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Concern about salient pathogen threats increases sensitivity to disgust☆

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ABSTRACT

Individuals vary in their sensitivity to disgust—differences that have implications for intergroup attitudes, political ideology, and beyond. However, the source of this variability in disgust sensitivity remains a subject of debate. In this work, we test the hypothesis that sensitivity to disgust is "calibrated" by an individual's concern about disease threats in their local ecology. Leveraging the COVID-19 pandemic, we obtain strong support for this hypothesis, finding that disgust sensitivity increased following the COVID-19 outbreak and that the degree of this increase was moderated by an individual's subjective concern about contracting the disease. This work fills a longstanding theoretical gap regarding the sources of variability in disgust sensitivity, while challenging the view that disgust sensitivity is an immutable individual difference. Given the role of disgust in motivating intergroup prejudice and political ideology, we anticipate that these increases in disgust sensitivity are likely to have important downstream societal implications.

1. Introduction

Disgust is theorized to have evolved in order to aid in the detection and avoidance of pathogens (Ekman, 1970; Faulkner et al., 2004; Navarrete & Fessler, 2006). Specifically, disgust is believed to have originally developed to facilitate the avoidance of oral contamination by potentially pathogenic substances such as rotten foods (Curtis & Biran, 2001; Rozin & Fallon, 1987). When these pathogen-laden foods are consumed, their unpleasant taste triggers a set of physiological responses (e.g., projection of the tongue, opening of the mouth) that inhibits ingestion of the noxious stimulus. This oral rejection response is believed to have formed the basis for the emotion of disgust, which later expanded to be elicited by a broader range of pathogen threats, including certain insects and animals, unusual sexual acts, bodily fluids (e.g., blood, vomit), and humans exhibiting signals of disease (Schaller, 2006; Schaller & Park, 2011). In this way, disgust is presumed to serve a disease avoidance function by limiting contact with potentially pathogenic objects and individuals.

Disgust constitutes a core component of the "behavioral immune system"—a suite of affective, cognitive, and behavioral responses that are activated upon encountering a potential disease threat (Schaller, 2006). The affective system elicits the emotion of disgust, the cognitive triggers thoughts about disease, and the behavioral motivates avoidance of the disease source. This behavioral immune system operates in complement to humans' biological immune response. While the biological immune system fights pathogens once they have entered the body, the activation of this system is costly, compared with simply avoiding contact with these pathogens in the first place. The latter is the purview and function of the behavioral immune system (Schaller & Duncan, 2007; Schaller & Park, 2011).

Although the behavioral immune system is common to all humans, there are nonetheless substantial individual differences in the strength of this system's response. In particular, some individuals are more "disgust sensitive" than others – experiencing a stronger emotional response to disgusting stimuli (Curtis et al., 2011; Haidt et al., 1994; Tybur et al., 2009). These individual differences in disgust sensitivity, in turn, have implications for such characteristics as avoidance of novel stimuli (Faulkner et al., 2004; Shook et al., 2019), intergroup prejudice (Hodson & Costello, 2007; Karinen et al., 2019; Navarrete & Fessler, 2006), and political conservatism (Inbar et al., 2009; Terrizzi et al., 2010).

But why do individuals vary in sensitivity to disgust? Several perspectives have been proposed to explain this variation, including parental rearing (Stevenson et al., 2010; Widen & Olatunji, 2016),

☆ All data, syntax, materials, and preregistration documentation are available on the Open Science Framework at https://osf.io/a4mgv/?view_only=022cc0ec5d114575aa872184b06c05ca

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natural selection (Nesse & Williams, 1995), broader underlying traits of negative emotionality (e.g., neuroticism; Clark & Watson, 1995; Curtis et al., 2011), and different reproductive strategies (especially greater motivation to avoid unfit sexual partners; Tybur et al., 2018). However, each of these theoretical perspectives has received mixed support in the literature (Druschel & Sherman, 1999; Shook et al., 2015; Tybur et al., 2018).

Another theorized source of variation in disgust sensitivity concerns individual differences in exposure and vulnerability to pathogens. This theoretical perspective, which we refer to as the "calibration hypothesis," posits that disgust sensitivity is adaptively tailored or "calibrated" to regulate an individual's likelihood of contracting disease (Schaller, 2011; Schaller & Murray, 2008). The calibration hypothesis stems from a broader perspective, sometimes referred to as "facultative calibration," which suggests that human variations in many traits and behaviors exists because these characteristics have been calibrated to fit different environments (Buss, 2009; Lukaszewski & von Rueden, 2015; Zietsch, 2016). According to the calibration hypothesis, individuals in ecologies that are higher in disease threat (e.g., developing countries; the tropics) should exhibit greater sensitivity to disgust. In these environments, the costs of being insufficiently vigilant against potential pathogens are especially high, given the greater probability of contracting diseases (Hruschka & Hackman, 2014; Oaten et al., 2009). A heightened sense of disgust is therefore theorized to be adaptive in such environments.

For the same reasons, individuals who are particularly vulnerable to disease threats (e.g., those with compromised immune systems) are also theorized to be more sensitive to disgust to mitigate their higher risk of contracting diseases (Miller & Maner, 2011; Stevenson et al., 2009). By the same token, individuals who feel subjectively more concerned about disease threats (that is, over and above their objective degree of vulnerability to disease) are also expected to develop heightened disgust sensitivity (Ackerman et al., 2018; Oaten et al., 2009; Schaller & Murray, 2008).

Importantly, however, although the calibration hypothesis appears to be consistent with the theorized evolutionary function of disgust, it has received relatively little direct empirical support. While some studies have demonstrated that sexual disgust (Crosby et al., 2021; Lieberman & Patrick, 2018; Tybur et al., 2013) and disease avoidance motivations (Brown, M., & Sacco, D. F, in press; Makhanova et al., 2021; Rozin, 2008; Sacco et al., 2014) can change in response to changes in the environment, few have focused primarily on pathogen disgust sensitivity and even fewer having done so by employing a longitudinal methodology. One recent longitudinal study found pathogen disgust decreased in students who were subjected to harsher environments (e.g. military cadets) when compared to students whose environments did not change, providing some initial support that pathogen disgust sensitivity may be calibrated by the features of one's environment (Batres & Perrett, 2019). Other small-scale studies provided evidence consistent with this hypothesis (e.g., Skolnick and Dzkoto's (2013) finding that disgust sensitivity was higher in Ghana than the U.S.). However, other large-scale studies involving multiple nations (Curtis et al., 2004; Tybur et al., 2016) failed to replicate this effect, raising doubts about its generalizability. Indeed, in a comprehensive review of the literature Tybur et al. (2018) offered the interpretation that the available evidence regarding covariation between disease threat and disgust sensitivity revealed "little-to-no relationship between disgust sensitivity and pathogens in the ecology, personal history of infectious disease or ability to resist pathogens" (p.8). However, they also suggested that such hypotheses might be tested more fruitfully by pursuing a longitudinal approach. This is one of the aims of the current research.

Beyond the lack of empirical support, many important theoretical questions about the calibration hypothesis remain. In particular, although research has examined whether disgust sensitivity varies as a function of *chronic* disease threat (i.e., ecologies with higher pathogen load), the question of whether *situational* disease threats – e.g., a pandemic or disease outbreak – may shape disgust sensitivity, has not been addressed. Such an effect would provide more compelling support for the calibration hypothesis, given that this kind of "natural experiment" can help strip away many potential confounding factors that may have complicated research on chronic variation in disease threats between nations (e.g., different cultural contexts, national histories, etc.).

Prior work on the calibration of psychological traits more generally suggests that such characteristics are not only calibrated by one's environment, but also by other contextual factors, including idiosyncratic beliefs, motivations, and concerns of the individual (Buss, 2009; Lukaszewski & von Rueden, 2015; Zietsch, 2016). Such work provides further support for the prediction that increases in disgust sensitivity may be particularly likely for individuals who feel greater concern or subjective vulnerability to a given disease. In other words, to the degree that a "disease threat" is indeed seen as threatening, we should expect larger increases in sensitivity to disgust. For individuals who experience little or no worry about the disease threat, however, we should not see concomitant changes in sensitivity to disgust. If this prediction holds true, it would provide strong support for the idea that disgust sensitivity is calibrated to individuals' concerns about disease threats.

Beyond these theoretical questions, if situational factors can indeed influence disgust sensitivity, this would have important methodological and practical implications. Researchers tend to treat pathogen disgust sensitivity as a relatively stable and immutable individual difference—for example, examining how pathogen disgust influences other attitudes (e.g., conservatism, intergroup attitudes) and behavior (e.g., responses to COVID-19 and other diseases), without considering the alternative causal pathway, or the possibility that disgust sensitivity may be influenced by other external situational factors. Finding that disgust is influenced by situational factors may prompt a reconsideration of this research.

2. The present research

In this work we revisit and reexamine the calibration hypothesis. To do so, we took advantage of a naturally occurring disease threat—the COVID-19 disease pandemic that began in late 2019—to examine whether, how, and among whom disgust sensitivity changes in response to a salient disease threat. More specifically, we tested the hypothesis that *people will exhibit increases in pathogen disgust sensitivity following the outbreak of the pandemic as a function of the extent to which they are personally concerned about contracting COVID-19.*

We used both cross-sectional and longitudinal methodologies (N = 3066) to test this hypothesis. First, we compared a series of nine cross-sectional studies—seven studies conducted in the months immediately prior to the COVID-19 outbreak, and two conducted during the height of the pandemic (Studies 1A and 1B). Using these data, we tested whether participants—especially those worried about contracting the virus—exhibited greater disgust sensitivity during this highly salient disease threat. We then built on these findings using a longitudinal methodology (Study 2), re-contacting participants that we had surveyed shortly before the pandemic to determine whether disgust sensitivity increased following the outbreak of COVID-19, and whether the degree of these changes differed as a function of a person's subjective concern about contracting the coronavirus. This mixed-methods approach allowed us to balance the weaknesses and strengths of each design while providing convergent evidence for our hypotheses. All data, materials, syntax, and preregistration documentation are available at https://osf.io/a4mgv/?view_only=022cc0ec5d114575aa872184b06c05ca. For all studies, we adhere to the "21 word solution" proposed by Simmons et al. (2012): We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study.

3. Study 1A

We first leveraged data from seven studies (N = 2056) that we conducted shortly before the COVID-19 pandemic in the U.S. (between

December 19th, 2018 and January 14th, 2020). Each of these studies included a measure of pathogen disgust sensitivity (the contamination subscale of the Disgust Scale-Revised; Haidt et al., 1994; Olatunji, 2008). Given that the pandemic is a significant pathogenic threat, we opted to focus primarily on pathogen disgust and not other measures of disgust sensitivity (i.e. sexual or moral disgust). We used these studies to measure pre-pandemic levels of disgust sensitivity. Following the COVID-19 outbreak, we conducted an additional study to assess levels of disgust sensitivity at the height of the pandemic.

3.1. Method

3.1.1. Participants

Participants from Amazon Mechanical Turk (see Buhrmester et al., 2016) were recruited and compensated $1.00 for a 10-min study. In this and all studies we collected large samples to ensure stable estimates of effect sizes, based on the guidelines outlined by Schönbrodt and Perugini (2013). Sample sizes of our pre-pandemic studies ranged from 200 to 400 participants, with an average sample size of 294. For the study we conducted at the height of the pandemic, we collected a sample of 506 participants. This sample size provided 80% power to detect an effect size of Cohen's $d = 0.14$ (two-tailed test).

3.1.2. Procedure

In the pre-pandemic studies, participants first completed a series of measures unrelated to the current research (full materials for all studies are available at the OSF page for this research). To assess disgust sensitivity, participants completed the contamination subscale of the Disgust Scale-Revised (DS-R; Haidt et al., 1994; Olatunji et al., 2007). (In Studies 5, 6, and 7 participants completed the full DS-R scale.) The disgust sensitivity items asked participants to rate on 5-point scales how disgusted they would be by various scenarios such as "A friend offers you a piece of chocolate shaped like dog doo" and to rate their agreement with statements such as "I never let any part of my body touch the toilet seat in a public washroom." We calculated participants' mean scores on this scale, which served as our measure of disgust sensitivity (average $\alpha = 0.69$).

The pandemic study was part of a large-scale study we conducted examining social distancing behavior. We conducted this study in early May 2020, when most states were under shelter-in-place orders. To assess subjective vulnerability/concern about COVID-19, participants were asked "Generally speaking, how worried are you that *you personally* will contract COVID-19?" measured on a 7-point scale from "1 Not worried at all" to "7 Extremely worried".

3.2. Results

We first compared mean levels of disgust sensitivity in our pre-pandemic studies to the study conducted at the height of the COVID-19 pandemic. Consistent with the calibration hypothesis, disgust sensitivity was significantly higher during the pandemic, $t(2551) = 8.70$, $p < .001$, Cohen's $d = 0.44$. To better understand the robustness of this effect, we also compared mean levels of disgust sensitivity among each of our individual studies. These analyses revealed that disgust sensitivity levels during the COVID pandemic were significantly higher than in *each of our seven individual pre-pandemic studies* (t's > 4.04, dfs > 703, $ps < 0.002$, Cohen's $ds > 0.27$; Bonferroni corrections; see Table 1 and Fig. 1, respectively, for means and distributions of disgust sensitivity). This was true of no other study in the series that we conducted; the levels of disgust sensitivity we observed during the pandemic were uniquely and substantially higher than in any and all of our pre-pandemic studies. On average, disgust sensitivity scores measured during the pandemic ($M = 3.22$, $SD = 0.88$, 95% CI [3.14, 3.30]) were approximately 0.4 points higher (on a 5-point scale, 95% CI [0.30,0.47]) than those measured pre-pandemic ($M = 2.83$, $SD = 0.89$ 95% CI [2.79, 2.87]).

We next tested our central hypothesis: that increases in disgust

Table 1
Disgust sensitivity means and standard deviations for all cross-sectional studies.

Study	Mean disgust sensitivity	SD disgust sensitivity	Lower CI	Upper CI	N	Date
Pre-Pandemic Study 1	2.88	0.93	2.75	3.01	200	12-19-2018
Pre-Pandemic Study 2	2.80	0.89	2.70	2.90	300	07-01-2019
Pre-Pandemic Study 3	2.87	0.91	2.78	2.96	400	09-16-2019
Pre-Pandemic Study 4	2.98	0.90	2.89	3.07	400	10-24-2019
Pre-Pandemic Study 5	2.80	0.90	2.69	2.91	251	11-08-2019
Pre-Pandemic Study 6	2.70	0.82	2.60	2.80	253	01-13-2020
Pre-Pandemic Study 7	2.70	0.85	2.60	2.81	252	01-14-2020
Pre-Pandemic Average	2.82				294	
Pandemic Study 1A	3.22	0.88	3.14	3.30	506	05-07-2020
Pandemic Study 1B	3.29	0.93	3.21	3.37	504	06-09-2020
Pandemic Average	3.26				505	

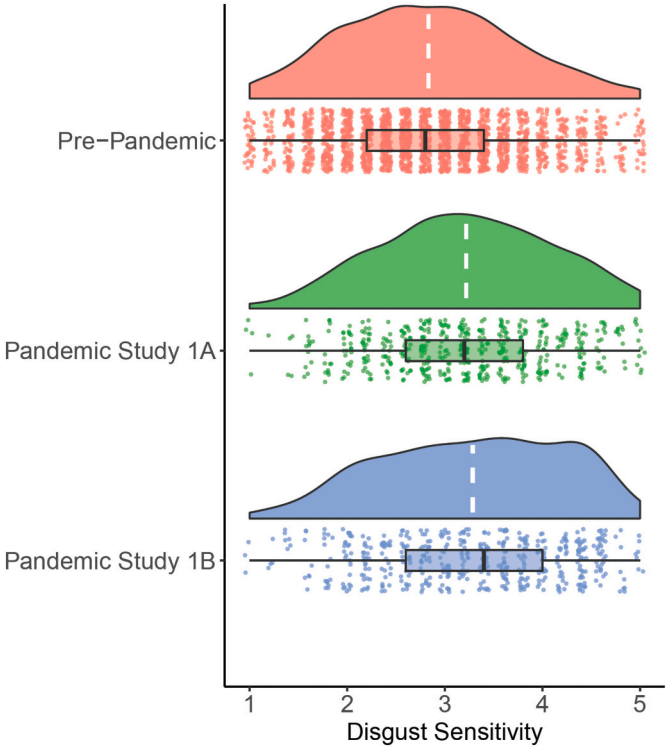

Fig. 1. Distributions of disgust sensitivity before the pandemic and during the height of the pandemic. Dashed lines indicate mean disgust scores.

sensitivity would vary as a function of an individual's personal concern about contracting COVID-19. Although the present data are cross-sectional and a direct test of moderation could therefore not be performed (a limitation we address in Study 2), we tested this hypothesis by examining the relationship between worry/concern about COVID-19 and disgust sensitivity. As predicted, we found a significant relationship between COVID worry and sensitivity to disgust, $r = 0.36$, $t(503) = 8.30$, $p < .001$, 95% CI[0.28,0.45], such that individuals most concerned about the virus exhibited the highest levels of disgust sensitivity.

To better understand the nature of this relationship, we examined mean disgust sensitivity levels among individuals who were generally unconcerned about COVID-19 (1 SD below the mean on our COVID worry measure; $N = 100$) and individuals who were generally concerned about the virus (1 SD above the mean on COVID worry; $N = 143$). We found that individuals who were generally unconcerned about COVID-19 exhibited mean levels of disgust sensitivity ($M = 2.80$, $SD = 0.82$, 95% CI [2.63, 2.96]) that were nearly identical to (and statistically indistinguishable from) the levels of disgust sensitivity observed in our pre-pandemic studies ($M = 2.82$, $SD = 0.89$; mean difference $p = .71$). Conversely, individuals who were generally concerned about the virus exhibited disgust sensitivity levels ($M = 3.68$, $SD = 0.85$, 95% CI [3.54, 3.82]) that were significantly—and substantially—higher than those in our pre-pandemic studies (a difference of 0.86 on a 5-point scale; $t(2189) = 10.95$, $p < .001$, 95% CI[0.69, 0.99].[1] Comparing this sample to our previous studies revealed that individuals who were concerned about COVID-19 exhibited disgust sensitivity scores that were significantly higher than in each of our seven pre-pandemic studies ($ts > 8.054$, dfs > 341, $ps < 0.001$, Cohen's $ds > 0.80$; Bonferroni corrections).

We next tested a possible alternative explanation for our effects—namely, that some of the disgust sensitivity items might be seen as having some direct relevance for social distancing or transmission of COVID-19, and that these items may have driven our effects. We identified the two items that could arguably be seen as having direct relevance for disease transmission ("I would not go to my favorite restaurant if I found out the cook had a cold." and "You take a sip of soda, and then realize that you drank from the glass that an acquaintance of yours had been drinking from."). Importantly, our effects remained significant after excluding these two items—and in fact, the increases in disgust that we observed were significant for all three of the remaining (COVID-19-irrelevant) items of the ("As part of a sex education class, you are required to inflate a new lubricated condom, using your mouth," "A friend offers you a piece of chocolate shaped like dog-doo," and "I never let any part of my body touch the toilet seat in a public washroom") (all $ps < 0.005$). Using the composite of these three items, disgust sensitivity scores were significantly higher than in each of our pre-pandemic studies ($F(7, 2545) = 12.82$, $p < .001$ ($ts > 3.39$, dfs > 703, $ps < 0.02$, Cohen's $ds > 0.23$; Bonferroni corrections).

We also tested our central hypothesis using this more stringent 3-item composite. As before, worry about contracting COVID-19 correlated with this composite, $r = 0.28$, $p < .001$, 95% CI[0.32, 0.60]. Individuals low in worry ($M = 2.69$, $SD = 0.98$) were statistically indistinguishable from participants in our pre-pandemic studies ($M = 2.69$, $SD = 1.03$; mean difference $p = .90$), whereas individuals high in COVID worry ($M = 3.54$, $SD = 1.00$) were significantly higher in disgust sensitivity than individuals in our pre-pandemic studies—both when looking at the mean of our pre-pandemic studies ($t(2048) = 9.43$, $p < .001$, 95% CI[0.65, 1.01]) and even when comparing them to each of the seven pre-pandemic studies individually ($F(7,2183) = 20.59$, $p < .001$, all $ts > 6.74$, dfs > 341, all $ps < 0.001$, Cohen's $> ds\ 0.66$; Bonferroni corrections).

[1] Further, this effect remains significant when controlling for gender, $\beta = 0.841$, $t(1683) = 10.91$, $p < .001$, 95% CI [0.69. 0.99] and when controlling for political ideology, $\beta = 0.85$, $t(2188) = 11.38$, $p < .0.001$, 95% CI [0.70, 0.99].

4. Study 1B

To assess the robustness of these effects, we next conducted a pre-registered direct replication of Study 1A, assessing disgust sensitivity at a second time point during the pandemic.

4.1. Participants

Five hundred and four participants were recruited via Amazon Mechanical Turk and were compensated $1.00 for a 10-min study (39.5% female; $M_{age} = 38.80$, $SD = 12.02$, range 18–70). This sample size provided 99% power to detect an effect of the size observed in Study 1A (Cohen's $d = 0.44$).

4.2. Procedure

We conducted this study on June 8th, 2020, when most U.S. states had relaxed lockdown restrictions. However, government officials were continuing to urge social distancing and other anti-virus measures (e.g., face masks, frequent handwashing). The pandemic therefore remained highly salient. Like Study 1A, this study was part of a large-scale study that we conducted concerning social distancing behavior. This study included the same disgust measure from Study 1A, the contamination subscale of the DSR ($\alpha = 0.76$). Participants also indicated their worry about COVID-19 on the same measure used previously.

4.3. Results

As in Study 1A, we began by comparing mean levels of disgust sensitivity during the pandemic to the mean levels observed across our seven pre-pandemic studies. Providing further support for the calibration hypothesis, we again found that disgust sensitivity was significantly higher during the pandemic than shortly before the pandemic, $t(746.16) = 9.88$, $p < .001$, unequal variances, Cohen's $d = 0.50$. We then compared the results of the pandemic study to each of our individual pre-pandemic studies. We found that the level of disgust sensitivity we observed during the pandemic once again was significantly higher than in each of our seven pre-pandemic studies ($ts > 5.03$, dfs > 702, $ps < 0.001$, Cohen's ds > 0.34; Bonferroni corrections). On average, disgust sensitivity scores observed during the pandemic ($M = 3.29$, $SD = 0.93$, 95% CI [3.21, 3.37]) were approximately 0.5 points, 95% CI[0.36,0.54], higher (on a 5-point scale) than those observed pre-pandemic ($M = 2.83$, $SD = 0.89$, 95% CI [2.79, 2.87]).

We next tested our central hypothesis that the increase in disgust sensitivity would be moderated by an individual's personal worry about contracting COVID-19. As predicted, we again found a significant relationship between worry about COVID and disgust sensitivity ($r = 0.46$, $p < .001$, 95% CI[0.37, 0.52]), such that individuals most concerned about the virus showed the highest levels of disgust sensitivity. As in Study 1A, we compared mean disgust sensitivity levels among individuals who were generally unconcerned about COVID-19 (1 SD below the mean on our COVID worry measure; $N = 113$) and individuals who were generally concerned about the virus (1 SD above the mean on COVID worry; $N = 155$). We once again found that individuals who were generally unconcerned about COVID-19 exhibited mean levels of disgust sensitivity ($M = 2.82$, $SD = 0.90$, 95% CI [2.65, 2.99]) that were nearly identical to the levels of disgust sensitivity observed in our pre-pandemic studies ($M = 2.82$, $SD = 0.89$, 95% CI [2.79, 2.87]; mean difference $p = .9$). Further replicating the results of Study 1A, individuals who were generally concerned about the virus exhibited disgust sensitivity scores ($M = 3.90$, $SD = 0.79$, 95% CI [3.77, 4.03]) that were substantially higher than those in our pre-pandemic studies (a difference of 1.1 points on a 5-point scale; $t(185.30) = 16.14$, $p < .001$, 95% CI[0.94,1.20], Cohen's $d = 1.16$, unequal variances). Comparing this subsample to our previous studies revealed that individuals who were concerned about COVID-19 exhibited disgust sensitivity scores that were significantly

higher than in each of our seven pre-pandemic studies ($F(8,2241) = 32.58$, $p < .001$; $ts > 11.00$, dfs > 353, $ps < 0.001$, Cohen's $ds > 1.19$; Bonferroni corrections).[2]

As in Study 1A, we again examined the pattern of effects on each of the individual items of the disgust sensitivity scale. Once again, we found a significant increase in disgust sensitivity for all five of the individual items (all $ps < 0.001$). Thus, this effect again extended to situations and stimuli with no relevance whatsoever for social distancing or COVID-19 transmission. (And, in fact, the size of the effect was actually significantly larger for the items that were irrelevant to disease transmission, $F(1,2550 = 5.54$, $p = .02$, $\eta_p^2 = 0.002$.)

As in our previous study, we also tested our central hypothesis after excluding items of potential relevance to COVID-19 transmission. We once again found that, even after excluding these items, disgust sensitivity correlated with worry about contracting the virus, $r = 0.40$, $p < .001$, 95% CI[0.56, 0.84]. Individuals low in worry about the virus (M = 2.73, $SD = 1.06$) were statistically indistinguishable from those in our pre-pandemic studies (M = 2.70, $SD = 1.03$; mean difference $p = .77$ Conversely, and replicating our previous findings, individuals high in COVID worry (M = 3.79, $SD = 0.93$) were significantly higher in disgust sensitivity than participants in our pre-pandemic studies—both when compared to the mean disgust sensitivity levels of these seven studies ($t(2048) = 12.78$, $p < .001$, 95% CI[0.92, 1.26]), and even when compared to each pre-pandemic study individually, $F(7,2544) = 17.90$, $p < .001$; $ts > 9.59$, dfs > 353, $ps < 0.001$, Cohen's $ds > 1.03$; Bonferroni corrections.

5. Study 2

We next tested our hypothesis using a longitudinal methodology to provide convergent support while ruling out alternative explanations—such as that the observed increase in disgust sensitivity stemmed from other extraneous design features (e.g., other survey content). Critically, in this study all materials and procedure were identical at both time points through the collection of our primary dependent measure. Further, in this study we also included the full disgust sensitivity scale (DS-R; Haidt et al., 1994; Olatunji, 2008) to determine whether the observed effects extended to broader measures of disgust sensitivity involving many more scale items—and, hence, substantially more observations per participant.

Participants also completed the perceived vulnerability to disease (PVD) scale (Duncan et al., 2009) to measure general feelings of propensity to contract illnesses, which we predicted might moderate increases in disgust sensitivity. Additionally, we included two measures of self- and resource-protection motivations to test the alternative explanation that the effects we had observed represent a broader heightened motivation for security stemming from the other threats (e.g., economic instability) associated with the COVID-19 outbreak and were not necessarily driven by pathogen disgust. Finally, as an exploratory, more experiential measure of disgust sensitivity, at Time 2 participants rated several disgusting images in order to provide convergent evidence for our effects.

5.1. Method

5.1.1. Participants

For our Time 1 survey we recruited 251 participants from Amazon Mechanical Turk. One hundred and fifty-four of these participants (39.04% female, $M_{age} = 36.84$, $SD = 10.95$: range 20–73) completed the Time 2 survey. Participants were paid $1.00 for completing each survey. This sample size provided 80% power to detect an effect size of Cohen's $d = 0.23$ (two-tailed test).

5.1.2. Procedure

We selected one of our pre-pandemic studies (Study 5) to serve as our Time 1 survey because it included the full DS-R scale, and because the mean level of disgust sensitivity in this study ($M = 2.80$, $SD = 0.90$, 95% CI [2.69, 2.91]) was nearly identical to the overall mean level of disgust sensitivity observed across our pre-pandemic studies ($M = 2.82$, $SD = 0.89$, 95% CI [2.79, 2.87]). The Time 1 survey was administered prior to the COVID-19 outbreak in the U.S., on November 8th, 2019. The Time 2 survey was administered during the height of the initial wave of the pandemic, on May 5th, 2020. At both time points, participants first completed a set of measures unrelated to the current research (full materials for all studies are available at the OSF page for this research). They then completed the full 25-item DS-R scale ($\alpha = 0.66$). Participants then completed the PVD scale (Duncan et al., 2009), which includes statements such as "If an illness is 'going around' I will catch it" ($\alpha = 0.75$). Participants next completed measures of self-protection and resource-protection motivations from Neel et al. (2016). The resource-protection scale assesses concerns with maintaining status and hierarchy, asking participants to rate their agreement with items such as "It's important to me that others respect my rank or position" ($\alpha = 0.79$). The self-protection scale includes items such as "I am motivated to keep myself safe from others" ($\alpha = 0.88$). We included these measures to rule out the possible alternative explanation that our results merely stemmed from heightened motivations to protect oneself and ones resources as a function of the COVID-19 pandemic.

At Time 2, participants completed the same measures and then indicated their worry about contracting COVID-19 on the same measure from Studies 1A and 1B. Finally, as an exploratory experiential measure of disgust sensitivity, participants were asked to rate a series of images. They viewed 12 images presented in random order, four of which were positive (e.g., a piece of cheesecake) and eight of which were disgusting (e.g., rotten meat with maggots in it). Participants rated how appealing each image was from −5 (extremely unappealing) to +5 (extremely appealing). We included this task to further verify that these increases in disgust sensitivity were not limited to situations with the potential for disease transmission, but truly extended to sensitivity to disgusting situations and stimuli more generally.

5.2. Results

Replicating the results of Studies 1A and 1B, participants' scores on the contamination subscale of the DS-R significantly increased from Time 1 ($M = 2.67$, $SD = 0.86$; 95% CI [2.54, 2.80]) to Time 2 ($M = 2.79$, $SD = 0.84$, 95% CI [2.65, 2.91]), $t(153) = 2.76$, $p = .006$, 95% CI [0.03,0.20], Cohen's $d = 0.14$. Further, we also found that participants exhibited significant increases on the more general measure of disgust sensitivity, the full version of the DSR, from Time 1 pre-pandemic ($M = 3.15$, $SD = 0.68$, 95% CI [3.04, 3.26]), to Time 2, ($M = 3.22$, $SD = 0.69$, 95% CI[3.11, 3.33]), at the height of the pandemic ($t(153) = 2.27$, $p = .02$, 95% CI[0.009,0.12], Cohen's $d = 0.09$). These results show that the effects that we previously observed were not limited to contamination-related disgust but extend to sensitivity to disgusting situations and stimuli more generally.

We next tested our central hypothesis that the increase in disgust sensitivity would be moderated by an individual's personal sense of vulnerability to COVID-19. As predicted, and consistent with our previous studies, we again found that worry about contracting COVID-19 predicted increases in disgust sensitivity, such that individuals who were more worried about contracting the virus exhibited greater increases in disgust sensitivity ($\beta = 0.082$, $t(151) = 1.97$, $p = .05$, 95% CI [0.00, 0.31]) (controlling for Time 1 disgust sensitivity).

Importantly, however, these analyses of mean DSR scale scores do not take full advantage of the diversity of items that comprise the scale and the statistical power that can be gained by considering each scale

[2] Further, this effect remains significant when controlling for gender, $\beta = 1.08$, $t(1695) = 14.59$, $p < .001$, 95% CI [0.93. 0.1.22] and when controlling for political ideology, $\beta = 1.05$, $t(2198) = 14.63$, $p < .0.001$, 95% CI [0.91, 1.19].

item as a unit of analysis. To leverage this, we also examined each scale item individually. Table 2 presents the mean difference (pandemic minus pre-pandemic) for each scale item, a t-value testing that mean against zero, and the standardized beta predicting scores on the item at Time 2 from worry about contracting COVID-19, controlling for the corresponding Time 1 item scores. Of note, 19 of the 25 scale items showed a mean difference greater than zero and 21 of the betas are in the predicted direction. Moreover, even if we exclude from consideration the two scale items that could be said to directly concern disease transmission (items #9 and #18), 17 of the remaining 23 show a positive mean difference and 19 show a positive beta.

To formally test the hypothesis using each item response from each participant, we constructed a two-level multi-level model, treating both individual DS-R scale items and participants as random factors (Judd et al., 2012). Our data consisted of 25 DS-R items nested within 154 participants. Our model was constructed such that DS-R scores at Time 2 were predicted independently by (1) DS-R scores at Time 1 and (2) individuals' subjective sense of vulnerability to this disease threat (i.e., worry about contracting COVID-19). At the participant level, the model involved both random intercepts and random slopes for each DS-R Time 1 item; at the level of the individual DS-R items, the model included random intercepts and random slopes for both DS-R item and the participant's expressed worry about contracting COVID-19.

As predicted, we found strong evidence that worry about contracting COVID-19 predicted increases in disgust sensitivity using all 25 items from the DS-R scale. Individuals who were more worried about contracting the virus exhibited the greatest increases in disgust sensitivity ($\gamma = 0.049$, $SE = 0.02$), ($t(119.618) = 2.52$, $p = .013$, 95% CI = [0.010, 0.088]). As before, this effect replicated even when excluding items on the DS-R that are directly relevant to disease transmission (Item #9 & Item #16. ($\gamma = 0.051$, $SE = 0.02$), $t(113.60) = 2.52$, $p = .013$, 95% CI = [0.011, 0.091]. Thus, as predicted—and providing further convergent evidence for the calibration hypothesis—changes in responses to the DS-R items following the outbreak of the pandemic varied as a function of participants' concern about personally contracting COVID-19: The more worried the participant, the more they exhibited an increase in their sensitivity to the wide variety of potentially disgusting situations and stimuli presented on the DS-R.

We next examined our exploratory measure of COVID-19 susceptibility, perceived vulnerability to disease. We had originally predicted that this measure, like our measure of COVID-19-specific worry, would moderate the degree to which an individual's disgust sensitivity increased, such that individuals higher in PVD would show greater increases in disgust sensitivity. Intriguingly, however, rather than finding that PVD moderated these effects, we observed significant *changes* in perceived vulnerability to disease following the COVID-19 outbreak, with PVD scores exhibiting a substantial increase from Time 1 ($M = 2.86$, $SD = 0.59$, 95% CI[2.77, 2.96]) to Time 2 ($M = 3.01$, $SD = 0.58$, 95% CI [2.92, 3.10]), $t(153) = 4.31$, $p < .001$, 95% CI [0.08,0.21], Cohen's $d = 0.24$. Although these results were unexpected and should therefore be interpreted cautiously, these findings suggest that rather than solely being a stable individual difference, perceived vulnerability to disease—like disgust sensitivity—may exhibit a similar sensitivity to context, being calibrated to an individual's local ecology and situational pressures.

Further, also consistent with our predictions, we found that these effects did not stem from motivations for safety and stability: Participants did not exhibit changes in either their concern about status/hierarchy preservation ($p = .83$), nor their general self-protection concerns ($p = .14$).[3] These results further suggest that the effects that we observed were truly indicative of an increase in disgust sensitivity *specifically*, rather than more general changes in self-protective motivations (e.g., stemming from other potential threats posed by the pandemic).

Finally, in exploratory analyses, we also examined the degree to which these changes in disgust sensitivity might generalize to other non-self report indices of disgust —such as disgust experienced in response to visual imagery. To test this question, we analyzed participants' evaluations of the eight disgusting images they were asked to rate. As expected, we found that disgust sensitivity scores at Time 2 significantly predicted more negative ratings of the disgusting images ($\beta = -0.42$, $t(151) = 5.76$, $p < .001$, 95% CI[−0.57, −0.28]). Further—and more interestingly—we also found that Time 2 disgust sensitivity scores continued to predict more negative ratings of these disgusting images *even when controlling for disgust sensitivity at Time 1* ($\beta = -0.29$, $t(150) = 2.04$, $p = .04$, 95% CI[−0.57, −0.01]).[4] This suggests that the increases in disgust sensitivity that we observed did, in fact, represent more general increases in sensitivity to disgusting situations and stimuli and were not limited to disease-related items. Further, and also consistent with our predictions, disgust sensitivity did not predict ratings of the positive images (Time 1 Disgust: $\beta = -0.03$, $p = .73$, 95% CI [−0.19, 0.13]; Time 2 disgust: $\beta = -0.06$, $p = .5$, 95% CI [−0.22, 0.11]). This provides further support for our contention that these effects specifically represent differences in disgust *sensitivity* (i.e., reactivity to potentially disgusting situations and stimuli), rather than, e.g., differences in state disgust. Although these analyses are post-hoc and should therefore be interpreted cautiously, these results provide further support for our hypothesis that disgust sensitivity is heightened in response to salient disease threats.

6. Discussion

The goal of this research was to reexamine the "calibration hypothesis": that disgust sensitivity is adaptively calibrated to local ecology. We tested this question using a naturally occurring disease threat, the COVID-19 pandemic. Using both cross-sectional and longitudinal methodologies, we found robust support for our predictions: Disgust sensitivity increased following the outbreak of the pandemic, and this increase was moderated by subjective feelings of vulnerability to COVID-19. Further, we ruled out alternative explanations, such as a broader increase in self-protection motivations. Additionally, we found evidence that perceived vulnerability to disease, like disgust sensitivity, might exhibit adaptive flexibility, increasing in response to disease threats. This result is consistent with recent cross-sectional studies that have suggested there may have been increases in perceived vulnerability to disease during the COVID-19 pandemic (Makhanova & Shepherd, 2020; Stevenson et al., 2021). As well as other, broader studies that have found that PVD can change as a function of situational factors (Brown, & Sacco, in press; Makhanova et al., 2021; Sacco et al., 2014). However, our research is the first to our knowledge to demonstrate this effect in a longitudinal sample. Finally—and importantly—we also found evidence that these increases in disgust sensitivity generalize to other indices of sensitivity to disgust, such as emotional responses to visual stimuli. Thus, worry about salient pathogens has consequences not only for self-reported agreement with statements indicative of greater disgust, but also with immediate affective reactions to disgusting stimuli.

This research has important implications for theories of disgust. As noted above, our research is consistent with Tybur et al.'s (2018) call for a longitudinal approach to the study of the relation between disgust sensitivity and pathogens in the ecology. Our research challenges the view that these factors are unrelated, suggesting that situational features

[3] Further, neither status/hierarchy protection, $\beta = 0.072$, $t(151) = 0.894$, $p = .373$, 95% CI [−0.09,0.23] nor self-protection concerns, $\beta = 0.137$, $t(151) = 1.62$, $p = .108$, 95% CI [−0.03, 0.30] moderated the observed increase in disgust sensitivity over time.

[4] Time 2 disgust sensitivity scores predict more negative ratings of these disgusting images even after excluding the two disease relevant items from the DS-R Scale and controlling for Time 1 disgust ($\beta = -0.62$, $t(150) = 2.05$, $p = .04$, 95% CI[−1.21, −0.02]).

Table 2
Mean differences (pandemic minus pre-pandemic), t-values, and standardized betas predicting scores on the item at Time 2 from worry about contracting COVID-19, controlling for Time 1 item scores.

DSR	Mean difference	SD	*t*	Standardized beta	*t*
1. I might be willing to try eating monkey meat, under some circumstances.	0.104	1.109	1.162	−0.044	0.799
2. It would bother me to be in a science class, and to see a human hand preserved in a jar.	0.078	1.100	0.879	−0.051	0.860
3. It bothers me to hear someone clear a throat full of mucous.	0.039	1.108	0.436	0.084	1.338
4. I never let any part of my body touch the toilet seat in public restrooms.	0.020	0.977	0.248	0.019	0.380
5. I would go out of my way to avoid walking through a graveyard.	0.058	0.945	0.768	0.121	2.448*
6. Seeing a cockroach in someone else's house doesn't bother me.	0.032	1.275	0.316	0.012	0.183
7. It would bother me tremendously to touch a dead body.	0.253	1.175	2.675**	0.082	1.316
8. If I see someone vomit, it makes me sick to my stomach.	0.032	1.057	0.981	0.083	1.347
9. I probably would not go to my favorite restaurant if I found out that the cook had a cold.	0.338	1.195	3.507***	0.034	0.490
10. It would not upset me at all to watch a person with a glass eye take the eye out of the socket.	0.052	1.472	0.438	−0.003	0.044
11. It would bother me to see a rat run across my path in a park.	0.111	1.104	1.245	0.092	1.513
12. Even if I was hungry, I would not drink a bowl of my favorite soup if it had been stirred by a used but thoroughly washed flyswatter.	−0.013	1.199	−0.134	−0.066	1.049
13. It would bother me to sleep in a nice hotel room if I knew that a man had died of a heart attack in that room the night before.	0.156	1.167	1.658†	0.106	1.719†
14. You see maggots on a piece of meat in an outdoor garbage pail.	−0.058	0.938	−0.774	0.121	2.042*
15. While you are walking through a tunnel under a railroad track, you smell urine.	0.084	0.963	1.088	0.126	2.019*
16. You take a sip of soda, and then realize that you drank from the glass that an acquaintance of yours had been drinking from.	0.097	1.040	1.162	0.086	1.392
17. Your friend's pet cat dies, and you have to pick up the dead body with your bare hands.	0.137	1.076	1.577	0.069	1.154
18. You see someone put ketchup on vanilla ice cream, and eat it.	−0.064	1.033	−0.780	0.053	0.905
19. You see a man with his intestines exposed after an accident.	0.000	0.800	0.000	0.085	1.571
20. You discover that a friend of yours changes underwear only once a week.	0.032	1.063	0.379	0.123	1.894†
21. A friend offers you a piece of chocolate shaped like dog-doo.	0.033	0.986	0.411	0.066	1.119
22. You accidentally touch the ashes of a person who has been cremated.	0.149	0.877	2.114*	0.051	0.962
23. You are about to drink a glass of milk when you smell that it is spoiled.	−0.026	1.019	−0.317	0.216	3.384***
24. As part of a sex education class, you are required to inflate a new unlubricated condom, using your mouth.	0.071	0.908	0.976	0.063	1.235
25. You are walking barefoot on concrete, and you step on an earthworm.	−0.033	1.00	−0.403	0.059	0.929
Average	0.06728	0.365	2.27*	0.082	1.972*

Note: p < .001***, $p < .01$**, $p < .05$* $p < .10$†.

of one's local environment indeed shape disgust sensitivity. During a salient disease threat—when heightened sensitivity to disgust would be adaptive (Schaller, 2011; Schaller & Murray, 2008))—people generally exhibited increased disgust sensitivity. Further, this increase was calibrated to one's personal subjective sense of vulnerability: People who felt more worried about contracting COVID-19 showed greater increases in disgust sensitivity. However, we also note that one major limitation to our research is the reliance on the DS-R scale. Prior research has found that the DS-R demonstrates relatively poor internal reliability when divided into its respective sub-scales (Tybur et al., 2009). Further, the usage of the DS-R does not allow us to test the extent to which our effects might generalize to other domains of disgust (i.e. sexual and moral disgust). Despite these scale limitations, we nonetheless see a consistent pattern of results that also generalizes to other indices of disgust (i.e. emotional reactions to visual stimuli).

This work has important methodological and practical implications as well. As noted above, research on disgust sensitivity typically treats the construct largely as a stable individual difference. Research on disgust sensitivity and COVID-19 has also overwhelmingly adopted this perspective, examining how disgust sensitivity shapes responses to the pandemic, without considering that the pandemic might also shape sensitivity to disgust. Our results serve as an important complement and caveat to this research, demonstrating that disgust sensitivity is also sensitive to situational influences. These results have important implications for research on COVID-19 specifically, as well as on disgust sensitivity and its consequences more generally.

Finally, beyond these theoretical and methodological contributions, these findings may also have societal implications. Disgust sensitivity, as discussed above, relates to intergroup prejudice and endorsement of right-wing political attitudes. Heightened disgust sensitivity may therefore motivate increased intergroup hostility—perhaps helping explain the greater prejudice against racial minority groups reported anecdotally and documented in some forthcoming research (Liu, 2020). Similarly, these findings suggest that if COVID-19 remains a salient threat—and disgust sensitivity remains heightened—we may see increased global support for right-wing parties and politicians. Future research will be needed to understand the consequences of the increases in disgust sensitivity documented here.

Open practices

Study 1B was preregistered. All data, materials, syntax, and preregistration documentation are available at https://osf.io/a4mgv/?view_only=022cc0ec5d114575aa872184b06c05ca.

Declaration of competing interest

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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CRediT authorship contribution statement

BC Ruisch developed the study concept in collaboration with ST Boggs and RH Fazio. All authors contributed to the study design. Data were collected and analyzed by BC Ruisch and ST Boggs. ST Boggs wrote the first draft of the manuscript, BC Ruisch provided critical revisions, and RH Fazio provided further comments and revisions. Upon receiving the revision decision ST Boggs provided major revisions and BC Ruisch provided further comments and revisions. All authors approved the final version of the paper for submission.

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), 57–70.

Batres, C., & Perrett, D. I. (2019). Pathogen disgust sensitivity changes according to the perceived harshness of the environment. *Cognition and Emotion, 34*(2), 377–383.

Brown & Sacco, in pressBrown, M., & Sacco, D. F. (in press). How and when crowd salience heightens pathogen-avoidant motives. Evolutionary Behavioral Sciences.

Buhrmester, M., Kwang, T., & Gosling, S. D. (2016). Amazon's mechanical Turk: A new source of inexpensive yet high-quality data? In A. E. Kazdin (Ed.), *Methodological issues and strategies in clinical research* (pp. 133–139). American Psychological Association.

Buss, D. M. (2009). How can evolutionary psychology successfully explain personality and individual differences? *Perspectives on Psychological Science, 4*(4), 359–366.

Clark, L. A., & Watson, D. (1995). Constructing validity: Basic issues in objective scale development. *Psychological Assessment, 7*(3), 309–319.

Crosby, C. L., Durkee, P. K., Sedlacek, A. G. B., & Buss, D. M. (2021). Mate availability and sexual disgust. *Adaptive Human Behavior and Physiology, 7*, 261–280.

Curtis, V., Aunger, R., & Rabie, T. (2004). Evidence that disgust evolved to protect from risk of disease. *Proceedings of the Biological Sciences, 271*(Suppl. 4), S131–S133.

Curtis, V., & Biran, A. (2001). Dirt, disgust, and disease: Is hygiene in our genes? *Perspectives in Biology and Medicine, 44*(1), 17–31.

Curtis, V., de Barra, M., & Aunger, R. (2011). Disgust as an adaptive system for disease avoidance behaviour. *Philosophical Transactions of the Royal Society B, 366*(1568), 389–401.

Druschel, B., & Sherman, M. (1999). Disgust sensitivity as a function of the big five and gender. *Personality and Individual Differences, 26*, 739–748.

Duncan, L., Schaller, M., & Park, J. (2009). Perceived vulnerability to disease: Development and validation of a 15-item self-report instrument. *Personality and Individual Differences, 47*(6), 541–546.

Ekman, P. (1970). Universal facial expressions of emotion. *California Mental Health Research Digest, 8*, 151–158.

Faulkner, J., Schaller, M., Park, J., & Duncan, L. (2004). Evolved disease-avoidance mechanisms and contemporary xenophobic attitudes. *Group Processes & Intergroup Relations, 7*(4), 333–353.

Haidt, J., McCauley, C., & Rozin, P. (1994). Individual differences in sensitivity to disgust: A scale sampling seven domains of disgust elicitors. *Personality and Individual Differences, 16*(5), 196–213.

Hodson, G., & Costello, K. (2007). Interpersonal disgust, ideological orientations, and dehumanization as predictors of intergroup attitudes. *Psychological Science, 18*(8), 691–698.

Hruschka, D. J., & Hackman, J. (2014). When are cross-group differences a product of a human behavioral immune system? *Evolutionary Behavioral Sciences, 8*(4), 265–273.

Inbar, Y., Pizarro, D. A., & Bloom, P. (2009). Conservatives are more easily disgusted than liberals. *Cognition and Emotion, 23*(4), 714–725.

Judd, C. M., Westfall, C., & Kenny, D. A. (2012). Treating stimuli as a random factor in social psychology: A new and comprehensive solution to a pervasive but largely ignored problem. *Journal of Personality and Social Psychology, 103*(1), 54–69.

Karinen, A. K., Molho, C., Kupfer, T. R., & Tybur, J. M. (2019). Disgust sensitivity and opposition to immigration: Does contact avoidance or resistance to foreign norms explain the relationship? *Journal of Experimental Social Psychology, 84*, Article 103817.

Lieberman, D., & Patrick, C. (2018). *Objection: Disgust, morality, and the law*. Oxford University Press.

Liu, E. (2020). Covid-19 has inflamed racism against Asian-Americans. Here's how to fight back. CNN. Retrieved from https://edition.cnn.com/2020/04/10/opinions/how-to-fight-bias-against-asian-americans-covid-19-liu/index.html.

Lukaszewski, A. W., & von Rueden, C. A. (2015). The extraversion continuum in evolutionary perspective: A review of recent theory and evidence. *Personality and Individual Differences, 77*, 186–192.

Makhanova, A., Plant, E. A., & Maner, J. K. (2021). Capturing fluctuations in pathogen avoidance: The situational pathogen avoidance scale. *Evolutionary Psychological Science, 7*, 21–38.

Makhanova, A., & Shepherd, M. A. (2020). Behavioral immune system linked to responses to the threat of Covid-19. *Personality and Individual Differences, 167*, Article 110221.

Miller, S. L., & Maner, J. K. (2011). Sick body, vigilant mind: The biological immune system activates the behavioral immune system. *Psychological Science, 22*(12), 1467–1471.

Navarrete, C. D., & Fessler, D. M. T. (2006). Disease avoidance and ethnocentrism: The effects of disease vulnerability and disgust sensitivity on intergroup attitudes. *Evolution and Human Behavior, 27*(4), 270–282.

Neel, R., Kenrick, D. T., White, A. E., & Neuberg, S. L. (2016). Individual differences in fundamental social motives. *Journal of Personality and Social Psychology, 110*(6), 887–907.

Nesse, G., & Williams, C. (1995). *Evolution and healing*. Weidenfeld & Nicolson.

Oaten, M., Stevenson, R. J., & Case, T. I. (2009). Disgust as a disease-avoidance mechanism. *Psychological Bulletin, 135*(2), 303–321.

Olatunji, B. (2008). Disgust, scrupulosity, and conservative attitudes about sex: Evidence for a mediational model of homophobia. *Journal of Research in Personality, 42*(5), 1364–1369.

Olatunji, B. O., Williams, N. L., Tolin, D. F., Abramowitz, J. S., Sawchuk, C. N., & Lohr, J. M. (2007). The disgust scale: Item analysis, factor structure, and suggestions for refinement. *Psychological Assessment, 19*(3), 281–297.

Rozin, P. (2008). Hedonic "adaptation": Specific habituation to disgust/death elicitors as a result of dissecting a cadaver. *Judgement and Decision Making, 3*, 191–194.

Rozin, P., & Fallon, A. E. (1987). A perspective on disgust. *Psychological Review, 94*(1), 23–41.

Sacco, D. F., Young, S. G., & Hugenberg, K. (2014). Balancing competing motives; adaptive trade-offs are necessary to satisfy disease avoidance and interpersonal affiliation goals. *Personality and Social Psychology Bulletin, 40*(12).

Schaller, M. (2006). Parasites, behavioral defenses, and the social psychological mechanisms through which cultures are evoked. *Psychological Inquiry, 17*(2), 96–101.

Schaller, M. (2011). The behavioural immune system and the psychology of human society. *Philisophical transactions of the Royal Society of LondonSeries B, Biological Sciences, 366*(1583), 3418–3426.

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

Schaller, M., & Murray, D. A. (2008). Pathogens, personality, and culture: Disease prevalence predicts worldwide variability in sociosexuality, extraversion, and openness to experience. *Journal of Personality and Social Psychology, 29*(1), 212–221.

Schaller, M., & Park, J. H. (2011). The behavioral immune system (and why it matters). *Current Directions in Psychological Science, 20*(2), 99–103.

Schönbrodt, F. D., & Perugini, M. (2013). At what sample size do correlations stabilize? *Journal of Research in Personality, 47*(5), 609–612.

Shook, N. J., Terrizzi, J. A., Clay, R., & Oosterhoff, B. (2015). In defense of pathogen disgust and disease avoidance: A response to Tybur et al., (2015). *Evolution & Human Behavior, 36*(6), 498–504.

Shook, N. J., Thomas, R., & Ford, C. G. (2019). Testing the relation between disgust and avoidance behavior. *Personality and Individual Differences, 150*.

Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2012). A 21 word solution. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2160588. Retrieved from.

Skolnick, A. J., & Dzkoto, V. A. (2013). Disgust and contamination: A cross-national comparison of Ghana and the United States. *Frontiers in Psychology, 4*, 91.

Stevenson, R. J., Case, T. I., & Oaten, M. J. (2009). Frequency and recency of infection and their relationship with disgust and contamination sensitivity. *Evolution and Human Behavior, 30*(5), 363–368.

Stevenson, R. J., Oaten, M. J., Case, T. I., Repacholi, B. M., & Wagland, P. (2010). Children's response to adult disgust elicitors: Development and acquisition. *Developmental Psychology, 46*(1), 165–177.

Stevenson, R. J., Saluja, S., & Case, T. I. (2021). The impact of the Covid-19 pandemic on disgust sensitivity. *Frontiers in Psychology, 11*, Article 600761.

Terrizzi, J. A., Shook, N. J., & Ventis, W. L. (2010). Disgust: A predictor of social conservatism and prejudicial attitudes toward homosexuals. *Personality and Individual Differences, 49*(6), 587–592.

Tybur, J. M., Cinar, C., Karinen, A. K., & Perone, P. (2018). Why do people vary in disgust? *Philosophical Transactions of the Royal Society B, 373*(1751).

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*(1), 103–112.

Tybur, J. M., Lieberman, D., Kurzban, R., & DeScioli, P. (2013). Disgust: Evolved function and structure. *Psychological Review, 120*(1), 65.

Tybur, J. M., et al. (2016). Parasite stress and pathogen avoidance relate to distinct dimensions of political ideology across 30 nations. *Proceedings of the National Academy of Sciences of the United States of America, 113*(44), 12408–12413.

Widen, S. C., & Olatunji, B. O. (2016). A developmental perspective on disgust: Implications for obsessive-compulsive disorder. *Current Behavioral Neuroscience Reports, 3*, 204–210.

Zietsch, B. P. (2016). Individual differences as the output of evolved calibration mechanisms: Does the theory make sense in light of empirical observations? *Current Opinion in Psychology, 7*, 71–75.