

Concern about Salient Pathogen Threats Increases Sensitivity to Disgust

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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Abstract

Individuals vary substantially 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 right-wing ideologies, we anticipate that these increases in disgust sensitivity are likely to have important downstream societal implications.

Keywords: Disgust, disease avoidance, behavioral immune system, COVID-19, natural experiment

Introduction

Disgust is one of our evolutionarily oldest emotions, and it is theorized to have evolved to aid in the detection and avoidance of pathogens (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). 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 (Haidt, McCauley, & Rozin, 1994; Tybur, Liberman, & Griskevicius, 2009). These individual differences in disgust sensitivity, in turn, have implications for such characteristics as avoidance of novel stimuli (Faulkner et al., 2004; Shook, Thomas, & Ford, 2019), intergroup prejudice (Hodson & Costello, 2007; Navarrete & Fessler, 2006), and political conservatism (Inbar, Pizarro, & Bloom, 2009; Terrizzi, Shook, & Ventis, 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, 1995), broader underlying traits of negative emotionality (e.g., neuroticism; Clark & Watson, 1995), 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 and remains a subject of debate (Buss & Schmidt, 1993; Druschel & Sherman, 1999; Shook, Terrizzi, Clay, & Oosterhoff, 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 (Zietsch, 2016). According to this perspective, 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.

Although appearing consistent with the theorized evolutionary function of disgust, the calibration hypothesis has received little direct empirical support. Some early small-scale studies provided evidence consistent with this hypothesis (e.g., Skolnick and Dzikoto's (2013) finding that disgust sensitivity was higher in Ghana than the U.S.). However, other large-scale studies involving multiple nations (Curtis, de Barra, & Aunger, 2011; 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—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.).

Further, such 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 disgust sensitivity as a relatively stable and immutable individual difference—for example, examining how 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 some of this research.

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 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 ($N = 3,066$) 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, Nelson, and Simonsohn (2012): We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study.

Study 1A

We first leveraged data from seven studies ($N = 2,056$) 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 disgust sensitivity (the contamination subscale of the Disgust Scale-Revised; Haidt, McCauley, & Rozin, 1994; Olatunji, 2007). 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.

Method

Participants

Participants from Amazon Mechanical Turk (see Buhrmester, Kwang, & Gosling, 2011) were recruited and compensated \$1.00 for a 10-minute 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 $d = .14$ (two-tailed test).

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 $\alpha = .69$).

The pandemic study was part of a large-scale study we conducted examining social distancing behavior. We conducted this study in early May 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”.

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, $t(2551) = 8.70, p < 0.001$, Cohen’s $d = .44$. 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 , $dfs > 703$, $ps < .002$, Cohen’s $ds > .27$; Bonferroni corrections; see Table 1 and Figure 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, $95\% CI [.30, .47]$) than those measured pre-pandemic ($M = 2.83, SD = 0.89, 95\% CI [2.79, 2.87]$).

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
<i>Pre-Pandemic Average</i>	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
<i>Pandemic Average</i>	3.26				505	

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

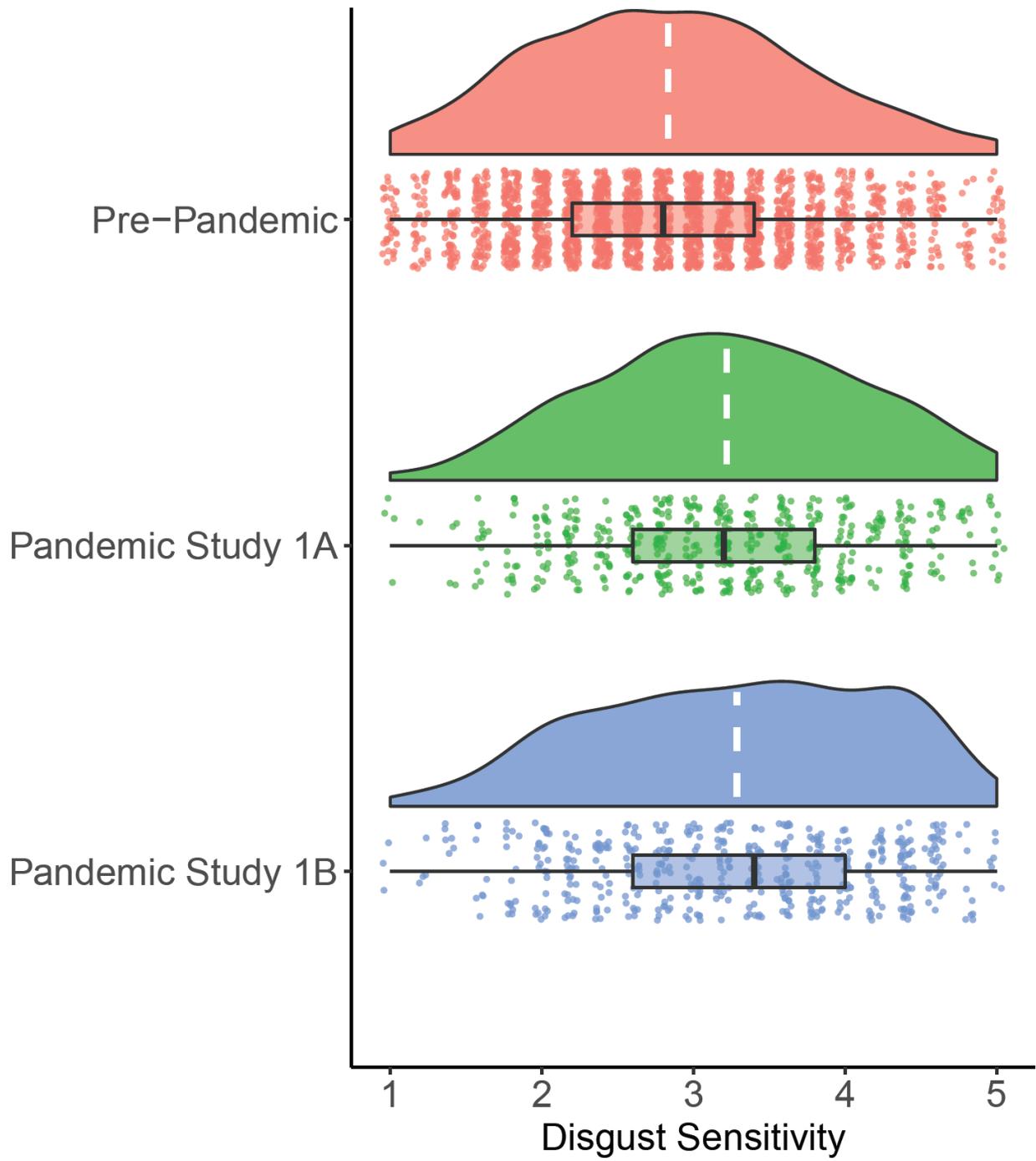


Figure 1. Distributions of disgust sensitivity before the pandemic and during the height of the pandemic. Dashed lines indicate mean disgust scores.

We next tested our central hypothesis: that increases in disgust 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, $r = .36$, $t(503) = 8.30$, $p < .001$, 95% CI[.28,.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[.69, .99]). 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 $ds > .80$; 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 p s < .005). Using the composite of these three items, disgust sensitivity scores were significantly higher than in each of our pre-pandemic studies ($F(7, 2545) = 12.82$, $p < .001$ (t s > 3.39, d fs > 703, p s < .02, Cohen’s d s > .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, $r = .28$, $p < .001$, 95% CI[.32, .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[.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 $t_s > 6.74$, $dfs > 341$, all $p_s < .001$, Cohen's $d_s > .66$; Bonferroni corrections).

Study 1B

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

Participants

Five hundred and four participants were recruited via Amazon Mechanical Turk and were compensated \$1.00 for a 10-minute 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 $d = .44$).

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 ($\alpha = .76$). Participants also indicated their worry about COVID-19 on the same measure used previously.

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 $d = .50$. 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 ($ts > 5.03$, $dfs > 702$, $ps < .001$, Cohen's $ds > .34$; 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 .5 points, 95% CI [.36, .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 ($r = .46, p < .001$, 95% CI [.37, .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; $t(185.30) = 16.14, p < .001, 95\% \text{ CI} [.94, 1.20]$, 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 ($F(8, 2241) = 32.58, p < 0.001; ts > 11.00, dfs > 353, ps < 0.001$, Cohen's $ds > 1.19$; Bonferroni corrections).

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 $ps < .001$). 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, $F(1, 2550) = 5.54, p = .02, \eta_p^2 = .002$.)

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, $r = .40, p < .001, 95\% \text{ CI} [.56, .84]$. 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 ($t(2048) = 12.78, p < .001, 95\% \text{ CI} [.92, 1.26]$), and even when compared to each pre-pandemic study individually, $F(7, 2544) = 17.90, p < .001; ts > 9.59, dfs > 353, ps < .001$, Cohen's $ds > 1.03$; Bonferroni corrections).

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, McCauley & Rozin, 1994; Olatunji, 2007) 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, Schaller, & Park, 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. Finally, as an exploratory, more experiential measure of disgust sensitivity, at Time 2 participants rated several disgusting images.

Method

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, $M_{\text{age}} = 36.84$, $SD = 10.95$; 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 $d = .23$ (two-tailed test).

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 ($\alpha = .66$). 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” ($\alpha = .75$). Participants next completed measures of self-protection and resource-protection motivations from Neele, Kenrick, White, and Neuberg (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” ($\alpha = .79$). The self-protection scale includes items such as “I am motivated to keep myself safe from others” ($\alpha = .88$).

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.

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 [.03, .20], Cohen's $d = .14$. 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 [.009, .12], Cohen's $d = .09$). 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 ($\beta = .082$, $t(151) = 1.97$, $p = .05$, 95% CI [.00, .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 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.

DSR	Mean Difference	SD	<i>t</i>	Standardized Beta	<i>t</i>
1. I might be willing to try eating monkey meat, under some circumstances.	.104	1.109	1.162	-.044	.799
2. It would bother me to be in a science class, and to see a human hand preserved in a jar.	.078	1.100	.879	-.051	.860
3. It bothers me to hear someone clear a throat full of mucous.	.039	1.108	.436	.084	1.338
4. I never let any part of my body touch the toilet seat in public restrooms.	.020	.977	.248	.019	.380
5. I would go out of my way to avoid walking through a graveyard.	.058	.945	.768	.121	2.448*
6. Seeing a cockroach in someone else's house doesn't bother me.	.032	1.275	.316	.012	.183
7. It would bother me tremendously to touch a dead body.	.253	1.175	2.675**	.082	1.316
8. If I see someone vomit, it makes me sick to my stomach.	.032	1.057	.981	.083	1.347
9. I probably would not go to my favorite restaurant if I found out that the cook had a cold.	.338	1.195	3.507***	.034	.490
10. It would not upset me at all to watch a person with a glass eye take the eye out of the socket.	.052	1.472	.438	-.003	.044
11. It would bother me to see a rat run across my path in a park.	.111	1.104	1.245	.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.	-.013	1.199	-.134	-.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.	.156	1.167	1.658†	.106	1.719†
14. You see maggots on a piece of meat in an outdoor garbage pail.	-.058	.938	-.774	.121	2.042*
15. While you are walking through a tunnel under a railroad track, you smell urine.	.084	.963	1.088	.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.	.097	1.040	1.162	.086	1.392
17. Your friend's pet cat dies, and you have to pick up the dead body with your bare hands.	.137	1.076	1.577	.069	1.154
18. You see someone put ketchup on vanilla ice cream, and eat it.	-.064	1.033	-.780	.053	.905
19. You see a man with his intestines exposed after an accident.	.000	.800	.000	.085	1.571
20. You discover that a friend of yours changes underwear only once a week.	.032	1.063	.379	.123	1.894†
21. A friend offers you a piece of chocolate shaped like dog-doo.	.033	.986	.411	.066	1.119
22. You accidentally touch the ashes of a person who has been cremated.	.149	.877	2.114*	.051	.962
23. You are about to drink a glass of milk when you smell that it is spoiled.	-.026	1.019	-.317	.216	3.384***
24. As part of a sex education class, you are required to	.071	.908	.976	.063	1.235

inflate a new unlubricated condom, using your mouth.					
25. You are walking barefoot on concrete, and you step on an earthworm.	-.033	1.00	-.403	.059	.929
Average	.06728	.365	2.27*	.082	1.972*

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

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.

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, Westfall, & Kenny, 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 DSR 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 ($\gamma = .049$, $SE = .02$), ($t(119.618) = 2.52$, $p = .013$, 95% CI = [.010, .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. ($\gamma = .051$, $SE = .02$), $t(113.60) = 2.52$, $p = .013$, 95% CI = [.011, .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]), $t(153) = 4.31$, $p < 0.001$, 95% CI [.08, .21], Cohen's $d = .24$. 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 extend to other 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 ($p = .14$).¹ 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 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

¹ Further, neither status/hierarchy protection, $\beta = .072$, $t(151) = .894$, $p = .373$, 95% CI [-.09, .23] nor self-protection concerns, $\beta = .137$, $t(151) = 1.62$, $p = .108$, 95% CI [-.03, .30] moderated the observed increase in disgust sensitivity over time.

scores at Time 2 significantly predicted more negative ratings of the disgusting images ($\beta = -.42$, $t(151) = 5.76$, $p < .001$, 95% CI[-.57, -.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* ($\beta = -.29$, $t(150) = 2.04$, $p = .04$, 95% CI[-.57, -.01])². 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. Further, and also consistent with our predictions, disgust sensitivity did not predict ratings of the positive images (Time 1 Disgust: $\beta = -.03$, $p = .73$, 95% CI [-.19, .13]; Time 2 disgust: $\beta = -.06$, $p = .5$, 95% CI [-.22, .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.

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

² 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 ($\beta = -.62$, $t(150) = 2.05$, $p = .04$, 95% CI[-1.21, -.02])

increase in self-protection motivations. Additionally, we found evidence—albeit unexpected—that perceived vulnerability to disease, like disgust sensitivity, might exhibit adaptive flexibility, increasing in response to disease threats. Finally, 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.

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 of one's local environment indeed shape disgust sensitivity. During a salient disease threat—when heightened sensitivity to disgust would be adaptive (Zietsch, 2016)—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.

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.

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