**Pathogen disgust sensitivity:
Individual differences in pathogen perception or pathogen avoidance?**

Draft version: 7 April 2022

This paper is has been accepted for publication at *Motivation and Emotion*:

<https://link.springer.com/article/10.1007/s11031-022-09937-2>

Author note

Florian van Leeuwen, Department of Social Psychology, Tilburg University. Bastian Jaeger, Department of Experimental and Applied Psychology, Vrije Universiteit University. Both authors have contributed equally to this paper.

For help with data collection, we thank Rick Oortwijn, Falco Pulles, Alvaro Evers, Bram van Gulick, Estela Perez, Tessa van Avendonck, Yusi Li, Maria Zhuravleva, Anastasia Grigoreva, and Anastasiia Burakova.

Correspondence concerning this article should be addressed to Florian van Leeuwen, Department of Social Psychology, Tilburg University, Professor Cobbenhagenlaan 225, 5037 DB, Tilburg, Netherlands. Email: f.vanleeuwen@tilburguniversity.edu.

Abstract

The emotion disgust motivates the avoidance of pathogens and contaminants. Individuals differ in their tendency to experience disgust and this is reflected in pathogen disgust sensitivity. Yet, it remains unclear which differences in psychological processes are captured by pathogen disgust sensitivity. We tested two hypotheses about how the information processing structure underlying pathogen avoidance might give rise to individual differences in pathogen disgust sensitivity. Participants ($n = 998$) rated the perceived health of individuals with or without facial blemishes and indicated how comfortable they would feel about having physical contact with them. For participants with high disgust sensitivity, facial blemishes were more indicative of poor health and perceived health was more strongly related to comfort with physical contact. These findings suggest that pathogen disgust sensitivity reflects individual differences in the tendency to interpret stimuli as an infection risk *and* the weight given to estimated infection risk when deciding who should be approached or avoided.

Keywords: disgust; disgust sensitivity; approach-avoidance motivations; individual differences; behavioral immune system

Pathogen disgust sensitivity:

Individual differences in pathogen perception or pathogen avoidance?

In addition to a physiological immune system that affords resistance and tolerance to pathogens, humans also have a behavioral immune system that motivates avoidance of pathogens (e.g., Ackerman et al., 2018; Schaller, 2015; Tybur & Lieberman, 2016; Gangestad & Grebe, 2014). How does this system operate? At least three features of the system are fairly well established. First, the system tends to work in a better-safe-than-sorry manner (also referred to as the smoke detector principle; Nesse, 2005). It is biased toward making false-positive errors rather than false-negative errors (i.e., inferring the presence of pathogens when in fact none are present; Miller & Maner, 2012; Ryan et al., 2012), in order to avoid committing the relatively more costly error of coming into contact with potentially lethal pathogens. Second, the emotion disgust, in particular pathogen disgust (Tybur et al., 2009), is the proximate mechanism that motivates individuals to avoid potential sources of pathogens (e.g., Curtis et al., 2004; Lieberman & Patrick, 2014; Oaten et al., 2009; Tybur et al., 2013)¹. Third, there are trait-like individual differences in pathogen avoidance motivations, which are commonly referred to as pathogen disgust sensitivity (e.g., Tybur & Karinen, 2018).

Several scales have been developed to measure individual differences in pathogen disgust sensitivity (e.g., Tybur et al., 2009; Olatunji et al., 2007). These measures are widely used and pathogen disgust sensitivity has been invoked as a proximate explanation for various phenomena, such as social trust (Aarøe et al., 2016), social conservatism (Terrizzi et al., 2013), intergroup attitudes (van Leeuwen & Petersen, 2018), and risk taking (Sparks et al., 2019). Two of the most widely used measures of pathogen disgust sensitivity are the pathogen subscale of the Three Domain Disgust Scale (TDDS; Tybur et al., 2009) and the core and contamination subscales of the Disgust Scale-Revised (DS-R; Olatunji et al., 2008). Both the TDDS and the DS-R include self-report items designed to measure the frequency and intensity of experiencing disgust towards a set of disgust elicitors (stimuli that typically evoke some disgust response, such as spoiled food). Scores on these scales are assumed to capture individual differences in pathogen avoidance and this assumption is supported by two findings. First, measures of pathogen disgust sensitivity show a strong positive correlation with self-report measures of germ aversion (Duncan et al., 2009; Tybur et al., 2015). Second,

¹ Disgust is sometimes described as an output of the behavioral immune system. However, when one defines an emotion as a mechanism that coordinates thoughts and behaviors towards a particular goal (Tooby & Cosmides, 1990), rather than the experience of an affective state, then the emotion pathogen disgust is equivalent to the behavioral immune system (Lieberman & Patrick, 2014). We use the term pathogen disgust to refer to the mechanism.

several studies found positive associations between measures of pathogen disgust sensitivity and behavioral avoidance of potential sources of pathogens (e.g., avoiding contact with a cookie that had fallen on the floor; Deacon & Olatunji, 2007; Fan & Olatunji, 2013; Olatunji et al., 2007; Rozin et al., 1999). Together, these results suggest that pathogen disgust sensitivity captures individual differences in pathogen avoidance motivations.

Yet, it remains unclear what kind of individual differences in the behavioral immune system are captured by measures of pathogen disgust sensitivity. As Tybur and Lieberman (2016, p. 8) concluded: “Trait-level pathogen avoidance could result from more sensitive cue detection, or it could result from strategically favoring Type I errors...relative to Type II errors...or it could result from greater pursuit of benefits of contact with pathogens (e.g., eating, mating).”

Here, we examine how pathogen disgust sensitivity is associated with variation in the psychological processes underlying pathogen avoidance motivations. As a theoretical framework, we take the information processing model proposed by Tybur and Lieberman (2016). In short, they proposed that pathogen avoidance mechanisms include (1) perceptual systems that monitor the environment for cues of pathogens; (2) a pathogen presence estimator that integrates these cues and computes a pathogen index (i.e., an estimate of infection risk, a representation of the probability that pathogens are present); and (3) a contact value estimator that computes the expected value of contact by integrating the pathogen index with other indices relevant to contact value (e.g., genetic relatedness, potential value as a sexual partner; see Figure 1).

Figure 1

A simplified version of the information processing system underlying pathogen avoidance motivations (adapted from Tybur & Lieberman, 2016)

Note. The figure illustrates two possibilities for what kind of individual differences in information processing might be captured by pathogen disgust sensitivity. Pathogen disgust sensitivity might involve individual differences in the weight given to pathogen cues when computing the pathogen index (i.e., variation in relation A). We label this the pathogen estimation hypothesis. Pathogen disgust sensitivity could also reflect individual differences in weight given to the pathogen index when computing the contact value index (i.e., variation in relation B). We label this the contact regulation hypothesis.

Although the model proposed by Tybur and Lieberman (2016) succeeds in synthesizing previous findings on pathogen avoidance, it remains unclear how pathogen disgust sensitivity fits into this system. Based on the proposed architecture, one possibility is that pathogen disgust sensitivity reflects people's sensitivity to pathogen cues. In other words, the degree to which a particular stimulus (e.g., a person with a cough, a banana with brown spots) is taken as evidence of infection risk may be higher for people who score high on pathogen disgust sensitivity (Miller & Maner, 2012). This may occur because of variation in thresholds or because of variation in integrating information about cues when computing the pathogen index. If pathogen disgust sensitivity reflects such variation, then this leads to the following hypothesis: The relation between the presence of pathogen cues and the pathogen index is stronger for individuals who score high on pathogen disgust sensitivity. We refer to this hypothesis as the *pathogen estimation hypothesis*.

A second possibility is that pathogen disgust sensitivity captures the weight placed on the pathogen index when computing the estimated value of contact. There may be individual differences in being invested in pathogen avoidance when making trade-offs about nutrition, sex, social contact, and other behaviors that pose infection risk (e.g., Tybur et al., 2018; Tybur & Lieberman, 2016). In other words, pathogen disgust sensitivity may reflect how

strongly the pathogen index (compared to other indices) motivates approach-avoidance behavior. If pathogen disgust sensitivity reflects individual differences in the weight given to the pathogen index, then this leads to the following hypothesis: The relation between the pathogen index and the contact value index is stronger for individuals who score high on pathogen disgust sensitivity. We refer to this hypothesis as the *contact regulation hypothesis*.

Here, we test the two hypotheses. Specifically, we examine (a) whether people who score high on pathogen disgust sensitivity have a stronger tendency to interpret cues that (probabilistically) indicate the presence of pathogens as an infection risk (the pathogen estimation hypothesis) and (b) whether people who score high on pathogen disgust sensitivity have a stronger tendency to consider potential pathogen threats when deciding with whom they want to have physical contact (the contact regulation hypothesis). These two hypotheses do not reflect the only possible roles of pathogen disgust sensitivity in the information processing underlying pathogen avoidance motivations. Yet given the extant knowledge, these two hypotheses capture the most plausible roles of individual differences in pathogen avoidance. Furthermore, the two hypotheses are not mutually exclusive. It is possible that pathogen disgust sensitivity reflects both variation in estimating infection risk *and* variation in weighing infection risk when estimating the expected value of contact.

Methods

Participants

Three convenience samples of participants were recruited between November 2018 and February 2019. The samples were recruited by students under supervision of the first author. In all three samples, participants completed an online survey, which included additional questions unrelated to the current hypotheses. Participants were provided with information about the study procedures and provided consent at the start of the survey. The study procedures were approved by the Ethics Review Board of Tilburg University.

Sample 1 included both first-year undergraduate psychology students at a Dutch university and contacts of students recruited via Dutch social media websites ($n = 539$; $M_{age} = 21.36$ years, $SD_{age} = 6.59$, $Mdn_{age} = 20$, $Min_{age} = 17$, $Max_{age} = 63$; 81.45% female, 18.00% male, 0.56% missing). The study was advertised as a study about consumer behavior and personality. Participants could complete the study in either English or Dutch. The undergraduate students earned course credits with their participation. Those recruited via social media websites received no compensation. Sample 2 was recruited among contacts of both Dutch and international students via multiple social media websites ($n = 271$; $M_{age} = 28.73$ years, $SD_{age} = 10.66$, $Mdn_{age} = 25$, $Min_{age} = 16$, $Max_{age} = 71$; 62.73% female, 36.90%

male, 0.37% missing). The study was advertised as a study about social perception and emotion. Participants completed the study in English and received no compensation. Sample 3 was recruited via Russian social media websites ($n = 188$; $M_{age} = 29.88$ years, $SD_{age} = 10.29$, $Mdn_{age} = 25.5$, $Min_{age} = 17$, $Max_{age} = 72$; 63.30% female, 36.70% male). The study was advertised as a study about the social and psychological consequences of disgust. As compensation, participants were given the opportunity to enter a lottery for a small prize (approximately 13 EUR). Participants completed the study in Russian. Taken together, the total sample included 998 participants ($M_{age} = 24.99$ years, $SD_{age} = 9.48$, $Mdn_{age} = 22$, $Min_{age} = 16$, $Max_{age} = 72$; 72.95% female, 26.65% male, 0.40% missing).

Materials and Procedure

All participants were randomly assigned to one of two between-subject conditions. In the pathogen cue condition, participants were shown images of eight white male faces with salient pathogen cues. Images were taken from the Center for Vital Longevity Face Database (Minear & Park, 2014) and the pathogen cues were added by superimposing images of acne (Petersen, 2017). While acne is not infectious, it contains cues (inflamed skin, pus) believed to activate pathogen avoidance motivations. In the control condition participants were shown images of the same eight white male faces, but without the added pathogen cues. We relied on these stimuli for three reasons. First, previous work that included a subset of these stimuli showed that faces with these pathogen cues are indeed perceived as less healthy (Van Leeuwen & Petersen, 2018). Second, our primary goal was to measure the influence of pathogen cues on approach-avoidance motivations. We therefore kept other cues that might influence approach-avoidance motivations, such as targets' sex and ethnicity, constant. Third, we chose white targets because we anticipated the majority of our participants to be white.

For each face that was presented, participants were asked to evaluate the person in terms of comfort with contact (e.g., "How would you feel about shaking hands with the person in the picture?" rated on a 5-point scale from *very uncomfortable* to *very comfortable*) and perceived health (e.g., "How healthy does this person look?" rated on a 5-point scale from *very unhealthy* to *very healthy*). The exact wording of the questions and the number of answer options differed slightly across the three samples (see Supplementary Materials).

Later in the survey, after completing items related to other research questions, participants completed the Three-Domain Disgust Scale (TDDS; Tybur et al., 2009). The TDDS asks participants to indicate how disgusted they feel about a particular event or action. The TDDS included a subscale of seven items rated on a scale from *Not at all disgusting* (0) to *Extremely disgusting* (6) that measure pathogen disgust sensitivity (e.g., "Stepping in dog

poop”, “Sitting next to a stranger who has sweaty palms”). The number of answer options differed across the three samples, using a 7-point scale in sample 1, an 11-point scale in sample 2 and a 6-point scale in sample 3 (see Supplementary Materials). The reliability of the scale was acceptable (Cronbach’s α s = .71, .70, and .73).

All data, analysis scripts, and materials are available at the Open Science Framework (<https://osf.io/2zunm/>).

Results

All continuous variables were z -standardized prior to analysis. This standardization of variables was performed within each sample due to differences in response scales between the samples. All analyses were performed in R (R Core Team, 2021). We used the *lme4* package (Bates et al., 2015) and the *lmerTest* package (Kuznetsova et al., 2016) to estimate multilevel regression models with random intercepts and slopes per target and participant.² Before testing our main hypotheses, we examined three basic predictions derived from the pathogen avoidance model by Tybur and Lieberman (2016).

First, we tested whether individuals with pathogen cues were perceived as less healthy than individuals without pathogen cues. Regressing health ratings on pathogen cue presence (-0.5 = facial blemishes absent, 0.5 = facial blemishes present) revealed a significant negative effect, $\beta = -0.917$, $SE = 0.225$, 95% CI [-1.312, -0.516], $p = .004$. Participants perceived individuals with facial blemishes as less healthy.

Second, we tested whether participants were reluctant to have physical contact with individuals with pathogen cues. Regressing participants’ comfort with contact on pathogen cue presence (-0.5 = facial blemishes absent, 0.5 = facial blemishes present) revealed a significant negative association, $\beta = -0.431$, $SE = 0.131$, 95% CI [-0.689, -0.157], $p = .009$. Participants were more reluctant to have physical contact with individuals with facial blemishes.

Third, we tested whether people were more averse to physical contact with individuals who they perceived as unhealthy. Regressing participants’ comfort with contact on their health ratings of targets revealed a significant positive association, $\beta = 0.474$, $SE = 0.020$, 95% CI [0.434, 0.512], $p < .001$. Participants were more comfortable with contact with individuals who were perceived as healthy and more reluctant to have contact with

² We first ran all analyses with a maximal random effects structure (Barr et al., 2013) that also included random effects per sample. However, many models failed to converge as the variance that was explained by sample-specific slopes was near zero. We therefore omitted sample-specific random effects from our models. When testing for the effects of pathogen cues, we only included random slopes per target but not per participant as pathogen cue presence was manipulated between-subjects.

individuals who were perceived as unhealthy. These associations are consistent with several posited relationships in the pathogen avoidance model (Tybur & Lieberman, 2016).

Primary Analyses

Next, we examined the role of individual differences in pathogen disgust. Above, we showed that individuals with facial blemishes were perceived as less healthy. Here, we tested whether this effect was stronger for participants who score high on pathogen disgust sensitivity, as predicted by the pathogen estimation hypothesis. We estimated a model in which we regressed health ratings on pathogen cue presence (-0.5 = facial blemishes absent, 0.5 = facial blemishes present), pathogen disgust sensitivity, and their interaction (the full model results are reported in the Supplemental materials). This revealed a negative main effect of pathogen cue presence, $\beta = -0.940$, $SE = 0.225$, 95% CI [-1.395, -0.518], $p = .004$, and a negative main effect of disgust sensitivity, $\beta = -0.110$, $SE = 0.018$, 95% CI [-0.149, -0.075], $p < .001$. Participants who scored high on pathogen disgust sensitivity generally perceived targets as less healthy and targets with facial blemishes were perceived as less healthy than targets without facial blemishes. Crucially, the interaction effect was also significant, $\beta = -0.103$, $SE = 0.036$, 95% CI [-0.176, -0.035], $p = .005$ (see Figure 2A). Individuals with facial blemishes were perceived as less healthy and this effect was stronger for participants who scored high (i.e., one standard deviation above the mean) on pathogen disgust sensitivity, $\beta = -1.159$, $SE = 0.224$, 95% CI [-1.591, -0.697], $p < .001$, compared to participants who scored low (i.e., one standard deviation below the mean) on pathogen disgust sensitivity, $\beta = -0.826$, $SE = 0.226$, 95% CI [-1.262, -0.374], $p = .004$.

To further explore this interaction, we conducted a Johnson-Neyman floodlight analysis. We examined the effect of pathogen cues on perceived health as a function of participants' pathogen disgust sensitivity (see Figure 4A). Across the entire range of pathogen disgust sensitivity scores observed in our sample, there was a significant negative effect of pathogen cues on perceived health. Crucially, this negative effect was stronger the higher participants scored on pathogen disgust sensitivity. Thus, the current data support the pathogen estimation hypothesis.

Figure 2

The effect of pathogen cues on the perceived health of targets as a function of participants' pathogen disgust sensitivity

We then tested the contact regulation hypothesis. We tested whether the positive association between perceived health and comfort with contact was stronger for participants who scored high on pathogen disgust sensitivity. We estimated a model in which we regressed comfort with contact ratings on perceived health, pathogen disgust sensitivity, and their interaction. This revealed a positive main effect of perceived health, $\beta = 0.473$, $SE = 0.020$, 95% CI [0.431, 0.514], $p < .001$, and a negative main effect of disgust sensitivity, $\beta = -0.163$, $SE = 0.019$, 95% CI [-0.205, -0.127], $p < .001$. Participants who scored high on pathogen disgust sensitivity were generally less comfortable with physical contact and participants were less comfortable with contact for targets who were perceived as less healthy. Crucially, the interaction effect was also significant, $\beta = 0.032$, $SE = 0.012$, 95% CI [0.011, 0.054], $p = .006$ (see Figure 3). Participants were more comfortable with having physical contact with individuals that were perceived as more healthy and this association was stronger for participants who scored high (i.e., one standard deviation above the mean) on pathogen disgust sensitivity, $\beta = 0.486$, $SE = 0.022$, 95% CI [0.444, 0.526], $p < .001$, compared to participants who scored low (i.e., one standard deviation below the mean) on pathogen disgust sensitivity, $\beta = 0.413$, $SE = 0.030$, 95% CI [0.354, 0.478], $p < .001$.

To further explore this interaction, we conducted a Johnson-Neyman floodlight analysis (Spiller et al., 2013). We examined the association between perceived health and comfort with contact as a function of participants' pathogen disgust sensitivity (see Figure 4B). Across the entire range of pathogen disgust sensitivity scores observed in our sample, there was a significant positive effect of perceived health on comfort with contact. Crucially, this positive effect was stronger the higher participants scored on pathogen disgust sensitivity. Thus, the current data also support the contact regulation hypothesis.

Figure 3

The association between perceived health and participants' comfort with contact as a function of participants' pathogen disgust sensitivity

Robustness Checks

To test the robustness of these results, we examined whether our primary findings still emerged when controlling for the sex and age of participants. Two participants did not disclose their sex, six participants did not disclose their age, and two participants did not disclose either, which means that the current analyses were based on a sample of 988 participants. For the pathogen estimation hypothesis, we again estimated a model in which we regressed health ratings on pathogen cue, pathogen disgust sensitivity, and their interaction, while also including sex (0 = female, 1 = male) and age in the model. There was a

negative effect of sex, $\beta = -0.218$, $SE = 0.042$, 95% CI [-0.303, -0.144], $p < .001$, and a positive effect of age, $\beta = 0.007$, $SE = 0.002$, 95% CI [0.004, 0.011], $p < .001$, showing that female participants and older participants perceived targets as less healthy. Moreover, the interaction effect between pathogen cue presence and pathogen disgust sensitivity remained significant and the effect size was similar, $\beta = -0.102$, $SE = 0.036$, 95% CI [-0.171, -0.027], $p = .005$.

For the contact regulation hypothesis, we again estimated a model in which we regressed comfort with contact ratings on perceived health, pathogen disgust sensitivity, and their interaction, while also including sex (0 = female, 1 = male) and age in the model. There was no significant effect of sex, $\beta = 0.016$, $SE = 0.045$, 95% CI [-0.082, 0.097], $p = .724$, but a positive effect of age, $\beta = 0.006$, $SE = 0.002$, 95% CI [0.002, 0.010], $p = .006$, showing that older participants were less comfortable with having physical contact with targets. More importantly, the interaction effect between perceived health and pathogen disgust sensitivity remained significant and the effect size was similar, $\beta = 0.030$, $SE = 0.012$, 95% CI [0.007, 0.052], $p = .010$. In short, we still found support for both hypotheses when controlling for participant sex and age.

Figure 4

Johnson-Neyman plots illustrating (A) the effect of pathogen cues on the perceived health of targets and (B) the association between perceived health and comfort with contact conditional on participants' pathogen disgust sensitivity

Discussion

How do humans avoid pathogens? The pathogen avoidance model proposed by Tybur and Lieberman (2016) synthesizes an extensive literature on this topic to outline the information processing system underlying human pathogen avoidance motivations. In the present study, we aimed to extend this model by examining two plausible (not mutually exclusive) roles of individual differences in pathogen disgust in this model.

First, we tested the *pathogen estimation hypothesis*—the idea that people who score high on pathogen disgust sensitivity weigh pathogen cues more heavily when estimating infection risk. The current study yielded support for this hypothesis. We found that individuals with facial blemishes were perceived as less healthy. More importantly, the strength of this relationship varied with the pathogen disgust sensitivity of perceivers. Thus, the same pathogen cues were interpreted as stronger evidence of infectiousness by participants who scored high on pathogen disgust sensitivity.

Second, we tested the *contact regulation hypothesis*—the idea that people who score high on pathogen disgust sensitivity put more weight on the pathogen index (i.e., the estimated probability that an individual poses an infection risk) when deciding who should be approached or avoided. The current study also yielded support for this hypothesis. Participants felt more comfortable with having physical contact with individuals when they were perceived as healthier. Again, the strength of this relationship varied with participants' pathogen disgust sensitivity. Thus, when deciding whether an individual should be approached or avoided, participants who scored high on pathogen disgust sensitivity were more influenced by their perceptions of health.

In the current study, we also replicated several basic assumptions of the pathogen avoidance model by Tybur and Lieberman (2016). Participants perceived individuals with facial blemishes, which could indicate the presence of an infectious disease, as less healthy and were more reluctant to have physical contact with them. There was also a strong positive relationship between perceived health and comfort with contact, showing that participants were more motivated to avoid physical contact with individuals when they perceived them as unhealthy. Moreover, we replicated prior findings on associations between individual differences in pathogen disgust sensitivity and perceptions and behaviors geared towards avoiding pathogen threats (Park, 2015; Park et al., 2012). Our results showed that more disgust sensitive participants generally perceived others as less healthy and were more motivated to avoid physical contact with others, consistent with an increased concern for contracting an infectious disease.

While the current results confirmed basic premises and replicated prior findings, they also extend the pathogen avoidance model by Tybur and Lieberman (2016) by showing how individual differences relate to the information processing underlying pathogen avoidance motivations. In short, we found that people who are chronically concerned about pathogens (a) more readily interpret stimuli as a pathogen threat and (b) are more likely to be guided by pathogen concerns when deciding who should be approached or avoided.

Our interpretation of the findings is guided by the model outlined by Tybur and Lieberman (2016). The current findings are also amenable to alternative interpretations guided by different theory and assumptions about emotions in general or disgust in particular. Here we briefly describe one plausible alternative interpretation. An appraisal-tendency approach to emotions and judgment assumes that each emotion is characterized by an appraisal (i.e., a particular interpretation of events, such as being exposed to imminent threat) and action-tendencies (i.e., a particular action or goal, such as fleeing) which influences

judgments in line with that appraisal tendency. Disgust is assumed to be characterized by appraisals of contamination and action-tendencies of pushing away and keeping distance (Keltner & Lerner, 2010). From an appraisal-tendency perspective, disgust sensitivity (including pathogen disgust sensitivity) can be interpreted as a measure of trait disgust, the dispositional tendency of feeling disgust (e.g., Horberg et al., 2009; Lerner & Keltner, 2001). Taking this perspective, the findings can be interpreted as showing that trait disgust moderates both (1) the relation between perceived pathogen cues and estimated health and (2) the relation between estimated health and expected value of contact. In this interpretation, the findings are consistent with the general notion of the appraisal-tendency framework that emotions influence cognitive processes such as judgment and decision-making and also with the more specific view that trait disgust is associated with appraisals of contamination and guides judgments towards avoidance or removal of the contaminant (e.g., Keltner & Lerner, 2010).

Limitations and Future Directions

Our study was based on several assumptions. First, we measured both the contact value index and the pathogen index with self-report scales. Previous work suggests that self-reports of comfort with physical contact provide a measure of the contact value index (with higher comfort reflecting a higher contact value index) and that self-reports of perceived health provide a measure of the pathogen index (with lower perceived health reflecting a higher value for the pathogen index; Van Leeuwen & Petersen, 2018; Tybur et al., 2020). Second, we assumed that facial blemishes resembling acne are perceived as a pathogen cue, so that faces with such blemishes are on average assigned a higher value on the pathogen index (and hence are evaluated as less healthy by perceivers). Previous work suggests that this assumption is plausible (Curtis et al., 2004; Jaeger et al., 2018; Van Leeuwen & Petersen, 2018). Still, the generalizability of the present results needs to be tested with alternative operationalizations. For example, future studies could measure estimation of infection risk by directly asking participants whether they think a target poses an infection risk or could directly measure pathogen cue detection by using signal detection methods (Stanislaw & Todorov, 1999). Behavioral measures, such as measuring how closely participants choose to sit next to targets (Houston & Bull, 1994), could be used to measure comfort with physical contact.

We tested our hypotheses in the context of interpersonal contact because many pathogens are transmitted via human-to-human contact and estimating the risk of an individual being infectious is likely one of the primary tasks the human pathogen avoidance

system has evolved to perform (Axelsson et al., 2018; Regenbogen et al., 2017). In addition, humans encounter many other potential sources of pathogens (e.g., rotten food, dead animal bodies, bodily fluids) and more work is needed to confirm that pathogen disgust sensitivity relates to avoidance of these hazards in the same way as it relates to avoidance of other humans.

In the current study, we examined the role of pathogen disgust sensitivity in a cross-sectional design, investigating how between-person differences relate to the information processing underlying pathogen avoidance. One promising avenue for future research is to test whether the same pattern of results is observed when examining within-person changes in pathogen disgust sensitivity. Based on the current findings, we would predict that individuals should be more likely to perceive ambiguous pathogen cues as infection risks and be more motivated to avoid potential sources of pathogens in situations in which their disgust sensitivity is upregulated (relative to their average level of disgust sensitivity).

Finally, future studies should examine how well the current results generalize across different countries and cultures. Our samples included participants from both the Netherlands and Russia and in all our statistical models, the variance explained by sample-specific random effects was close to zero. In other words, we found no evidence that, for example, the effect of pathogen cues on perceived health and comfort with physical contact varied across the samples. Still, the current study was not specifically designed to test for cultural differences and more systematic work is required. Future work should also examine if the findings generalize to a more diverse set of stimuli. We relied on a relatively small set of white, male targets in our studies. Many common infectious diseases (e.g., influenza, respiratory tract infections, staph infections) spread similarly between individuals regardless of ethnicity or sex. Thus, there were no strong reasons to expect a different pattern of results when testing people's responses to groups of individuals that are more demographically diverse. Still, replicating the current results with a large, demographically diverse sample of targets would be important for two reasons. The current design may have overestimated the effect of pathogen cues by holding other cues that people would normally rely on constant. Moreover, given the widespread focus on white faces in the impression formation literature (Cook & Over, 2021), it would be valuable to explore the generalizability and variability of pathogen avoidance mechanisms in response to more diverse sets of targets.

Conclusion

In sum, the current study provides insights into how individual differences in pathogen disgust sensitivity are associated with psychological processes underlying pathogen

avoidance motivations. Our results provide evidence for two complementary roles. Our results suggest that people who score high on pathogen disgust sensitivity more readily interpret cues that could potentially indicate the presence of pathogens as an actual pathogen threat. That is, they are more sensitive when estimating pathogen threats. At the same time, people who score high on pathogen disgust sensitivity place more weight on potential pathogen threats when deciding whether they want to have physical contact. That is, their approach-avoidance tendencies are more informed by pathogen concerns.

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(2), e12371.
- Aarøe, L., Osmundsen, M., & Petersen, M. B. (2016). Distrust as a disease avoidance strategy: Individual differences in disgust sensitivity regulate generalized social trust. *Frontiers in Psychology*, 7, 1038. <https://doi.org/10.3389/fpsyg.2016.01038>
- Axelsson, J., Sundelin, T., Olsson, M. J., Sorjonen, K., Axelsson, C., Lasselin, J., & Lekander, M. (2018). Identification of acutely sick people and facial cues of sickness. *Proceedings of the Royal Society B: Biological Sciences*, 285, 20172430. <https://doi.org/10.1098/rspb.2017.2430>
- 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., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67(1). <https://doi.org/10.18637/jss.v067.i01>
- Cook, R., & Over, H. (2021). Why is the literature on first impressions so focused on white faces? *Royal Society Open Science*, 8, 211146. <https://doi.org/10.1098/rsos.211146>
- 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(suppl_4), S131-S133.
- Deacon, B., & Olatunji, B. O. (2007). Specificity of disgust sensitivity in the prediction of behavioral avoidance in contamination fear. *Behaviour Research and Therapy*, 45, 2110-2120.
- 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(6), 541-546.
- Fan, Q., & Olatunji, B. O. (2013). Individual differences in disgust sensitivity and health-related avoidance: Examination of specific associations. *Personality and Individual Differences*, 55, 454-458.
- Gangestad, S. W., & Grebe, N. M. (2014). Pathogen avoidance within an integrated immune system: Multiple components with distinct costs and benefits. *Evolutionary Behavioral Sciences*, 8(4), 226–234. <https://doi.org/10.1037/ebs0000023>

- Horberg, E. J., Oveis, C., Keltner, D., & Cohen, A. B. (2009). Disgust and the moralization of purity. *Journal of Personality and Social Psychology*, 97, 963–976.
- Houston, V., & Bull, R. (1994). Do people avoid sitting next to someone who is facially disfigured? *European Journal of Social Psychology*, 24, 279–284.
- Jaeger, B., Wagemans, F. M. A., Evans, A. M., & van Beest, I. (2018). Effects of facial skin smoothness and blemishes on trait impressions. *Perception*, 47(6), 608–625.
<https://doi.org/10.1177/0301006618767258>
- Keltner, D., & Lerner, J. S. (2010). Emotion. In D. T. Gilbert, S. T. Fiske & G. Lindsay (Eds.), *The Handbook of Social Psychology* (5th ed., pp. 312–347). New York, NY: McGraw Hill.
- Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2016). *lmerTest: Tests in linear mixed effects models* (R package version 2.0-32).
- Lerner, J. S., & Keltner, D. (2001). Fear, anger and risk. *Journal of Personality and Social Psychology*, 81, 146–159.
- Lieberman, D., & Patrick, C. (2014). Are the behavioral immune system and pathogen disgust identical?. *Evolutionary Behavioral Sciences*, 8(4), 244–250.
- Miller, S., & Maner, J. (2012). Overperceiving disease cues: The basic cognition of the behavioral immune system. *Journal of Personality and Social Psychology*, 102(6), 1198–1213.
- Miner, M. & Park, C.D. (2004). A lifespan database of adult facial stimuli. *Behavior Research Methods, Instruments, and Computers*, 36, 630–633.
- Nesse, R. M. (2005). Natural selection and the regulation of defenses: A signal detection analysis of the smoke detector principle. *Evolution and Human Behavior*, 26(1), 88–105. <https://doi.org/10.1016/j.evolhumbehav.2004.08.002>
- Oaten, M., Stevenson, R. J., & Case, T. I. (2009). Disgust as a disease-avoidance mechanism. *Psychological Bulletin*, 135, 303–321. doi:10.1037/a0014823
- Olatunji, B. O., Haidt, J., McKay, D., & David, B. (2008). Core, animal reminder, and contamination disgust: Three kinds of disgust with distinct personality, behavioral, physiological, and clinical correlates. *Journal of Research in Personality*, 42, 1243–1259.
- Olatunji, B. O., Lohr, J. M., Sawchuk, C. N., & Tolin, D. F. (2007). Multimodal assessment of disgust in contamination-related obsessive-compulsive disorder. *Behaviour Research and Therapy*, 45, 263–276.

- Olatunji, B. O., Williams, N. L., Tolin, D. F., Abramowitz, J. S., Sawchuk, C. N., Lohr, J. M., & Elwood, L. S. (2007). The Disgust Scale: Item analysis, factor structure, and suggestions for refinement. *Psychological Assessment*, 19(3), 281-297.
- Park, J. H. (2015). Introversion and human-contaminant disgust sensitivity predict personal space. *Personality and Individual Differences*, 82, 185–187.
<https://doi.org/10.1016/j.paid.2015.03.030>
- Park, J. H., Leeuwen, F. Van, & Stephen, I. D. (2012). Homeliness is in the disgust sensitivity of the beholder: Relatively unattractive faces appear especially unattractive to individuals higher in pathogen disgust. *Evolution and Human Behavior*, 33(5), 569–577. <https://doi.org/10.1016/j.evolhumbehav.2012.02.005>
- Petersen, M. B. (2017). Healthy out-group members are represented psychologically as infected in-group members. *Psychological Science*, 28(12), 1857-1863.
- R Core Team. (2021). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. <https://www.r-project.org/>
- Regenbogen, C., Axelsson, J., Lasselin, J., Porada, D. K., Sundelin, T., Peter, M. G., Lekander, M., Lundström, J. N., & Olsson, M. J. (2017). Behavioral and neural correlates to multisensory detection of sick humans. *Proceedings of the National Academy of Sciences*, 114, 6400-6405. <https://doi.org/10.1073/pnas.1617357114>
- Rozin, P., Haidt, J., McCauley, C., Dunlop, L., & Ashmore, M. (1999). Individual differences in disgust sensitivity: Comparisons and evaluations of paper-and-pencil versus behavioral measures. *Journal of Research in Personality*, 33, 330-351.
- Ryan, S., Oaten, M., Stevenson, R. J., & Case, T. I. (2012). Facial disfigurement is treated like an infectious disease. *Evolution and Human Behavior*, 33(6), 639-646.
- Schaller, M. (2015). The behavioral immune system. In D.M. Buss (Ed.), *Handbook of Evolutionary Psychology* (2nd ed.). New York: Wiley.
- Sparks, A.M., Fessler, D.M., Chan, K.Q., Ashokkumar, A., & Holbrook, C. (2018). Disgust as a mechanism for decision making under risk: Illuminating sex differences and individual risk-taking correlates of disgust propensity. *Emotion*, 18(7), 942-958.
- Spiller, S. A., Fitzsimons, G. J., Lynch Jr., J. G., & McClelland, G. H. (2013). Spotlights, floodlights, and the magic number zero: Simple effects tests in moderated regression. *Journal of Marketing Research*, L, 277–288.
- Stanislaw, H., & Todorov, N. (1999). Calculation of signal detection theory measures. *Behavior Research Methods, Instruments, & Computers*, 31(1), 137-149.

- Terrizzi Jr, J. A., Shook, N.J., & McDaniel, M.A. (2013). The behavioral immune system and social conservatism: A meta-analysis. *Evolution and Human Behavior*, 34(2), 99-108.
- Tooby, J., & Cosmides, L. (1990). The past explains the present: Emotional adaptations and the structure of ancestral environments. *Ethology & Sociobiology*, 11, 375–424.
- Tybur, J. M., & Karinen, A. K. (2018). Measurement and theory in disgust sensitivity. In Zeigler-Hill, V., & Shackelford, T. K. (Eds.) *Handbook of Personality and Individual Differences*, 159-179.
- Tybur, J. M., Çınar, Ç., Karinen, A. K., & Perone, P. (2018). Why do people vary in disgust?. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 373(1751), 20170204.
- Tybur, J. M., Inbar, Y., Güler, E., & Molho, C. (2015). Is the relation between pathogen avoidance and ideological conservatism explained by sexual strategies? *Evolution and Human Behavior*, 36, 489-497.
- 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.
- 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.
- Tybur, J.M., Lieberman, D., Kurzban, R., & DeScioli, P. (2013). Disgust: Evolved function and structure. *Psychological Review*, 120, 65–84. doi:10.1037/a0030778
- 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.