is more likely to carry novel pathogens than the average ingroup

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members, and, consequently, any single intergroup interaction poses a higher infection risk than any single intragroup interaction. Historical events illustrate the disastrous potential consequences of such interactions. For example, the introduction of measles and smallpox from Europeans to Native Americans led a 57% reduction in effective population size (Lindo et al., 2016). Naturally, events of such magnitude would be rare, and unlikely to shape the evolution of the BIS. Nevertheless, researchers have argued that less severe intergroup pathogen threats were a regular feature of ancestral environments (Fincher & Thornhill, 2012).

The outgroup-as-pathogen-cue hypothesis of intergroup bias suggests that individuals avoid, stigmatize, exclude, and derogate outgroup members to avoid the infection threats putatively posed by intergroup contact (e.g., Aarøe, Petersen, & Arceneaux, 2017; Navarrete & Fessler, 2006; Tybur et al., 2016). Studies using each of the three approaches commonly used in the BIS literature - cross-cultural studies examining covariation with population-level parasite stress, experimental priming studies, and studies assessing individual differences in disgust or contamination sensitivity (Tybur, Frankenhuis, & Pollet, 2014) – have been interpreted as supporting this hypothesis. For example, at the ecological level, one study reported that U.S. state-level infectious disease rates covary with implicit and explicit racial prejudice (O'Shea, Watson, Brown, & Fincher, 2019). Another study of 177 independent states around the world revealed more intrastate armed conflict in states with higher infectious disease rates (Letendre, Fincher, & Thornhill, 2010). At the experimental priming level, one series of studies on Canadian students reported that individuals primed to consider infectious diseases demonstrate more negative attitudes toward subjectively foreign immigrants (Faulkner et al., 2004). Another study on Dutch students reported that the same prime led men to have more negative implicit attitudes toward Italians (Klavina, Buunk, & Pollet, 2011). Regarding individual differences, one study reported that ethnocentric attitudes increased as a function of perceived vulnerability to disease (Study 1, Navarrete & Fessler, 2006), and others have reported similar relations between pathogen disgust sensitivity and negative attitudes toward foreigners (Aarøe et al., 2017; Brenner & Inbar, 2015; Clifford, Erisen, Wendell, & Cantu, 2022; Hodson et al., 2013).

1.2. Challenges to the outgroup-as-pathogen-cue hypothesis

Although seemingly supported by multiple studies, doubts remain regarding the outgroup-as-pathogen-cue hypothesis. Anthropologists have found that intergroup interactions occur frequently, both now and in ancestral environments (e.g., Blades, 2006; d'Errico et al., 2009). Even if any single intergroup interaction poses a higher infection risk than any single intragroup interactions, avoiding an intergroup interaction might have little impact on infection risk, because once one ingroup member interacts with outgroup members, any pathogens transmitted by that interaction can spread to other ingroup members. Put simply, avoiding intergroup interactions might have very limited anti-pathogen benefits unless all other ingroup members similarly avoid such interactions. Benefits of intergroup interactions – trade, expanded access to territorial resources, mating opportunities, knowledge transfer, and so on – might outweigh these small pathogen-avoidance benefits (for a review, see Fessler, Clark, & Clint, 2015). Moreover, de Barra and Curtis (2012) argue that pathogens evolve to have greater fitness within their local host population. Thus, the pathogens carried by outgroups might be less, rather than more, infectious than those carried by ingroups. Meanwhile, perceptions of group membership and intergroup biases are strongly shaped by interdependencies between individuals rather than ecological origins per se (Balliet, Wu, & De Dreu, 2014; Pietraszewski, 2021; Rabbie, Schot, & Visser, 1989; Tybur, Inbar, Güler, & Molho, 2015).

In addition to these conceptual points, multiple empirical findings seem inconsistent with the idea that outgroup members are perceived as more infectious than ingroup members. Whereas the outgroup-as-pathogen-cue hypothesis posits that even minor geographical distances are sufficient for localized pathogen adaptation, some evidence suggests that any relation between pathogen avoidance and intergroup bias is group specific. One such study reported that, after viewing germ-related pictures rather than accident-related ones, anti-immigration attitudes were more negative against immigrants from subjectively exotic nations, but not against those from familiar ones (Faulkner et al., 2004). Another study found that disgust sensitivity relates to antipathy toward immigrants described as not assimilating with the local culture, but not toward immigrants described as having frequent contact with the local population (Karinen, Molho, Kupfer, & Tybur, 2019). Another study detected no relation between pathogen disgust sensitivity and negative sentiments toward immigrants described coming from an unspecified ecology, but a relation between pathogen disgust sensitivity and negative sentiments toward immigrants described as coming from a pathogen-rich ecology (Ji, Tybur, & van Vugt, 2019). And another study drawing from U.S. and Indian samples reported that, while people are less comfortable with contact with an individual with a sore on his face, they are no less comfortable with contact with an ethnic outgroup member than with an ethnic ingroup member (van Leeuwen & Petersen, 2018). Further, the effect of the cue to infection (i.e., the sore on the face) was not moderated by target ethnicity. Hence, participants reported no additional aversion to engaging in potentially-infectious acts with outgroup targets, regardless of whether a target appeared infectious.

This last study (van Leeuwen & Petersen, 2018) arguably offers the most persuasive evidence that people do not interpret outgroups as more infectious than ingroups. However, results were equivocal for two broad reasons. First, one recent reanalysis argues that findings actually support the outgroup-as-pathogen-cue hypothesis (Bressan, 2021). Instead of using the dichotomous factor of nationality employed in the original study, Bressan regressed contact comfort on the variable "Does this man look like the men in your local community?", which was included in the original study as a manipulation check. Seemingly consistent with the outgroup-as-pathogen-cue hypothesis, participants who rated the target as more similar to faces in their local community were more comfortable with contact with the target. Second, a number of methodological issues limited the study's ability to evaluate the outgroup-as-pathogen-cue hypothesis. The small number of stimuli used (four White targets and four Indian targets) limits the generalizability of its findings (Yarkoni, 2020). Further, analyses did not model variation in responses across stimuli. Additionally, because all stimuli were male, potential inferences are limited to responses to men. Studies have shown that intergroup biases vary across outgroup men and women and that this target sex difference varies as a function of the threat perceived from outgroups (e.g., Jensen & Tisak, 2020; Ji et al., 2019; Ji, Tybur, & van Vugt, 2021; Navarrete, McDonald, Molina, & Sidanius, 2010), and other work suggests that comfort with potentially-infectious contact varies across target sex (Tybur, Lieberman, Fan, Kupfer, & de Vries, 2020). Findings were also potentially limited by the breadth of assessment of contact comfort, with only two items used.

Further, multiple studies have raised doubts regarding the quality of MTurk data collected from India, an approach used by van Leeuwen and Petersen (2018). For example, one study that used a squared discrepancy procedure – a quality assurance approach based on response consistency for survey tasks – revealed that data were of lesser quality among India-based than among U.S. participants, even when optimal payment strategies were used (Litman, Robinson, & Rosenzweig, 2015). Another study revealed that Indian MTurk workers have lower accuracy rates than their American counterparts on text-related tasks (Aker, El-Haj, Albakour, & Kruschwitz, 2012). This lower accuracy might stem from surveys being presented in a non-native language (e.g., Muda, Niszczota, Białek, & Conway, 2018; Wong & Ng, 2018). In van Leeuwen and Petersen (2018), the survey was presented in English in both samples, and native language and English competency were not assessed.

The current study is inspired by van Leeuwen and Petersen (2018), but is designed to overcome the limitations discussed above and to further test the outgroup-as-pathogen-cue hypothesis in light of Bressan's (2021) critique. In addition to testing the outgroup-as-pathogen-cue hypothesis, it also aims to gather exploratory data assessing the degree to which comfort with intergroup contact is moderated by information potentially interpreted as reducing infection risks: facemasks.

1.3. Infection cues can emerge from cultural artifacts

Several infectious diseases cause changes in facial appearance, such as skin color or texture (Oaten, Stevenson, & Case, 2011). Consequently, people interpret the physical byproducts of infection, such as sores (e.g., van Leeuwen & Petersen, 2018), port-wine stains (e.g., Ryan, Oaten, Stevenson, & Case, 2012) and poxes (e.g., Ackerman et al., 2009; Schaller, Miller, Gervais, Yager, & Chen, 2010) as indicative of infectiousness. These features should be interpreted as indicative of infectiousness regardless of the nationality of a target.

However, pathogen risk can also be inferred from cultural artifacts, and such inferences can be further moderated by different cultural background. Facemasks can serve as an example. Attitudes toward facemasks differ across cultures (e.g., Cheung, 2020; Lynteris, 2020). In Western nations, they are perceived as tools to reduce the chance of spreading airborne diseases to others during illness (Olivera-La Rosa, Chuquichambi, & Ingram, 2020). In East Asians nations (e.g., Chinese, Japanese), they are widely used to protect the wearer against infections (e.g. during the COVID-19 pandemic, Lee & You, 2020; Muto, Yamamoto, Nagasu, Tanaka, & Wada, 2020), as they were seen as effective during the SARS pandemic (Lau, Tsui, Lau, & Yang, 2004) and the COVID-19 pandemic (Feng et al., 2020; Howard et al., 2021). East Asians also sometimes wear masks to prevent hay fever, protect against UV radiation, filter pollutants, or even conceal misapplied makeup (e.g., Woman's Labo, 2019; Zhang, 2019). For these reasons, facemasks might provide less information regarding the infectiousness of a wearer for East Asians than for members of Western cultures. Moreover, facemasks limit information regarding the health of the wearer by concealing potential facial texture or skin abnormalities. Such increased ambiguity might lead observers to avoid contact with that wearer. In sum, Westerners might interpret facemasks as more diagnostic of infection status than East Asians – an interpretation that would generate higher pathogen avoidance, which, according to the outgroup-as-pathogen-cue hypothesis, should be stronger for ethnic outgroup than ethnic ingroup targets.

However, the COVID-19 pandemic might have changed perceptions of facemasks, which were recently recommended or required in both East Asian and Western nations. Recent work indicates that more prosocial people tend to engage in behaviors that serve public health benefits, including facemask wearing (Jordan, Yoeli, & Rand, 2020; West et al., 2020). Wearing a facemask is regarded as a responsible precaution behavior, both for the wearer and for others (e.g., Olivera-La Rosa et al., 2020). Previous research has also found that people have higher contact comfort for honest and trustworthy targets (Tybur et al., 2020). Thus, facemasks might also be interpreted as a cue to prosociality, which increases the contact comfort regardless of target's group membership. And, of course, relative to not wearing a mask, wearing a mask reduces the probability of transmitting pathogens via aerosols and respiratory droplets (e.g., Asadi et al., 2020).

1.4. Current study

The current study aims to test (1) whether people are more averse to contact with an ethnic outgroup target than an ethnic ingroup target, and (2) whether this bias is exacerbated by further information regarding infectiousness. To accomplish these goals, we assessed comfort with microbe-sharing contact toward East Asian and White targets in samples drawn from China and the UK. Targets were presented either unmodified, with a cue to infectiousness, or with a facemask. The outgroup-as-pathogen-cue hypothesis predicts lower comfort with microbe-sharing contact with outgroup members than with ingroup members (i.e., an interaction between target ethnicity and participant ethnicity). Further, visual cues to infection could exacerbate this effect. Alternatively, if findings from van Leeuwen and Petersen (2018) are correct, we should not find an interaction between participant and target ethnicity on contact comfort. In addition to these confirmatory hypothesis tests, we also include exploratory tests of the effects of facemasks on contact comfort.

We followed the APA ethical standards in the conduct of the pilot study and the main study. We obtained ethical approval of the current project from the Scientific and Ethical Review Board (VCWE) of the Faculty of Behavior & Movement Sciences, VU University Amsterdam [VCWE-2020-175R1].

2. Pilot study

Before testing these hypotheses, we conducted a pilot study to assess the quality of data collected in China and the UK, to test the validity of contact comfort items, and to estimate parameters for a power analysis for the main study.

2.1. Method

2.1.1. Participants

Participants were recruited from the UK and China using the platforms Prolific (https://www.prolific.co/) and WJX (also previously known as SurveyStar or SoJump, https://www.wjx.cn/) respectively. WJX and Prolific are widely-used online survey crowdsourcing platforms, with 2.6 million and 150 thousand active participants, respectively. Previous studies report good data quality with relatively low exclusion rates on both platforms (for Prolific, e.g., 6.02% in Demoulin et al., 2020; 0.99% in Jones, Du, Panattoni, & Henrikson, 2019; for WJX, e.g., 7.21% in Wang, Chudzicka-Czupała et al., 2020; 0.5% in Wang, Xia et al., 2020; 15.71% with stricter criteria in Yuan, Wu, & Kou, 2018, Study 2). For the UK sample, we recruited only participants who identify as White. The survey was conducted in the native language (English or simplified Mandarin) for each sample.

Not aiming to test any specific hypothesis in the pilot study, we did not conduct an a-priori power analysis. We enrolled 333 Chinese participants and 280 British participants. After exclusions, the final sample included 329 Chinese participants (144 female, age ranging from 18 to 68, $M_{age} = 32.53$, $SD_{age} = 8.53$) and 231 British participants (152 female, age ranging from 18 to 74, $M_{age} = 36.19$, $SD_{age} = 14.00$).

2.1.2. Procedures

We used procedures similar to those described in van Leeuwen and Petersen (2018). After providing consent, participants saw a single target face that was either male or female, East Asian or White, and either unmodified or modified to appear infectious. Participants completed a validation item asking what the target's nationality was, followed by items assessing perceived infectiousness and perceived prosociality of the target. They then completed contact comfort items, which were adapted from van Leeuwen and Petersen (2018) and Tybur et al. (2020). Participants also reported their own nationality, as well as their sex and age. Participants were also given the opportunity to leave comments on the study via a free response text box. All participants were compensated after reading the debriefing.

2.1.3. Materials

Face Stimuli. The face stimuli were retrieved from the Chicago face database (CFD, Ma, Correll, & Wittenbrink, 2015). We selected 20 White (10 male and 10 female) and 20 East Asian (10 male and 10 female) targets with neutral expressions. We selected only those East Asian that looked Chinese, as assessed via a group of Chinese nationals known by the first author. Attractiveness and age were matched across ethnicity and sex subgroups based on CFD validation data. Two different skin abnormalities – one modeled after shingles and one modeled after syphilis – were selected as pathogen cue candidates. We produced two modified versions of each face – one with the syphilis appearance, and one with the shingles appearance (see Fig. 1 for examples).

As approximately 7% of British citizens are of Asian descent (Office for National Statistics, 2014), we presented a line of text including the target's name, citizenship, and residency along with the face. All White faces were presented as having a British nationality and living in the UK, while all East Asian faces were presented as having a Chinese nationality and living in China. White faces were labeled as "Oliver Smith" or "Olivia Smith", and East Asian faces were labeled as "Haoyu Wang (王浩宇)" or "Shiyu Wang (王诗雨)", depending on the sex of the target. These are among the most commonly-used names in the UK and China (for Chinese names, retrieved from China Daily, 2019; for British names, retrieved from McElduff, Mateos, Wade, & Borja, 2008; Office for National Statistics, 2020).

Validation Check. We included two validation check items in the survey. After the initial presentation of the target's face, nationality, and name, participants answered "Does this person look like someone who was born in the UK/China?". Participants who answered incorrectly were removed. At the end of the survey, participants reported their ethnicity and nationality. Only responses that met the inclusion criteria were retained. We also checked responses in the free-response box. Respondents with nonsensical answers were removed.

Perceived Infectiousness. We used a single item "How likely is it that the person has a disease that could be passed on to others?" on a six-point scale (1 = extremely unlikely, 6 = extremely likely) to measure participants' perceptions of the target's infectious likelihood.

Perceived Prosociality Measurement. Given that individuals higher in honesty-humility and agreeableness give more to strangers in dictator games (e.g., Thielmann & Hilbig, 2018; Zhao, Ferguson, & Smillie, 2016), we used a single-round reversed dictator game as a measure of perceived prosociality. In this task, participants imagined that the target was given £10/¥100 to allocate between himself/herself and the participant. We interpreted participants' expectations of the portion of the endowment that the target would offer as indicative of the target's prosociality.

Contact Comfort Measurement. We used 9 items (e.g., touching a handkerchief that (target) used to blow his or her nose; each rated on a seven-point scale ranging from 1 = very uncomfortable to 7 = very comfortable) to measure participants' comfort with microbe-sharing contact with the target person. A recent study reported that similar items are unidimensional and have good ($\alpha > 0.90$) reliability (Tybur et al., 2020). Due to cultural differences, we excluded and modified some items to improve their application to both British and Chinese cultures. Specifically, we removed the item "using (target)'s deodorant stick on yourself", since deodorant sticks are not commonly used in China, and we modified "taking a bite out of a sandwich that (target) had been eating" by replacing sandwich with bread, since sandwiches are not commonly eaten in China.

All materials, data and analysis codes can be found in supplement and on the OSF: https://osf.io/t476f/.

2.2. Results

2.2.1. Data quality of online platforms

We first checked the data quality of the two online survey crowd-sourcing platforms we selected. For WJX, all participants passed the two validation check items, though four participants wrote nonsensical comments in the free response text box. We removed these participants. Overall, the inclusion rate of WJX participants was 98.79%. For Prolific, 43 participants did not pass the validation check for target's nationality, while six did not meet the inclusion criteria of identifying as White. None wrote nonsensical responses. The overall inclusion rate of Prolific participants was 82.50%.

2.2.2. Pathogen cue manipulations

Faces with either manipulation were perceived as more infectious than untransformed faces (for shingles, $t(372.94) = -12.53$, $p < .001$,

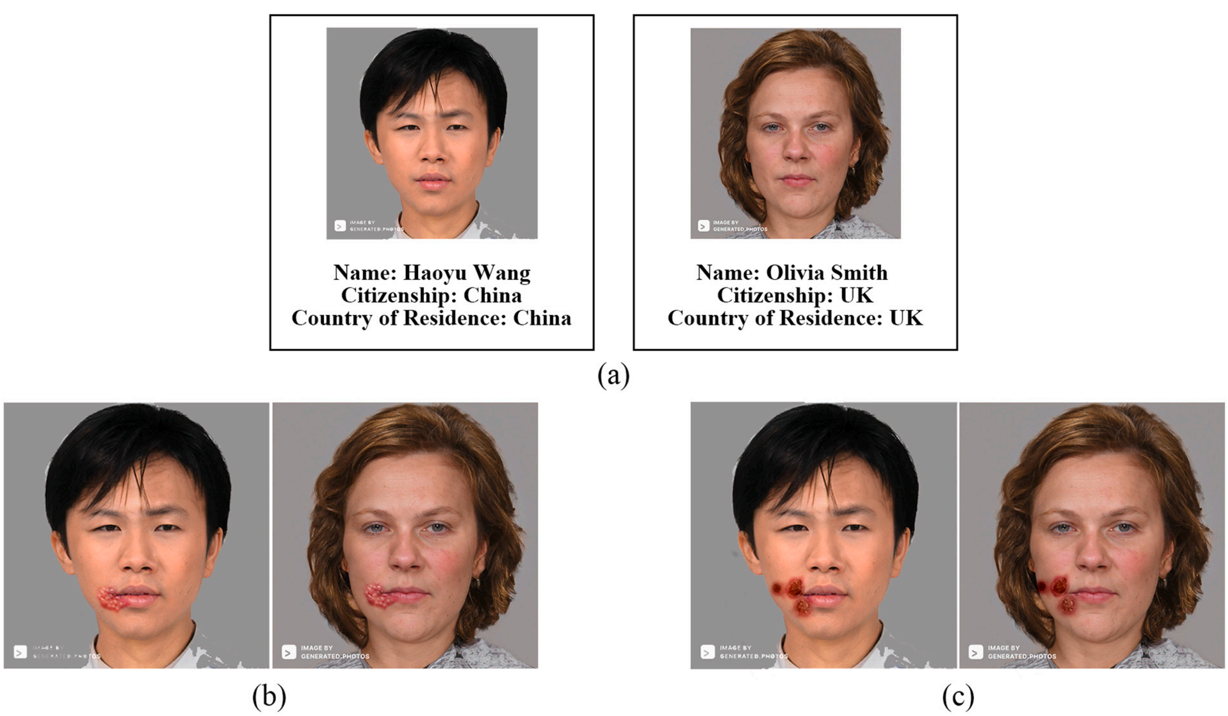

Fig. 1. Examples for different face stimuli manipulations in the pilot study (with information that was presented in all three conditions): (a) unmodified faces, (b) infectious faces – shingles, (c) infectious faces – syphilis. For privacy protection reasons, the faces displayed in the current article are demonstrations, not the exact materials used in the experiment. These displayed faces were generated by Generated Photos (https://generated.photos/) with AI algorithms. For faces used in the study, see Materials on OSF https://osf.io/t476f/.

Cohen's $d = 1.29$; for syphilis, $t(361.05) = -11.09$, $p < .001$, Cohen's $d = 1.15$; all presented *t*-tests were conducted with the Welch's *t*-test, which produces fractional degrees of freedom), and they were not perceived as differentially infectious from each other ($t(350.55) = 0.10$, $p = .92$, Cohen's $d = 0.01$). However, the difference in perceived infectiousness across the Chinese and UK samples was directionally smaller for the shingles manipulation ($M_{CHN} = 4.47$, $SD_{CHN} = 0.96$; $M_{GBR} = 4.32$, $SD_{GBR} = 0.96$; $t(165.42) = 1.07$, $p = .28$, Cohen's $d = 0.16$) than the syphilis manipulation ($M_{CHN} = 4.54$, $SD_{CHN} = 1.08$; $M_{GBR} = 4.18$, $SD_{GBR} = 1.29$; $t(132.04) = 1.96$, $p = .05$, Cohen's $d = 0.31$, see Fig. 2). For this reason, we selected the shingles manipulation for the main study.

2.2.3. Reliability and validity of contact comfort measurements

We used Cronbach's α and exploratory factor analysis to examine the reliability and validity of the contact comfort measurement. We removed two items to improve the fit of the single-factor model. The retained items showed acceptable structural validity (CFI = 0.98, RMSEA = 0.07, 95% CI [0.05,0.09]) and internal consistency both across and within samples ($\alpha_{Total} = 0.87$, 95% CI [0.85, 0.88]; $\alpha_{CHN} = 0.87$, 95% CI [0.85, 0.89]; $\alpha_{GBR} = 0.87$, 95% CI [0.84, 0.89]).

3. Main study

Using the materials developed in the pilot study, we aim to test the following hypotheses:

H1: Contact comfort is lower for infectious faces than for unmodified faces.
H2: As predicted by the outgroup-as-pathogen-cue hypothesis, contact comfort is lower for outgroup targets than ingroup targets (i.e., an interaction between participant nationality and target nationality).
H3: The outgroup-as-pathogen-cue hypothesis can also be used to predict that the interaction between participant nationality and target nationality is moderated by target infectiousness (i.e., a three-way interaction among participant nationality, target nationality, and the infectious versus unmodified face contrast). The pattern of simple effects within such an interaction could offer new insight into the outgroup-as-pathogen-cue hypothesis. On the one hand, if group membership is interpreted as a cue to infectiousness (i.e., outgroup targets are perceived as more *likely* to carry pathogens than ingroup targets when other infection cues are absent), then the higher-validity pathogen cue (the abnormal skin appearance on the face) should attenuate the difference in contact comfort between ingroup and outgroup targets observed in the unmodified condition. On the other hand, if group membership is interpreted as a cue to the *danger* of pathogens (i.e., infectious outgroup targets transmit pathogens more virulent than infectious ingroup targets do), then a pathogen cue should magnify the difference in contact comfort between ingroup and outgroup targets. Hence, we should observe a larger difference in contact comfort across ingroup and outgroup targets for infectious relative to unmodified faces.

We did not specify hypotheses regarding the effect of facemasks on contact comfort. We tested for main effects of facemasks compared with the unmodified faces, as well as moderation by participant nationality, target nationality, and both.

3.1. Method

3.1.1. Participants

Data were collected on WJX and Prolific between the 17th and 23rd of January 2022. According to an a-priori power analysis (see supplement materials) using R 4.0.3 (R Core Team, 2020) with the package SimR (Green & MacLeod, 2016), samples of 1400 participants in each country (including an approximate 5% exclusion rate) afford 90% power to detect greater contact comfort for unmanipulated East Asian faces than unmanipulated White faces for Chinese participants ($d = 0.3$), greater contact comfort for unmanipulated White faces than unmanipulated East Asian faces for British participants ($d = 0.3$), greater contact comfort for unmanipulated faces than infection cue face ($d = 0.3$ for ingroup pairs and $d = 0.6$ for outgroup pairs), and a three-way interaction among condition (pathogen vs. unmodified), participant nationality, and target nationality of $d = 0.24$. With the current proposed sample size, the lower limits of detectable effect sizes with 80% power are approximately $d = 0.23$ and $r_p = 0.20$ for the three-way interaction. Recruitment and inclusion criteria were the same as in the pilot study.

The Chinese sample was larger than anticipated due to the recruitment method used by WJX ($N = 1538$). The British sample size was

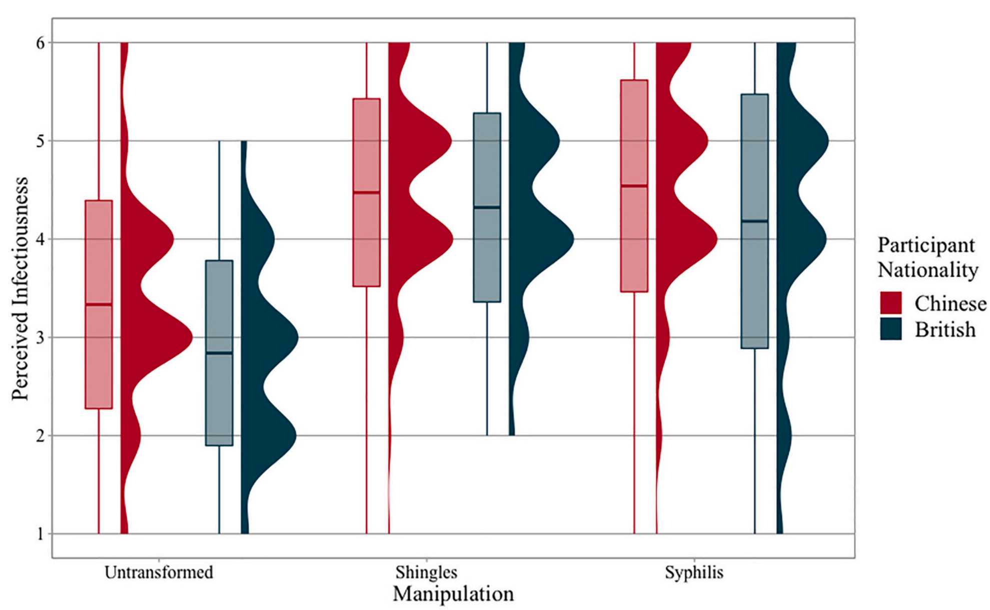

Fig. 2. Perceived infectiousness for targets with different manipulations in the pilot study with each sample. In each plot, the horizontal line indicates the mean, the box indicates plus and minor one standard deviation, the whisker indicates the range, and the shaded area indicates the density of the data.

similar to what we targeted ($N = 1399$). We excluded 33 participants based on our registered exclusion criteria. The final sample size was thus $N = 2904$ (1445 female, age ranging from 10 to 84, $M_{age} = 36.88$, $SD_{age} = 12.80$), including 1533 Chinese participants (753 female, age ranging from 10 to 73, $M_{age} = 31.31$, $SD_{age} = 8.34$) and 1371 British participants (692 female, age ranging from 18 to 84, $M_{age} = 43.12$, $SD_{age} = 14.00$).

3.1.2. Procedures

We used procedures similar to those used in the pilot study. Participants were randomly assigned to see one of 40 target faces from the pool of faces, which included 10 White males, 10 White females, 10 East Asian males, and 10 East Asian females. The face was shown in one of three ways: (1) control (unmodified); (2) infectious (shingles appearance); or (3) wearing a facemask. Each individual participant saw only one version of one of the 40 faces. Again, faces were labeled with a name and nationality (see Fig. 3 for examples). Participants then reported the target's nationality, rated the target's infectiousness, and reported the target's expected behavior in the reversed dictator game. Following van Leeuwen and Petersen (2018), we also assessed perceptions of similarity to the target ("Does this person look like someone from your local community?"), as well as an item that more specifically refers to frequency of contact with individuals of the target's ethnicity ("How often do you interact with people having the same ethnicity as this person?"). Participants completed the contact comfort items, the pathogen subscale of the Three-Domain Disgust Scale (TDDS, Tybur, Lieberman, & Griskevicius, 2009), and a 16-item measure of social dominance orientation (SDO_7, Ho et al., 2015), which is an aspect of ideology especially related to endorsements of intergroup barriers and negativity toward ethnic and racial outgroups. Participants then reported their sex, age, and ethnicity.

We also included a measure of the perceived intensity of infectious disease and other hazards present in multiple countries, including the UK and China. Specifically, we asked participants "How big of a problem is X" (with X representing separate three items for infectious disease, violent crime, and pollution, respectively) for each of seven nations (the UK, China, Canada, Russia, Turkey, India, and Nigeria). We selected these nations based on their presumed familiarity to participants and based on the fact that they include nations with both high and low historical infectious disease prevalence (Murray & Schaller, 2010). These items were intended to provide an idea of the degree to which participants associated the UK and China with specifically infectious-disease threats, and with other potential hazards. They can further be used in exploratory analyses to assess whether contact comfort with UK or Chinese targets covaries with perceptions of threats within those countries (cf. Moran, Goh, Kerry, & Murray, 2021).

Finally, participants were invited to provide comments on the study in a free response text box. All participants were compensated after completing the survey.

3.1.3. Materials

Most of the materials used in the main study were the same as those used in the pilot study. All materials can be found in the supplementary materials and on the OSF: https://osf.io/t476f/.

3.1.4. Analysis

Manipulation Check and Data Exclusion. We recruited only White participants from the UK and only Chinese participants from China. Participants who did not report being White in the UK sample or Chinese in China sample were excluded, as were participants who incorrectly recalled the target's nationality in a recall task. We also only included participants who reported being either male or female.

Main Analyses. Using mixed-effect modeling, we first regressed contact comfort on participant characteristics, including sex, age, pathogen disgust sensitivity, SDO, and nationality. Target characteristics, including sex, nationality, and appearance (unmodified, infectious, or wearing a face mask) were added to the model in Step 2. In Step 3, we added two-way interactions between participant and target nationality, participant nationality and appearance, and target nationality and appearance. In Step 4, we added the three-way interaction among these variables.

To test H1 (contact comfort is lower for infectious faces than for

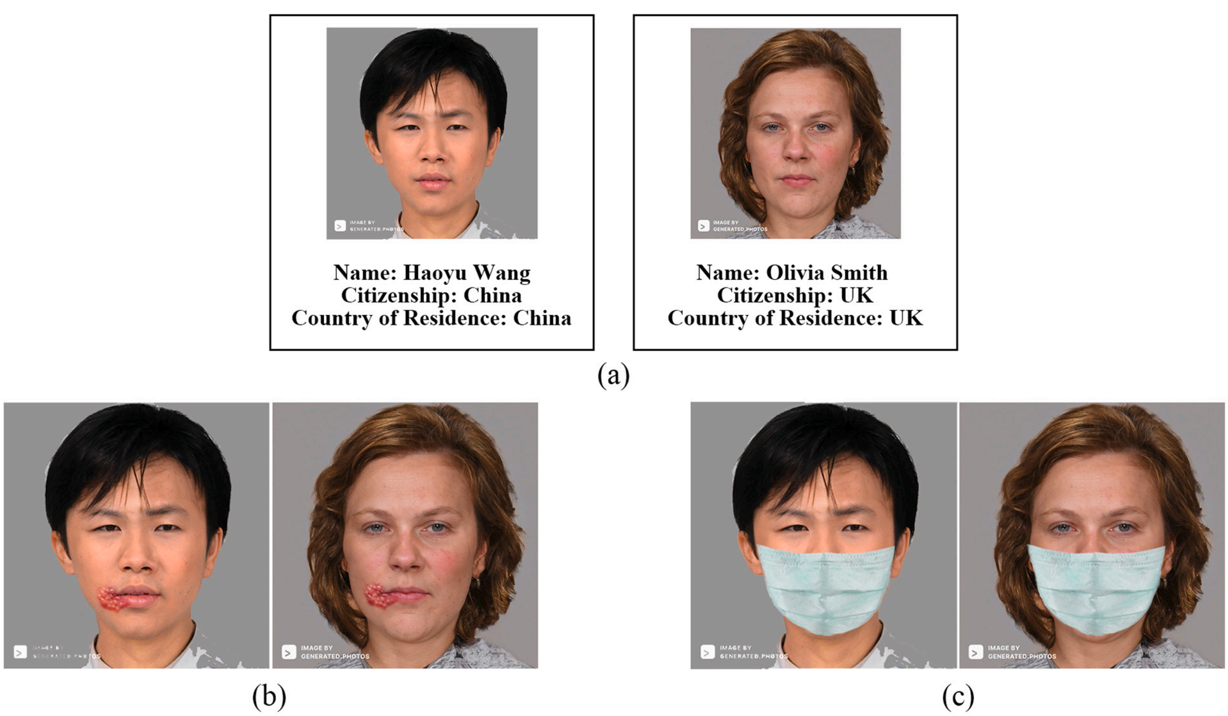

Fig. 3. Examples for different face stimuli manipulations in the main study: (a) unmodified faces (with information that was presented in all three conditions), (b) infection cue faces, (c) facemask faces. For privacy protection reasons, the faces displayed in the current article are demonstrations, not the exact materials used in the experiment. These displayed faces were generated by Generated Photos (https://generated.photos/) with AI algorithms. For faces used in the study, see Materials on OSF https://osf.io/t476f/.

unmodified faces), we examined the contrast between unmodified versus infectious targets. To test H2 (people are less comfortable with potentially-infectious contact with ethnic-outgroup members than ethnic-ingroup members), we examined the two-way interaction between participant nationality and target nationality. To test H3 (the same pathogen cues are interpreted differently depending on ethnic-group membership), we examined the three-way interaction among participant nationality, target nationality, and the contrast between the unmodified and pathogen cue conditions. Interactions were tested with lower-order simple-effect tests.

We conducted contrast comparisons for the unmodified targets and targets wearing facemasks for exploratory purposes. Exploratory analyses were also conducted with the data of similarity and interaction frequency items.

As all faces were nested within nationality and sex, for all mixed effect models we included random intercepts for stimuli with nesting structures. We followed the advice of Barr, Levy, Scheepers, and Tily (2013) to use a maximal random-effects structure for models. Significant differences for all fixed factors were indicated by *p* values.

4. Results

4.1. Manipulation check and preliminary analyses

Consistent with expectations, targets manipulated to appear infectious were rated as more infectious ($M = 4.56$, 95% CI [4.49, 4.63]) than were unmodified ones ($M = 3.08$, 95% CI [3.01, 3.15], $t(1930) = -28.14$, $p < .001$). Participants also expected these targets to return less money in a dictator game ($M = 2.78$, 95% CI [2.62, 2.93]) relative to unmodified targets ($M = 3.09$, 95% CI [2.93, 3.24], $\beta = -0.14$, 95% CI [−0.23, −0.05], $p = .002$, $t(2866) = 3.05$, $p = .01$). Consistent with other studies (e.g., Tybur et al., 2020; van Leeuwen & Petersen, 2018), pathogen disgust sensitivity negatively related to contact comfort ($\beta = -0.27$, 95% CI [−0.31, −0.24], $p < .001$). On average, participants in both nations perceived infectious disease as a larger problem in the other nation than in their own nation (for British participants, $M_{UK} = 4.49$, 95% CI [4.37, 4.61], $M_{CH} = 5.80$, 95% CI [5.69, 5.92]; for Chinese participants, $M_{UK} = 5.14$, 95% CI [5.03, 5.25], $M_{CH} = 2.97$, 95% CI [2.86, 3.08]).

4.2. Registered analyses

4.2.1. H1: Do symptoms of infection decrease contact comfort?

First, we tested whether people were less comfortable with microbe-sharing contact with faces modified to appear infectious than with unmodified faces. Contact comfort was indeed lower for infectious faces ($M = 1.87$, 95% CI [1.81, 1.94]) than for unmodified ones ($M = 2.17$, 95% CI [2.10, 2.23], $t(2862) = 6.89$, $p < .001$). The difference remained significant in all models we ran, including those adding two-way interactions involving appearance condition, target nationality, and participants nationality, and their three-way interaction (see the supplement materials for results of the full models).

4.2.2. H2: Is contact comfort lower for ethnic outgroup targets than ethnic ingroup targets?

Next, we tested whether people are less comfortable with microbe-sharing contact with ethnic-outgroup members than with ethnic-ingroup members. The interaction between participant nationality (UK or Chinese) and target nationality (UK or Chinese) was not significant ($\beta = -0.02$, 95% CI [−0.05, 0.02], $p = .37$). Hence, in line with van Leeuwen and Petersen (2018), we did not detect evidence consistent with the outgroup-as-pathogen-cue hypothesis.

4.2.3. H3: Do symptoms of infection moderate the effect of target ethnicity on contact comfort?

We next tested whether the outgroup-as-pathogen-cue hypothesis applied differently for targets with cues to infectiousness versus unmodified targets. The three-way interaction among participant nationality, target nationality, and the contrast between the unmodified and pathogen cue conditions was significant ($\beta = 0.10$, 95% CI [0.02, 18], $p = .02$, see Fig. 4). However, the lower-order two-way interactions between participant nationality and target nationality were non-significant for both unmodified targets ($t(2852) = 2.76$, $p = .10$) and for those with infection cues ($t(2853) = 2.85$, $p = .09$; see supplement materials for means). Thus, we did not detect evidence consistent with the outgroup-as-pathogen-cue hypothesis for either face type.

4.3. Exploratory analyses

4.3.1. How are masked targets perceived?

We followed the same analytic approach used in our confirmatory (i.e., registered) analyses to explore possible effects facemasks on contact comfort. British participants perceived higher infectiousness from targets that were masked ($M = 3.10$, 95% CI [3.00, 3.20]) than those that were unmodified ($M = 2.77$, 95% CI [2.66, 2.87], $t(2854) = -4.71$, $p < .001$). However, there was no difference of perceived infectiousness in the Chinese sample ($M_{Unmodified} = 3.36$, 95% CI [3.27, 3.46], $M_{Masked} = 3.46$, 95% CI [3.37, 3.56], $t(2855) = -1.51$, $p = .29$). We detected no differences in expectations of prosociality across masked targets ($M = 3.19$, 95% CI [3.04, 3.34]) and unmodified ones ($M = 3.09$, 95% CI [2.93, 3.24], $t(2865) = -1.01$, $p = .57$). We also did not detect differences in contact comfort with masked targets ($M = 2.12$, 95% CI [2.06, 2.19] or unmodified ones ($M = 2.17$, 95% CI [2.10, 2.23]), $t(2861) = 1.03$, $p = .56$), and neither target nor participant nationality moderated this effect (see supplementary materials).

4.3.2. Other predictors of contact comfort

We also explored relations between contact comfort and the other variables we assessed. Specifically, we examined relations between contact comfort and target sex, participant sex, social dominance orientation, perceived similarity of the target to locals in the participant's own community ("Does this person look like someone from your local community?"), frequency of contact with people of the target's ethnicity ("How often do you interact with people having the same ethnicity as this person?"), perceived prosociality of the target (target's expected behavior in a reversed dictator game), perceived infectiousness of the target, perceived disease threat from the target's country. Bivariate correlations are reported in Table 1. We highlight some of these findings here. In terms of features of the participant, contact comfort was most strongly related to pathogen disgust sensitivity, $r = -0.28$, followed by social dominance orientation, $r = -0.06$, and participant sex (with women having lower contact comfort than men, $r = 0.06$). In terms of objective features of the target, contact comfort related to target sex (with lower contact comfort with male relative to female targets, $r = -0.16$) and infection cue, $r = -0.14$. In terms of subjective perceptions of the target, contact comfort related most strongly to perceptions that the target was willing to offer benefits to the participant (as assessed via the reverse dictator game), $r = 0.24$, perceptions that the target is infectious, $r = -0.22$, perceptions that the target is similar to others in their local community, $r = 0.14$, and reported contact frequency with individuals of the target's ethnicity, $r = 0.11$. Some of these bivariate relations were moderated by features of participants and targets. More detailed analyses are provided in the supplementary materials.

5. Discussion

The current study was designed to improve upon van Leeuwen and Petersen (2018), which tested the outgroup-as-pathogen-cue hypothesis using only a small number of male targets and a two-item assessment of contact comfort via an English-language survey with participants recruited from the U.S. and India. Consistent with van Leeuwen and Petersen, but sampling from different populations, using larger stimulus

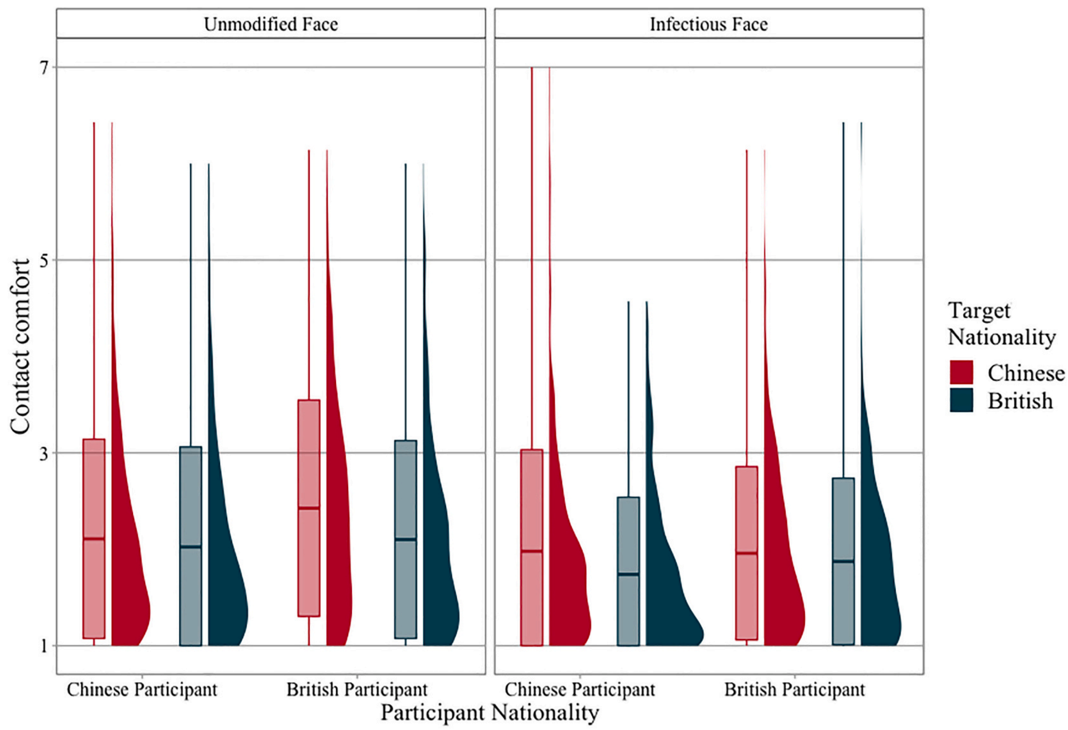

Fig. 4. Contact comfort for targets with different manipulations and target nationalities with each sample. In each plot, the horizontal line indicates the mean, the box indicates plus and minor one standard deviation, the whisker indicates the range, and the shaded area indicates the density of the data.

Table 1
Bivariate correlations between study variables ($N = 2904$).

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1 Contact comfort	0.86											
2 Pathogen disgust sensitivity	***−0.28***	0.76										
3 Social dominance orientation	**−0.06**	***0.11***	0.88									
4 Appearance (infectious face) [a]	***−0.14***	−0.04	0.04									
5 Appearance (masked face) [a]	−0.02	−0.00	0.02	–								
6 Target ingroup/outgroup [b]	0.02	−0.02	−0.03	0.01	0.01							
7 Target sex [c]	***−0.16***	0.00	−0.00	−0.01	−0.01	−0.00						
8 Participant sex [c]	***0.06***	***−0.09***	***0.08***	−0.03	−0.02	0.01	0.00					
9 Perceived target infectiousness	***−0.22***	***0.09***	***0.13***	***0.54***	***0.09***	***0.09***	0.03	−0.03				
10 Perceived target prosociality	***0.24***	−0.01	***−0.08***	**−0.07**	0.02	0.01	−0.03	*−0.04*	***−0.10***			
11 Perceived target similarity	***0.14***	−0.03	***−0.11***	***−0.10***	0.04	***−0.64***	*−0.04*	*−0.04*	***−0.14***	***0.09***		
12 Target contact frequency [d]	***0.11***	**−0.05**	***−0.20***	***−0.12***	0.04	***−0.60***	0.00	−0.01	***−0.19***	0.03	***0.70***	
13 Perceived infection threat [e]	0.00	0.02	***−0.12***	−0.01	0.04	***0.35***	−0.02	***−0.06***	***0.12***	0.03	***−0.14***	***−0.12***

Note: ***Bold and italics*** = $p < .001$, **bold** = $p < .01$, *italics* = $p < .05$. Cronbach's alphas of multi-item measurements are on the diagonal.
[a] For appearance conditions, 0 = unmodified, and 1 = infectious or masked.
[b] We recode the two nationality variables as target ingroup/outgroup, in which ingroup regarding when the target's nationality is the same as participants, while outgroup regarding different nationalities, 0 = ingroup and 1 = outgroup.
[c] For target and participant sex, 0 = female and 1 = male.
[d] Spearman rather than Pearson correlations are reported for contact frequency given the ordinal nature of this variable.
[e] Perceived infection threat refers to threats perceived within the target's country of origin.

pools and broader assessments of contact comfort, and presenting materials in participants' native languages, we did not detect effects supportive of the outgroup-as-pathogen-cue hypothesis. Nevertheless, many of our other findings were consistent with those from previous studies in the behavioral immune system literature. For example, contact comfort was negatively related to pathogen disgust sensitivity (Tybur et al., 2020; van Leeuwen & Jaeger, 2022), and was lower for faces manipulated to appear infectious relative to those unmanipulated (e.g., van Leeuwen & Petersen, 2018; van Leeuwen & Jaeger, 2022). Hence, while results indicated that people are more motivated to avoid microbe-sharing contact with individuals possessing symptoms of current infection, they did not reveal evidence that people are motivated to avoid microbe-sharing contact with ethnic-outgroup members more than ethnic-ingroup members.

5.1. Do other findings support the outgroup-as-pathogen-cue hypothesis?

We found that ethnic outgroup targets were rated as slightly more likely to have an infectious disease than were ethnic ingroup targets. However, participants reported no greater discomfort with pathogen-risky contact with outgroup members. This finding complements findings suggesting that people are averse to indirect contact with individuals possessing facial disfigurements known to not be symptoms of infection (Ryan et al., 2012). Here, rather than contact avoidance being higher for targets believed to be non-infectious, contact avoidance was no higher for targets believed to be (slightly) more infectious (cf.

Petersen, 2017). Thus, such results did not entirely support the outgroup-as-pathogen-cue hypothesis.

We also detected a small relation between contact comfort and perceptions that a target is similar to individuals in the local community (Bressan, 2021). Although perceived similarity has been interpreted as a continuous measure of outgroupness (Bressan, 2021), it can also reflect myriad factors unrelated to group membership (e.g., facial morphology, eye color, etc.). Further, similarity perceptions could reflect outputs of the behavioral immune system rather than inputs into it, if similarity perceptions partially regulate contact. And, while we also detected a relation between contact comfort and reported frequency of contact with members of the target's ethnic group, the pattern was quadratic. Contact comfort was lowest for participants who reported the least previous contact with people of the target's ethnicity. However, it was lower for participants who reported the most contact frequency than it was for people who reported intermediate contact frequency.

5.2. Effects of facemasks

In addition to investigating the effects of group membership and explicit cues of infectious disease on contact comfort, we also tested whether people were more or less comfortable with microbe-sharing contact with targets wearing facemasks. We carried out this latter test because facemasks might be interpreted as indicative of infection risk and/or prosociality, and perhaps differently in a Western versus an East Asian country. Although masked targets were perceived as slightly more likely to be infectious than unmasked targets (and more so among British participants than Chinese participants), we did not detect an effect of facemask wearing on contact comfort. However, the perception of infectiousness of targets wearing a facemask varied across the two samples. As with ethnic outgroups, beliefs about infectiousness in mask wearers might not influence the infection-neutralizing motivations outputted by the behavioral immune system. Alternatively, beliefs about target infectiousness could also be offset by beliefs about the prophylactic effects of facemasks. Future research could distinguish between these possibilities.

5.3. The impact of the COVID-19 pandemic

We collected data in January 2022, when many countries were experiencing a surge in infections caused by the Omicron variants of the SARS-CoV-2 virus. The degree to which pandemic conditions impact the behavioral immune system is an open question (Ackerman, Tybur, & Blackwell, 2021). Nevertheless, this surge – as well as infections over the previous two years – might have led to a general decrease in contact comfort across targets. Even so, any decrease in global contact comfort did not prevent us from observing an effect of infection symptom on contact comfort, nor did it prevent us from observing a relation between pathogen disgust sensitivity and contact comfort (cf. Tybur et al., 2022). Indeed, the relation between pathogen disgust sensitivity and contact comfort observed here ($r = -0.28$) was nearly identical to that observed in similar studies before the pandemic (e.g., Tybur et al., 2020, r's $= -0.22$, -0.24, and -0.33 across three studies). The pandemic might have also influenced how masked faces are perceived. Given that wearing a facemask was mandatory in many settings in both the UK and China from 2020 to 2022, the pandemic might have decreased the degree to which a mask is interpreted as providing information regarding infectiousness. Further, the widespread use of facemasks across the world might have also dampened cross-cultural differences in how masks are perceived.

5.4. Limitations and future research

We recruited from the White population in the UK and the East-Asian population in China, and we used White and East-Asian stimuli. Our inferences are thus limited to these two populations, both in terms of targets and perceivers. Some findings suggest that pathogen-avoidance motives only impact antipathy toward members of groups that are sufficiently culturally distant or sufficiently associated with infectious disease (Faulkner et al., 2004; Ji et al., 2019). Even so, UK participants explicitly associated China with infectious disease, as did Chinese participants the UK, perhaps due to the origins of COVID-19 (in the case of China) and the high number of COVID-19 cases in deaths in 2020 and 2021 (in the case of the UK). Further, China and the UK differ markedly along broad cultural variables (Muthukrishna et al., 2020). For these reasons, the UK and China seem they appear suitable for testing even a narrower version of the outgroup-as-pathogen-cue hypothesis that require additional associations between a target group and cultural differences in pathogens. Nevertheless, future work could certainly test the outgroup-as-pathogen-cue hypothesis using different target groups.

We also used only a single cue to infectiousness – a skin condition intended to mimic the appearance of shingles. Naturally, infectious disease can lead to other symptoms, including other skin changes (e.g., pallor, rashes, jaundice), vocal changes (e.g., hoarseness), behavioral changes (e.g., lethargy, coughing). Infectiousness and health status can also be detected via other senses, such as olfaction (e.g., body odor, Sarolidou et al., 2020; Zakrzewska et al., 2020) and audition (e.g., voice; Fasoli, Maass, & Sulpizio, 2018). Future studies could test whether the outgroup-as-pathogen-cue hypothesis applies when targets possess different cues to infectiousness.

To date, the literature examining relations between pathogen-avoidance and intergroup biases has largely focused on phenomena such as explicit prejudice (e.g., Huang, Sedlovskaya, Ackerman, & Bargh, 2011; O'Shea et al., 2019) or implicit attitudes (e.g., Faulkner et al., 2004; Klavina et al., 2011). Less work has focused on whether people treat individual outgroup members as if they pose more of a pathogen threat than individual ingroup members. Results reported here and in van Leeuwen and Petersen (2018) cast doubt on the outgroup-as-pathogen-cue interpretation of relations between disgust sensitivity and, for example, anti-immigrant bias. Future work can naturally use approaches apart from contact-comfort ratings to evaluate the outgroup-as-pathogen-cue hypothesis. In the meantime, the field will benefit from generating and testing other hypotheses for explaining why more pathogen-avoidant individuals might feel more negatively toward outgroups.

Open practices of data and code availability

All data, analysis scripts, and materials of the project have been registered and made available via OSF https://osf.io/t476f/.

Declaration of Competing Interest

The authors declare no competing interests. This project was supported by China Scholarship Council (201806990045).

Appendix A. Supplementary Materials

Supplementary materials to this article can be found online at https://doi.org/10.1016/j.evolhumbehav.2022.08.007.

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