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The Physiological Basis of Psychological Disgust and Moral Judgments

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PHARMACOLOGICAL INHIBITION OF DISGUST 2

To address ongoing debates about whether feelings of disgust are causally related to moral judgments, we pharmacologically inhibited spontaneous disgust responses to moral infractions and examined effects on moral thinking. Findings demonstrated, first, that the antiemetic ginger (*Zingiber officinale*), known to inhibit nausea, reduces feelings of disgust toward non-moral purity-offending stimuli (e.g., bodily fluids), providing the first experimental evidence that disgust is causally rooted in physiological nausea (Study 1). Second, this same physiological experience was causally related to moral thinking: ginger reduced the severity of judgments toward purity-based moral violations (Studies 2 and 4) or eliminated the tendency for people higher in bodily sensation awareness to make harsher moral judgments than those low in this dispositional tendency (Study 3). In all studies, effects were restricted to moderately severe purity-offending stimuli, consistent with pre-registered predictions. Together, findings provide the first evidence that psychological disgust can be disrupted by an antiemetic and that doing so has consequences for moral judgments.

Keywords: *disgust, moral judgment, purity violation, antiemetic*

The Physiological Basis of Psychological Disgust and Moral Judgments

In 1997, ethicist Leon Kass argued against human cloning by appealing to the “wisdom of repugnance”: things that revolt us are wrong. In direct opposition, philosopher Peter Singer (2005) argued that emotionally driven intuitions, such as beliefs about the wrongness of incest based on our feelings of disgust toward the practice, should *not* guide moral decision-making. While this debate is an appropriate target of philosophical – rather than psychological – inquiry, both views imply a similar assumption about human psychology: at times we rely on our feelings of disgust to inform our moral judgments. We find certain behaviors repulsive, report feeling disgusted in response, and decide on this basis that these acts are morally wrong (Haidt & Hersh, 2001). In fact, numerous studies have documented a positive association between self-reported disgust and moral judgments; the more disgusted people feel, the more wrong they judge a moral infraction to be (Gutierrez & Giner-Sorolla, 2007; Horberg, Oveis, Keltner, & Cohen, 2009; Inbar, Pizarro, Knobe, & Bloom, 2009).

Despite these findings, it remains unclear whether feelings of disgust elicited by moral infractions are, in fact, causally related to judgments of those infractions, for several reasons. First, when people report disgust about a moral infraction, it is unclear whether they mean it literally—that is, whether they *feel* nauseous—or, instead, are using the word “disgust” as a way of indicating that they don’t like the transgression, are angered by it, or hold beliefs about its wrongness which they label as a metaphorical “moral disgust” experience (see Chapman & Anderson, 2013). Second, even if physiological nausea is actually elicited by thoughts of moral transgressions, it is not clear that these same feelings play a causal role in judgments of *those* transgressions. These questions remain because most experimental studies addressing this issue

have manipulated *incidental* feelings of disgust—meaning that the induced disgust is separate from any disgust that might be evoked by a moral transgression. Typically, participants are placed in a dirty room or near a noxious odor, then asked to judge a potential moral infraction that is unrelated to the disgust manipulation experienced (e.g., Eskine, Kacinik, & Prinz, 2011). Results generally converge to show that incidental disgust increases the severity of such judgments; for example, exposure to foul-smelling or dirty stimuli causes harsher judgments of morally problematic acts such as cannibalism, lying, and incest (Schnall, Haidt, Clore, & Jordan, 2008). These studies do not, however, address the question of whether disgust that spontaneously arises as a result of thinking about a moral infraction is causally related to judgments of *that* infraction.

This distinction may seem trivial, but addressing it is essential to establishing the internal validity of the presumed causal link between disgust and moral thinking. In incidental disgust studies, there is an assumption that the disgust experienced upon exposure to a noxious odor is the same psychological or physiological experience that occurs when exposed to a moral infraction, yet these two experiences may differ in meaningful ways. For example, a noxious odor may elicit physiological feelings of nausea, whereas a moral infraction may elicit a cognitive sense of wrongness, but no nausea. Though both these experiences may be labeled as “disgusting,” and the experience of one (malodorous-elicited disgust) may be causally related to the other (moral disgust), that does not mean that the same experience is the critical factor in both; nor does it tell us how people feel when they encounter a moral infraction in the absence of any other disgust-eliciting stimulus. Furthermore, inductions of incidental disgust may also make people angry or upset, and these negative emotions may be displaced onto the task at hand,

resulting in harsher moral judgments—but not as a result of disgust felt about the moral infraction (Landy & Goodwin, 2015; Royzman, 2014).

In addition, even if physiological nausea does play a causal role in judgments of moral transgressions, it is not clear that this is the case for all kinds of moral transgressions. Moral Foundations Theory (MFT; Graham, Nosek, Haidt, Iyer, Koleva, & Ditto, 2011) posits five foundations of moral thinking: harm/care, fairness, loyalty, authority/tradition, and purity/sanctity. These foundations represent five distinct areas of concern that individuals may consider important when judging others' behavior as morally right or wrong. Although numerous studies have shown links between moral thinking and specific emotions, including disgust, conflicting findings have emerged regarding which moral foundations are most strongly associated with feelings of disgust, and thus whether moral judgments in all domains in fact rely on these feelings (e.g., Cannon, Schnall, & White, 2011; Graham, Haidt, Koleva, Motyl, Iyer, Wojcik, & Ditto, 2013; Horberg et al., 2009).

Finally, a broader concern regards the robustness of these studies; a meta-analysis found a small effect ($d = .11$) of incidental disgust on moral judgments, but no significant effect when accounting for publication bias (Landy & Goodwin, 2015). However, this work did not consider a variable previously found to interact with the disgust-moral judgment link: awareness of one's bodily sensations. Several researchers have argued that the effects of incidental disgust on moral judgments are particularly pronounced for individuals who are highly attuned to their bodily feelings, because it is awareness of one's embodied emotional experiences that influences moral thinking (Schnall, Haidt, Clore, & Jordan, 2015). In other words, individuals with a dispositionally heightened awareness of their bodily sensations may be more prone to effects of

disgust on their moral judgments, because they are more aware of their internal physiological experiences (such as potential feelings of nausea) and thus more able to draw on these feelings when making moral judgments. Supporting this account, those high in bodily sensation awareness tend to make more severe judgments of moral infractions (Johnson et al., 2016). This main effect has emerged across incidental disgust experimental conditions, and therefore provides indirect support for the suggestion that moral judgments are based, in part, on internal subjective experiences—such as naturally occurring feelings of disgust in response to reading about a moral violation.

In sum, although psychologists have debated for some time about the role of disgust in moral thinking (e.g., Pizarro & Bloom, 2003; Haidt, 2001; Huebner, Dwyer, & Hauser, 2009; Pizarro, Inbar, & Helion, 2011; Wheatley & Haidt, 2005), it remains unclear whether moral infractions actually elicit feelings of disgust that are attributable to physiological nausea, and, if so, whether such feelings are causally related to judgments of those infractions.

More broadly, studies have yet to test whether feelings of disgust resulting from *non-moral* purity-violating stimuli, known as “core disgust elicitors” (e.g., noxious odors, dirty toilets) are causally rooted in physiological feelings of nausea. Although lay people might assume that the disgust feelings experienced in response to such stimuli are a psychological manifestation of physiological nausea, no studies have experimentally tested this claim. Research using electrogastrography has documented associations between reported feelings of disgust and gastric precursors to nausea in response to core disgust elicitors (Harrison, Gray, Gianaros, & Critchley, 2010; Shenhav & Mendes, 2014), but these correlational data do not address the question of whether nausea *causes* psychological disgust feelings.

In the present research we used a novel approach to address all of these issues: to test (1) whether psychological feelings of disgust emerge from physiological nausea, (2) whether these same feelings are elicited by thoughts of moral infractions and consequently promote harsher judgments of those infractions, and (3) whether this is the case for moral judgments rooted across all five foundations. Specifically, we adopted a pharmacological interference method to block spontaneously occurring feelings of nausea. We used ginger (*Zingiber officinale*), an antiemetic with known medicinal effects specific to reducing nausea in response to a variety of elicitors including early pregnancy sickness, post-operative sickness, and motion sickness (e.g., Chaiyakunapruk et al., 2006; Lien et al., 2003). In Study 1 we tested whether ginger, by virtue of its nausea-reducing properties, reduces psychological feelings of disgust toward core disgust elicitors; that is, purity-violating stimuli outside the moral domain.

In Studies 2, 3, and 4 we used the same approach to interfere with spontaneous nausea-based feelings of disgust that might arise from reading about a moral infraction, then measured downstream consequences on judgments of that infraction. In Studies 2 and 3 we focused largely on moral situations that involved a purity violation, meaning an act perceived as taboo or degrading (e.g., incest, body-envelope violations), because extant theorizing and empirical work suggest that this is the moral domain most likely to be influenced by actual, rather than metaphorical, feelings of disgust (Graham et al., 2013; Haidt & Graham, 2007; Horberg et al., 2009; Rozin, Lowery, Imada, & Haidt, 1999; Wagemans, Brandt, & Zeelenberg, 2018). More specifically, studies have shown that individuals report higher levels of disgust in response to purity violations compared to violations in other domains (Landmann & Hess, 2017), and purity violations are more likely to elicit disgust nonverbal expressions, compared to other domains (Cannon et al., 2011). Furthermore, dispositional disgust sensitivity is more strongly associated

with a tendency to harshly judge purity violations, compared to violations in other domains (Horberg et al., 2009; Wagemans et al., 2018).

If spontaneous feelings of nausea occur as a result of thinking about a moral purity violation, and consequently increase the severity of judgments of that violation, then inhibiting those feelings should reduce moral judgment severity in the purity domain. However, in Study 4 we moved beyond this particular moral foundation, to test whether the same pharmacological inhibitor might affect moral judgments in other domains as well; specifically, we examined the effect of ginger on judgments of violations in all five moral domains.¹ Together, these studies are the first body of research to test whether the disgust elicited by moral infractions is the same psychological experience that promotes harsher judgments of those infractions, and whether this form of moral disgust is rooted in physiological nausea.

Study 1

Method

Participants and Procedure. Two-hundred, fifty-eight undergraduates participated in exchange for course credit; this sample was determined on the basis of our goal of collecting as much data as possible during one semester. Sixteen participants were excluded due to procedural errors, resulting in a final sample of 242 (69% women, $M_{age} = 20.34$, $SD = 2.74$). A power analysis conducted after data collection was complete suggested that this sample size would provide greater than 80% power to detect a small-to-moderate effect.

¹ We also conducted an additional study –reported in detail in the SOM–in which we examined the effect of ginger on moral infractions in the harm/care domain only. No significant results emerged; see SOM7.

Participants were brought to the lab to participate in what they were told was a study of the effects of ginger on memory; they were told that they would be randomly assigned to ingest three pills that contained either ginger powder or sugar. In a double-blind design (i.e., both the experimenter and the participant were blind to each participant's assigned condition), participants were assigned to take either 1.5 grams of ginger powder (3 capsules in total) or 3 equivalently sized sugar-filled capsules. This amount of ginger was chosen based on prior studies examining the efficacy of ginger as an antiemetic, which have typically used doses of 1-2 grams (e.g., Chaiyakunapruk et al., 2006; Lien et al., 2003). Not all traces of ginger could be removed from the outside of the ginger capsules, resulting in a mild ginger taste, so all capsules in both conditions were lightly dusted with ginger powder, and participants were told, "All pills used in this study will have a light dusting of ginger on them in order to disguise the real ginger pill." Although the capsule dusting resulted in some tiny amount of ginger being ingested by participants in the control condition, this methodological limitation works against our predicted effects, and rules out the possibility that any results are attributable to the taste of ginger as opposed to its pharmacological properties.

After ingesting the capsules, participants responded to demographic questions, and, given that the absorption of ginger—and therefore its efficacy—may vary depending on when participants last ate, also reported when they last ate. Next, for the sake of our cover story and to allow time for ginger to digest, participants passively viewed (on a computer screen) a slideshow of photographs for presumed later recall. Each photo appeared for 7 seconds, and the entire slideshow lasted about 13 minutes. Most photos were drawn from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1999) and were of neutral valence, but

several disgusting photos were also included so that participants would not be surprised by the subsequent presentation of (different) disgusting photos during the test phase.

Prior studies on the efficacy of ginger for nausea reduction and the absorption of ginger's active ingredients suggest a delay of 30 minutes to 1 hour before testing its efficacy (e.g., Jiang, Wang, & Mi, 2008; Lien et al., 2003). Therefore, after the slideshow ended participants completed several filler questionnaires to allow for ample time to pass. At 40 minutes post ingestion, participants were shown several new photos and asked to rate their emotional responses to each. Specifically, for each photo participants were asked, "How disgusted does this image make you feel?" Ratings were made on a 7-point Likert-scale, ranging from 1 (*not at all disgusted*) to 4 (*somewhat disgusted*) to 7 (*very disgusted*). To test whether ginger might reduce experiences of other emotions, participants next responded to the same question rephrased for happiness, sadness, and anger. For the sake of our cover story, participants were finally asked whether they had seen the photo earlier in the study, and to rate their certainty of that judgment. Participants completed this entire set of questions for each photo individually. Finally, they were asked to indicate whether they believed they had ingested ginger, sugar, or did not know.

Materials. No prior studies have examined whether ginger interferes with feelings of disgust, so we had no basis for predicting whether it would be effective for: (a) all purity-offending stimuli (i.e., core-disgust elicitors), (b) moderately purity-offending stimuli only, or (c) highly purity-offending stimuli only. If disgust is causally rooted in nausea, ginger might be efficacious for all purity-offending stimuli. However, it is also possible that ginger would reduce feelings of disgust only in situations where individuals are highly repulsed and feeling very nauseous. Alternatively, because ginger's effect on nausea is typically not very strong (e.g., Ernst

& Pittler, 2000), it might not reduce feelings of disgust toward highly offensive stimuli—which are likely to have an overpowering impact—but instead be effective only for moderately offensive stimuli, which are more likely to lead to variable responses that could be influenced by a ginger-induced inhibition of physiological disgust. (Of note, a range of effect sizes have been observed across studies using ginger as an antiemetic, but one fairly representative meta-analysis observed a 31% reduction in the risk of post-operative nausea relative to those on a placebo; Chaiyakunapruk et al., 2006). Given this uncertainty, prior to data collection we pre-tested a set of images for their perceived disgustingness in order to separately examine ginger’s efficacy regarding highly and moderately offensive stimuli. Our goal was to determine whether ginger might have any effect on either set of stimuli, in order to capitalize on these results when designing (and pre-registering hypotheses for) subsequent studies examining moral judgments; for this reason, we did not plan to treat severity as a factor and test for interactions. In other words, because our ultimate goal was to maximize our chances of finding an effect of a manipulation that we expected to be relatively weak, on moral thinking, we thought it useful, in this first study examining the psychological effects of pharmacologically inhibiting nausea, to separately probe effects within each of the two stimulus sets.

Purity-offending photos were drawn from the IAPS as well as from internet searches. Five undergraduate research assistants viewed 16 images and rated the disgustingness of each on a 7-point Likert-scale ($ICC = .66$). They were also asked whether the emotion of disgust or some other emotion best captured their reaction to each image. Based on their ratings, three photos were selected that were determined to be highly disgusting (diarrhea in a toilet, vomit in a toilet, and a man vomiting in a toilet), and were found to be significantly more disgusting than three other photos that were determined to be moderately disgusting (snot in a napkin, rotten meat, and

a man sneezing out particles in the direction of the camera): $M_{\text{high}} = 5.93$ (.76); $M_{\text{moderate}} = 3.60$ (.83), paired-sample $t(4) = 3.38$ $p = .028$, ICC for selected stimuli = .73. Given that we had no strong expectations for whether ginger would more effectively reduce disgust toward highly versus moderately severe stimuli, we planned, prior to data collection, to separately examine the impact of ginger on each set of images; analyses are therefore presented separately for the two sets (with ancillary analyses conducted across stimulus set and treating severity as a factor; of note, we had no basis for predicting an interaction between experimental condition and stimulus severity, and in this exploratory stage expected that a finding of condition on any set of images, or both, would be useful for designing subsequent studies). Interspersed among the disgust photos were 4 neutral photos: a chair, popsicles, a flower, and tissues. All photos were shown to participants in a within-subjects counterbalanced order.

Results

Main analyses. Supporting the results of our pre-testing, participants judged the highly disgusting photos to be significantly more disgusting than the moderately disgusting photos, $M_{\text{high}} = 6.59$, $SD = .74$; $M_{\text{moderate}} = 5.20$, $SD = 1.14$; paired-sample $t(241) = 22.06$, $p < .0001$. Examining results for the highly disgusting images only, ginger did not significantly reduce feelings of disgust toward these stimuli; $M_{\text{ginger}} = 6.54$ ($SD = .81$); $M_{\text{sugar}} = 6.64$ ($SD = .66$), independent sample $t(240) = 1.04$, $d = .13$, 95% CI [-.12, .39], $p = .30$. In contrast, ginger did significantly reduce feelings of disgust toward the moderately disgusting images, $M_{\text{ginger}} = 5.06$ ($SD = 1.16$), $M_{\text{sugar}} = 5.35$ ($SD = 1.11$), independent sample $t(240) = 2.03$, $d = .26$, 95% CI [.008, .51] $p = .04$. This effect held when controlling for time since participants last ate, $M_{\text{ginger}} = 5.06$ ($SD = 1.16$); $M_{\text{sugar}} = 5.35$ ($SD = 1.11$), $F(1, 239) = 3.88$, $p = .05$. Analyzing the data from

moderately and highly severe disgusting stimuli together in a repeated-measures ANOVA, the interaction between condition and disgust severity did not reach statistical significance, $F(1, 240) = 2.41, p = .12$; however, the main effect of ginger on disgust ratings, collapsing across severity, was marginally significant, $F(1, 240) = 3.47, p = .064$.

The observed main effect of ginger on moderately severe stimuli was unique to disgust; all other emotions measured (anger, sadness, happiness) did not differ significantly between conditions, for either highly or moderately disgusting photos. Specifically, in response to highly disgusting photos, means for anger were $M_{\text{ginger}} = 2.89 (SD = 1.76)$; $M_{\text{sugar}} = 2.95 (SD = 1.86)$, independent sample $t(240) = .24, p = .81$; means for sadness were $M_{\text{ginger}} = 2.13 (SD = 1.51)$; $M_{\text{sugar}} = 2.39 (SD = 1.76)$, independent sample $t(240) = 1.22, p = .23$; and means for happiness were $M_{\text{ginger}} = 1.06 (SD = .25)$; $M_{\text{sugar}} = 1.04 (SD = .17)$, independent sample $t(240) = .66, p = .51$. In response to moderately disgusting photos, means for anger were $M_{\text{ginger}} = 2.38 (SD = 1.40)$; $M_{\text{sugar}} = 2.34 (SD = 1.34)$, independent sample $t(240) = .23, p = .82$; means for sadness were $M_{\text{ginger}} = 2.01 (SD = 1.11)$; $M_{\text{sugar}} = 2.02 (SD = 1.25)$, independent sample $t(240) = .08, p = .94$; and means for happiness were $M_{\text{ginger}} = 1.30 (SD = .49)$; $M_{\text{sugar}} = 1.23 (SD = .43)$, independent sample $t(240) = 1.23, p = .22$.

Nonetheless, to further probe this issue, we ran an ANCOVA predicting feelings of disgust toward moderately disgusting photos controlling for feelings of anger, and found that the effect of ginger held, $M_{\text{ginger}} = 5.06 (SD = 1.16)$; $M_{\text{sugar}} = 5.35 (SD = 1.11)$, $F(1, 239) = 5.45, p = .02$. This result also held controlling simultaneously for all emotions measured (anger, happiness, sadness): $M_{\text{ginger}} = 5.08 (SD = 1.16)$; $M_{\text{sugar}} = 5.34 (SD = 1.11)$, $F(1, 237) = 4.12, p = .04$; and controlling for negative affect (based on the mean of anger and sadness), $M_{\text{ginger}} = 5.06 (SD =$

1.16); $M_{sugar} = 5.35$ ($SD = 1.11$), $F(1, 239) = 4.12$, $p = .04$. We also examined whether the 95% confidence interval around the beta weight for the effect of condition predicting disgust feelings toward moderately severe stimuli contained the point estimate of condition predicting negative affect, and vice versa. In both cases, no such overlap was observed: $b_{disgust} = -.30$, 95% CI [-.60, -.005], $b_{NA} = .014$, 95% CI [-.28, .31]). These results further suggest that the ginger manipulation uniquely affected feelings of disgust.²

Testing for demand effects. Next, to test whether these results might have been driven by demand characteristics (i.e., participants who ingested ginger might somehow have guessed that they were in that condition, and, if aware of its antiemetic properties, shifted their responses accordingly), we examined whether participants assigned to the ginger condition were aware of having ingested ginger. Fifty-two participants (41% of those in the ginger condition) guessed correctly, and 25 (22% of those in the sugar condition) incorrectly, that they had ingested ginger. By contrast, 17 participants (15% of those in the sugar condition) guessed correctly, and 8 incorrectly (6% of ginger condition), that they had ingested sugar. The remainder of participants reported not knowing which condition they were in. Based on these results, we created three new sub-samples of participants: (1) excluding those who correctly guessed that they had ingested ginger, (2) excluding those who correctly guessed that they had ingested ginger *and* those who believed they had ingested ginger but were incorrect, and (3) excluding all participants who correctly guessed which condition they were in. We then re-ran the main analysis, on moderately

² To further probe this issue, we conducted an additional study in which participants ($N=271$) viewed and judged fear-inducing stimuli, instead of disgust-inducing stimuli. No evidence emerged for an effect of ginger on feelings of fear, for highly severe ($M_{ginger}=5.06$, $SD=1.47$; $M_{sugar}=4.90$, $SD=1.58$, independent sample $t(269)=.87$, $d=.10$, 95% CI [-.13, .34], $p=.39$) or moderately severe ($M_{ginger}=4.39$, $SD=1.66$, $M_{sugar}=4.31$, $SD=1.66$, independent sample $t(269)=.39$, $d=.05$, 95% CI [-.19, .29] $p=.70$) stimuli. These results suggest that ginger's effect in Study 1 cannot be attributed to generalized arousal-reduction or calming (See SOM1 for more details).

severe stimuli, separately for each of these subsamples. For all three subsamples, the effect of ginger on feelings of disgust toward moderately disgusting stimuli held; for Subsample 1, $M_{\text{ginger}} = 4.91$ ($SD = 1.14$); $M_{\text{sugar}} = 5.35$ ($SD = 1.11$), independent sample $t(188) = 2.66$, $d = .39$, $p = .008$; for Subsample 2, $M_{\text{ginger}} = 4.91$ ($SD = 1.14$); $M_{\text{sugar}} = 5.33$ ($SD = 1.09$), independent sample $t(163) = 2.41$, $d = .38$, $p = .017$; and for Subsample 3, $M_{\text{ginger}} = 4.91$ ($SD = 1.14$); $M_{\text{sugar}} = 5.32$ ($SD = 1.14$), independent sample $t(171) = 2.36$, $d = .38$, $p = .019$.

These results suggest that the effect of ginger on feelings of disgust is unlikely to have been due to experimenter demand; furthermore, the replication of this effect across all three subsamples attests to its robustness. Nonetheless, as a final probe of this issue, at the very end of the study we asked just under half the sample (47%) to “list what you think the effects of ginger are on the body and/or brain.” Not all participants were asked this question because we inadvertently included it only after data collection was already underway. Based on our review of participants’ open-ended responses, only 2 participants (out of 113) mentioned anything remotely related to nausea (these two responses were: “soothing for upset stomach” and “possibly assist in controlling stomach functions”). Four additional participants mentioned that ginger was used to treat “colds”. Still, including these 4 participants, only 5% of participants surveyed reported any awareness of a link between ginger and illness, and the large majority of participants queried (98%) seemed unaware of any association between ginger and nausea or disgust.

In summary, the results of Study 1 provide the first experimental evidence that physiological nausea is causally related to psychological feelings of disgust. In addition to providing new insights about the nature of disgust, these findings lay the groundwork for Study

2, by suggesting that the use of ginger to inhibit feelings of nausea-based disgust may be a valid method of testing whether such feelings are causally related to moral judgments. Furthermore, because ginger influenced responses to moderately but not highly severe disgusting stimuli, in Study 2 we expected to find the strongest effects of ginger on moderately severe stimuli—but, in this case, stimuli of a morally problematic nature. We pre-registered this specific hypothesis, of a main effect on moderately severe purity-related moral violations, through the Open Science Framework [see <https://osf.io/pbqn5/>, “Study 3 (planned)”³].

In Study 2 we also conducted an exploratory (i.e., not pre-registered) test of whether ginger might moderate the effect of bodily sensation awareness on moral judgments. Previous studies have found that individuals with a heightened awareness of their bodily sensations tend to make more severe moral judgments (Johnson et al., 2016). If this is a result of these individuals being particularly attuned to any nauseous response they might experience toward potentially immoral stimuli, then, by inhibiting nausea, ginger might sever the otherwise positive association between bodily awareness and moral judgment severity (i.e., if there is little nausea to be sensitive to, bodily sensation awareness should have little impact on psychological responses to nausea). It is also worth noting, however, that prior studies examining the effects of incidental disgust on moral thinking have produced somewhat inconsistent results regarding the impact of bodily sensation awareness, at times demonstrating a main effect of incidental disgust only, and at other times an interaction between incidentally manipulated disgust and bodily sensation awareness (e.g., Schnall et al., 2008).

³ See our Executive Summary Document for a complete description of all studies conducted and preregistered in this line of research; <https://osf.io/ucx38/>.

Study 2

Method

Participants and Procedure. Three-hundred and seven undergraduate students participated in exchange for course credit. One participant was excluded due to a procedural error, resulting in a final sample of 306 (80% women, $M_{age} = 20.39$, $SD = 3.31$). The final sample size was determined in part from a power analysis based on 75% power to detect a main effect of a magnitude similar to that observed in Study 1, and in part by aiming to collect as much data as possible until the end of the school semester, even if that meant including a sample slightly larger than the calculated estimate.

Participants followed a similar procedure as in Study 1: we used the same cover story about a memory test and the same experimental manipulation (1.5 grams of ginger or sugar, both in gel-capsules coated with ginger powder). There were, however, four critical differences from the procedure of Study 1. First, instead of the key dependent variable involving judgments of disgusting photos, participants made judgments about several possible moral violations, on a scale from 1 (*Perfectly OK*) to 9 (*Extremely Wrong*); the only exception was for judgments of legislation allowing first cousins to marry, which were made on a scale from 1 (*Strongly Support Legalization*) to 9 (*Strongly Oppose Legalization*).

Second, the disgusting photos used during the early “photo memorization” component of Study 1 were replaced with photos of a neutral valence so as to not accidentally induce feelings of disgust at any point in the experiment, separate from feelings that might spontaneously occur as a result of reading about moral violations. Third, to examine our exploratory hypothesis

regarding bodily sensation awareness, we measured this dispositional tendency using the same scale that has been used to measure it in the relevant past research—the Private Body Consciousness Scale (Miller et al., 1981; Schnall et al., 2008). Participants completed this measure after responding to the vignettes about moral violations.

Fourth, to test whether reduced feelings of disgust—and not other emotions—might mediate any observed effects of ginger on moral judgments, at the very end of the study participants completed a post-task measure of emotions. Specifically, participants were asked to “rate the extent to which you feel each of the following emotions, right now” (in the following order: angry, anxious, afraid, disgusted, embarrassed, happy, proud, sad) on a scale from 1 (*Not at all*) to 4 (*Somewhat*) to 7 (*Very*).⁴ Although it not clear that participants would still feel disgust from the vignettes at the end of the study, measuring disgust earlier on—either prior to or simultaneously with our measure of moral judgments—would have primed participants to think about their disgust feelings, and potentially led them to use those feelings (or the lack thereof) in making their moral judgments. Because we wanted to avoid this potential confound (which is the benefit of using a pharmacological means to inhibit feelings of disgust without participants’ awareness), we opted to measure disgust feelings at the very end of the experiment only – knowing that an absence of experimental effects on this measure might be attributable to the time delay since presentation of the moral violations.

Materials. As in Study 1, prior to data collection we pre-tested a set of purity-based moral infractions for their severity. These vignettes were taken either directly from past research (i.e., Schnall et al., 2008), amended slightly from past research (i.e., Rozin et al., 1999), or

⁴ Due to a clerical error, anger was assessed on a 9-point scale.

constructed anew in their entirety for the present research. To pre-test the severity of these 13 vignettes, twelve undergraduate research assistants and graduate students read and rated how wrong each was on a 9-point Likert-scale ranging from 1 (*Perfectly OK*) to 9 (*Extremely Wrong*); ICC = .81. We then selected 4 highly severe and 4 moderately severe moral violations for inclusion (ICC = .74): $M_{High} = 5.31 (SD = 1.74)$; $M_{Moderate} = 3.58 (SD = 1.24)$, paired-sample $t(11) = 3.83$ $p = .003$ [see <https://osf.io/pbqn5/>, “Study 3 (planned)”, for pre-registered predictions for these two sets of items].

The 4 highly severe vignettes included were as follows: (1) “Some U.S. states allow first cousins to marry each other. Other U.S. states are considering making marriage among first cousins legal.” (For this item, RAs and participants responded to the probe: “What do you think about such legislation?”), (2) “How moral or immoral do you, personally, find consensual sex between first cousins to be?”, (3) “Frank’s dog was killed by a car in front of his house. Frank had heard that in China people occasionally eat dog meat, and he was curious what it tasted like. So he cut up the body and cooked it and ate it for dinner”, and (4) “Matthew is playing with his new kitten late one night. He is wearing only his boxer shorts, and the kitten sometimes walks over his genitals. Eventually, this arouses him, and he begins to rub his bare genitals along the kitten’s body. The kitten purrs, and seems to enjoy the contact.”

The 4 moderately severe vignettes included were as follows: (1) “A man who is not in a romantic relationship orders an inflatable sex doll that looks like his secretary”, (2) “A chemist has used special purifier materials to completely sanitize a person's feces. A man decides to eat a spoonful of the feces”, (3) “A man decides to drink water out a toilet bowl that has never been used”, and (4) “When no one is looking, a morgue worker touches the open eye of a corpse.”

Finally, we also included two items describing a moral dilemma known as the Trolley Problem and asking participants to provide judgments of hypothetical responses. First, participants were presented with the Footbridge case: “A runaway trolley is heading down the tracks toward five workmen who will be killed if the trolley proceeds on its present course. You are on a footbridge over the tracks, in between the approaching trolley and the five workmen. Next to you on this footbridge is a stranger who happens to be very large. The only way to save the lives of the five workmen is to push this stranger off the bridge and onto the tracks below where his large body will stop the trolley. The stranger will die if you do this, but the five workmen will be saved. Is it appropriate for you to push the stranger on to the tracks in order to save the five workmen?” Second, participants were presented with the Switch case: “You are at the wheel of a runaway trolley quickly approaching a fork in the tracks. On the tracks extending to the left is a group of five railway workmen. On the tracks extending to the right is a single railway workman. If you do nothing the trolley will proceed to the left, causing the deaths of the five workmen. The only way to avoid the deaths of these workmen is to hit a switch on your dashboard that will cause the trolley to proceed to the right, causing the death of the single workman. How wrong is it for you to hit the switch in order to avoid the deaths of the five workmen?”

We included these two items because in a previous study (Interim Study, see SOM2),⁵ a significant effect of the ginger manipulation had emerged on responses to these dilemmas (see SOM4, SOM5), suggesting that inhibiting physiological disgust via ginger may have led to greater utilitarian thinking, consistent with the suggestion that emotional responses to moral dilemmas reduce utilitarian decisions (e.g., Greene, Sommerville, Nystrom, Darley, & Cohen,

⁵ In our preregistration document this Interim Study was labeled “Study 2”; see <https://osf.io/pbqn5/>.

2001). Unfortunately, researcher error resulted in this Interim Study being insufficiently powered ($N = 94$) to detect an effect similar in magnitude to the effect that emerged in Study 1; we are therefore hesitant to draw conclusions from it (but see SOM4 for detailed results). However, in Study 2 we sought to test whether this underpowered effect would replicate in a more highly powered study, and in our pre-registration document we predicted this effect [<https://osf.io/pbqn5/>]. Importantly, the underpowered Interim Study did not include any moderately severe purity violations; all data we have collected pertaining to these violations are reported in the main text.

We again planned to separately analyze responses to highly and moderately severe purity violations, and pre-registered our prediction that ginger would be most effective for reducing responses to moderately severe infractions specifically [see <https://osf.io/pbqn5/>].

Results

Main analyses. Confirming pre-testing, participants judged the highly severe moral violations to be significantly more wrong than the moderately severe violations, $M_{\text{high}} = 7.18$, $SD = 1.48$; $M_{\text{moderate}} = 5.91$, $SD = 1.72$; paired-sample $t(305) = 14.13$, $p < .0001$. In addition, consistent with prior research (Johnson et al., 2016), a main effect of bodily sensation awareness emerged on judgments of moderately severe violations, such that participants higher in bodily sensation awareness perceived these transgressions to be more wrong, $b = .26$, $t(302) = 2.02$, $p = .044$, as would be expected if participants were relying, to some extent, on their bodily sensations to make these judgments. For the highly severe violations, there was also a main effect of bodily sensation awareness, with participants higher in this trait also judging these violations as more wrong, $b = .30$, $t(302) = 2.76$, $p = .006$. Importantly, although bodily sensation awareness was

measured toward the end of the experiment, mean levels of this trait did not vary as a function of condition, $M_{\text{ginger}} = 4.37$ ($SD = .73$); $M_{\text{sugar}} = 4.35$ ($SD = .83$), independent sample $t(304) = .26$, $p = .80$.

Turning to our experimental manipulation, consistent with our pre-registered hypotheses, ginger reduced the severity of participants' judgments of moderately severe purity violations, $M_{\text{ginger}} = 5.71$ ($SD = 1.82$); $M_{\text{sugar}} = 6.11$ ($SD = 1.60$), independent sample $t(304) = 2.08$, $d = .23$, 95% CI [.013, .46], $p = .039$. In contrast, as was the case in Study 1, ginger did not have any effect on judgments of highly severe purity violations, $M_{\text{ginger}} = 7.21$ ($SD = 1.46$); $M_{\text{sugar}} = 7.16$ ($SD = 1.50$), independent sample $t(304) = .33$, $d = -.03$, 95% CI [-.19, .26] $p = .74$. In addition, consistent with Study 1, the effect of ginger on judgments of moderate purity violations held controlling for time since participants last ate, $F(1, 303) = 4.67$, $p = .03$.

In contrast, no significant effect of ginger emerged for either trolley dilemma case. Specifically, for the switch case, $M_{\text{ginger}} = 5.46$ ($SD = 2.16$); $M_{\text{sugar}} = 5.32$ ($SD = 1.98$), independent sample $t(304) = .60$, $p = .55$; and for the footbridge case, $M_{\text{ginger}} = 6.57$ ($SD = 2.11$); $M_{\text{sugar}} = 6.63$ ($SD = 1.95$), independent sample $t(304) = .28$, $p = .78$. These results provide preliminary evidence to suggest that ginger does not affect responses to harm/care violations, at least when they are framed as hypothetical dilemmas about saving lives from a runaway trolley (see also SOM3, SOM7).

Although our preregistered predictions regarding purity infractions focused on the specific effect of ginger on moderately severe stimuli, for the sake of completeness we also analyzed the data from both the moderately and highly severe conditions together using a repeated measures ANOVA, and found a significant interaction between condition and moral

violation severity, $F(1, 304) = 6.70, p = .01$ [the main effect of ginger collapsing across moral violation severity was not significant, $F(1, 304) = 1.20, p = .27$].

We next tested whether ginger moderated the relationship between bodily sensation awareness and moral judgment severity. For both moderately and highly severe violations, no interaction emerged, $b = -.006, t(238) = -.05, p = .96$ for moderate violations; $b = .018, t(302) = .17, p = .87$, for highly severe violations.

Testing for demand effects. We next examined whether participants in the ginger condition were aware of being in that condition. Sixty-one participants (40% of those in the ginger condition) guessed correctly, and 20 (13% of those in sugar condition) incorrectly, that they had ingested ginger. By contrast, 36 participants (23%) guessed correctly, and 16 incorrectly (10%), that they had ingested sugar. The remainder of participants reported not knowing which condition they were in. As in Study 1, we next re-ran the main analysis, testing for an effect of ginger on moderately severe stimuli, for three separate subsamples of participants: (1) excluding those who correctly guessed that they had ingested ginger, (2) excluding those who correctly guessed that they had ingested ginger *and* those who believed they had ingested ginger but were incorrect, and (3) excluding all participants who correctly guessed which condition they were in. Once again, the effect of ginger on judgments of moderate stimuli held in all three subsamples; for Subsample 1, $M_{\text{ginger}} = 5.49 (SD = 1.95)$; $M_{\text{sugar}} = 6.11 (SD = 1.60)$, independent sample $t(243) = 2.69, d = .36, p = .008$; for Subsample 2, $M_{\text{ginger}} = 5.49 (SD = 1.95)$; $M_{\text{sugar}} = 6.06 (SD = 1.54)$, independent sample $t(223) = 2.42, d = .33, p = .016$; and for Subsample 3, $M_{\text{ginger}} = 5.49 (SD = 1.95)$; $M_{\text{sugar}} = 6.11 (SD = 1.59)$, independent sample $t(207) =$

2.51, $d = .35$, $p = .013$. These results again suggest that the observed effects are unlikely to be due to demand characteristics, and their consistency across subsamples attests to their robustness.

Did ginger affect post-task feelings of disgust? Finally, we examined results for our post-task measure of emotions, to determine whether the observed effect of ginger on moderately severe moral infractions might be mediated by a reduction in disgust feelings. When examining the full sample, post-task disgust ratings did not differ significantly by condition, $M_{\text{ginger}} = 2.39$ ($SD = 1.73$); $M_{\text{sugar}} = 2.68$ ($SD = 1.81$), independent sample $t(304) = 1.39$, $p = .17$. No other emotions measured varied significantly by condition either ($ps \geq .098$). However, when examining the three separate subsamples of participants we constructed based on knowledge of their assigned condition, post-task disgust varied significantly by condition, for all three subsamples; for Subsample 1, $M_{\text{ginger}} = 2.13$ ($SD = 1.50$); $M_{\text{sugar}} = 2.68$ ($SD = 1.81$), independent sample $t(243) = 2.42$, $d = .32$, $p = .01$; for Subsample 2, $M_{\text{ginger}} = 2.13$ ($SD = 1.50$); $M_{\text{sugar}} = 2.66$ ($SD = 1.78$), independent sample $t(223) = 2.34$, $d = .32$, $p = .02$; and for Subsample 3, $M_{\text{ginger}} = 2.13$ ($SD = 1.50$); $M_{\text{sugar}} = 2.72$ ($SD = 1.85$), independent sample $t(207) = 2.47$, $d = .35$, $p = .01$.

To examine whether these effects were specific to disgust, we created a standardized negative affect composite based on the other post-task negative emotions measured (i.e., anger, anxiety, fear, embarrassment, and sadness). In contrast to disgust, feelings of negative affect did not differ significantly by condition for any of the three subsamples; for Subsample 1, $M_{\text{ginger}} = -.10$ ($SD = .65$); $M_{\text{sugar}} = .04$ ($SD = .77$), independent sample $t(243) = 1.53$, $p = .13$; for Subsample 2, $M_{\text{ginger}} = -.10$ ($SD = .65$); $M_{\text{sugar}} = .05$ ($SD = .80$), independent sample $t(207) = 1.51$, $p = .13$ and for Subsample 3, $M_{\text{ginger}} = -.10$ ($SD = .65$); $M_{\text{sugar}} = .03$ ($SD = .73$), independent sample $t(223) = 1.37$, $p = .17$.

We next examined whether post-task disgust mediated the relationship between condition and moral judgment severity toward the moderate purity violations, again for participants in each of the three subsamples. First, we examined the direct effect of condition (ginger coded as 1, sugar coded as 0) on moral judgment severity toward moderate purity violations: for Subsample 1, $b = -.62, p = .008$; for Subsample 2, $b = -.57, p = .016$; and for Subsample 3, $b = -.62, p = .013$. Next, we tested whether condition predicted post task disgust feelings. We found that condition negatively predicted post task disgust: for Subsample 1, $b = -.54, p = .016$; for Subsample 2, $b = -.53, p = .02$; and for Subsample 3, $b = -.59, p = .014$. Next, we tested whether post-task disgust positively predicted judgment severity toward the moderate purity violations: for Subsample 1, $b = .29, p < .0001$; for Subsample 2, $b = .24, p < .0001$; and for Subsample 3, $b = .34, p < .0001$. Finally, using the partial posterior method (Biesanz, Falk, & Savalei, 2010), we tested for mediation by examining whether the indirect effect, ab , was significant. We found evidence consistent with mediation; for Subsample 1, $ab = -.16, p = .013$; for Subsample 2, $ab = -.13, p = .011$; and for Subsample 3, $ab = -.20, p = .01$. Together, these results suggest that the observed effects of ginger on moral judgments may be attributable to a reduction of disgust feelings, resulting from the ingestion of ginger. However, because we could not assess feelings of disgust prior to moral judgments without inherently confounding the two ratings, the presumed mediator (disgust) was measured *after* the presumed outcome (moral judgments). We therefore cannot be certain of the causal direction of these effects, nor their robustness—given that they were statistically significant only for the subsamples that excluded some participants and not for the full sample—so future studies are needed to more thoroughly address this issue.

The results of Study 2 provide the first empirical evidence that physiological feelings of disgust—the same nausea-based feelings elicited by non-moral purity-offending stimuli, or “core

disgust elicitors”—are causally related to moral judgments in the purity domain. These results further suggest that ginger is an effective interference tool for judgments of moderately severe disgust-inducing stimuli only. The specificity of the effect may be due to ginger being too weak to inhibit the strong feelings of disgust likely elicited by highly severe violations and highly offensive images. It also may be the case that individuals hold strong prior cognitive beliefs about the moral wrongness (or disgustingness) of more severe violations, making these beliefs more immune to the impact of momentary emotional responses (Robinson & Clore, 2002). Finally, the absence of an effect of ginger on responses to trolley dilemmas suggests that physiological disgust may not affect the moral thinking that is used to make utilitarian versus deontological moral decisions.

Study 3

Study 3 sought to replicate the findings of Study 2 on moderately severe violations of moral purity using a larger sample; because it was intended to be a straightforward direct replication, we did not pre-register this study. We again conducted an exploratory test of whether ginger might moderate the effect of bodily sensation awareness on these judgments. Though we did not find any interaction with bodily sensation awareness in Study 2, past studies have documented such an effect when examining the impact of incidental disgust on moral thinking (e.g., Schnall et al., 2008), and the present Study 2 did show expected main effects of this individual difference variable (i.e., individuals higher in bodily sensation awareness made more severe moral judgments).

Method

Participants and Procedure. Five-hundred and fifteen undergraduate students participated in exchange for course credit. Eighteen participants were excluded due to procedural errors, for a final sample of 497 (75% women, $M_{age} = 20.01$, $SD = 2.30$). Participants followed a procedure identical to that used in Study 2; the only exception was that post-task emotions were not assessed. Sample size was determined in part from a power analysis based on 75% power to detect a small two-way interaction between ginger and bodily sensation awareness, and in part by aiming to collect as much data as possible until the end of the school semester even if that meant including a sample slightly larger than the calculated estimate.

Results

Main analyses. Once again, participants judged the highly severe moral violations to be significantly more wrong than the moderately severe violations, $M_{high} = 7.11$, $SD = 1.47$; $M_{moderate} = 5.84$, $SD = 1.72$; paired-sample $t(496) = 17.87$, $p < .0001$. Following our pre-registered predictions for Study 2, we again separately examined results for moderately and highly severe violations. For moderate violations, as was the case in Study 2, a main effect of bodily sensation awareness emerged on judgments of moral wrongness, $b = .28$, $t(495) = 2.80$, $p = .005$. In contrast with Study 2, however, there was no main effect of ginger on these judgments, $b = .03$, $t(495) = .39$, $p = .70$; $M_{ginger} = 5.87$ ($SD = 1.73$); $M_{sugar} = 5.82$ ($SD = 1.75$), independent sample $t(495) = .32$, $d = -.03$, 95% CI $[-.14, .20]$, $p = .75$.

However, we did find a marginally significant interaction between experimental condition and bodily sensation awareness predicting judgments of moderate violations, $b = -.18$, $t(495) = -1.86$, $p = .063$; this interaction remained similar controlling for the time since participants last ate, $b = -.24$, $t(495) = -1.90$, $p = .059$. Breaking this down by condition revealed

that ginger significantly disrupted the link between people's bodily sensation awareness and their moral judgments: whereas awareness of bodily sensations strongly positively predicted how morally wrong participants in the sugar condition judged the moderate infractions to be, $b = .46$, $p = .0006$, for participants who ingested ginger the relation between bodily sensation awareness and moral judgment severity was dissipated, $b = .09$, $p = .53$ (see Figure 1). This difference suggests that by inhibiting nausea—the physiological component underlying feelings of disgust—ginger may have negated the difference that normally exists between individuals who tend to be more versus less aware of those feelings. Among participants in the placebo condition, those more attuned to their bodily sensations appeared to use those sensations to judge the moderately severe infractions more harshly. In contrast, for participants who had ingested ginger, individual differences in this dispositional variable no longer predicted judgment severity. This result is consistent with the suggestion that ginger inhibits feelings of nausea typically experienced in response to moral infractions, making these feelings unavailable to those who might otherwise be particularly likely to rely on them for moral thinking. However, given that this interaction did not emerge in Study 2 and was not pre-registered, these conclusions should be viewed with caution.

Turning to the highly severe violations, replicating Study 2, a main effect of bodily sensation awareness emerged, such that those higher in awareness of their bodily sensations judged highly severe violations as more wrong, $b = .28$, $t(495) = 3.35$, $p = .001$. Also consistent with Study 2, neither an interaction between bodily sensation awareness and experimental condition, $b = .009$, $t(495) = .10$, $p = .92$, nor a main effect of condition, $b = .09$, $t(495) = 1.36$, $p = .17$, emerged; $M_{\text{ginger}} = 7.19$ ($SD = 1.39$); $M_{\text{sugar}} = 7.03$ ($SD = 1.55$), independent sample $t(495) = 1.27$, $d = -.11$, 95% CI $[-.06, .29]$, $p = .20$. Importantly, there was no main effect of condition

on participants' ratings of their trait bodily sensation awareness, $M_{\text{ginger}} = 4.33$ ($SD = .74$); $M_{\text{sugar}} = 4.35$ ($SD = .83$), independent sample $t(496) = .40$, $p = .69$.

Testing for demand effects. Although demand characteristics are a less likely explanation for the observed interaction effect than for the main effect observed in Studies 1 and 2, we nonetheless again examined whether participants' awareness of having ingested ginger might have influenced results. In total, 114 participants (46% of those in the ginger condition) correctly, and 37 incorrectly (15% of those in the sugar condition), guessed that they had ingested ginger. By contrast, 55 participants (22%) guessed correctly, and 27 (11%) guessed incorrectly, guessed that they had ingested sugar. The remainder of participants reported not knowing which condition they were in. We re-ran the main interaction analysis on moderately severe stimuli separately for each of the three subsamples created in Studies 1 and 2: (1) excluding those who correctly guessed that they had ingested ginger, (2) excluding those who correctly guessed that they had ingested ginger and those who believed they had ingested ginger but were incorrect, and (3) excluding all participants who correctly guessed which condition they were in. Once again, the observed effect held for all three subsamples; for Subsample 1, $b = -.24$, $p = .04$; for Subsample 2, $b = -.25$, $p = .036$; and for Subsample 3, $b = -.25$, $p = .046$.

Study 4

Although both of the significant effects that emerged in Studies 2 and 3 are consistent with the theoretical logic guiding this work, the specific nature of the two study's effects is inconsistent, and only one (that emerging in Study 2) directly supports our preregistered predictions. We therefore designed Study 4 to, in part, be a direct replication of Study 3, with the aim of probing the robustness of both effects. We also wrote a new preregistration document for

this study, in which we made clear that our theoretical expectations would support either a main effect of ginger on responses to moderately severe purity violations *or* an interaction between the ginger experimental condition and bodily sensation awareness predicting these responses.

Importantly, in both cases we laid out the specific direction of effects that were expected, and that made clear that our expectations pertained to moderately severe purity violations only (see <https://osf.io/43tuw/>).

In addition to directly replicating the methods of Study 3, in Study 4 we also sought to examine whether physiological disgust influences judgments of moral infractions beyond purity. More specifically, we examined the impact of ginger on moral infractions in each of the five domains that, according to Moral Foundations Theory, are the “irreducible basic elements...that represent the breadth of the moral domain” (Graham, et al., 2013, p. 56); namely, harm/care, fairness, loyalty, authority, and purity.

As noted previously, there is good reason to suspect that literal, physiological disgust would be most relevant to moral judgments based on the purity foundation (Cannon et al., 2011; Graham et al., 2013; Horberg et al., 2009; Landmann & Hess, 2017; Rozin et al., 1999; Russell & Giner-Sorolla, 2013; Wagenmans et al., 2018). However, there is also reason to expect that disgust might be associated with moral judgments relevant to the loyalty and authority foundations. Loyalty, authority, and purity are, together, considered “binding foundations,” in that they are thought to help bind individuals together into cohesive groups by moralizing in-group favoritism (i.e., loyalty), the maintenance of societal traditions and order (i.e., authority), and the exclusion of individuals or groups who threaten the physical or spiritual well-being of the ingroup (i.e., purity; Graham & Haidt, 2010; Haidt, 2008). These three foundations are

contrasted with the “individualizing foundations” of harm/care and fairness, which emphasize the importance and protection of individuals and their rights.

Supporting the theoretical link between disgust and the binding foundations, studies have found that individuals high in dispositional disgust-sensitivity show stronger ingroup favoritism (Navarrete & Fessler, 2006) and greater endorsement of the binding foundations more generally (Garvey & Ford, 2014; van Leeuwen, Dukes, Tybur, & Park, 2017; Wagemans et al., 2018). We therefore thought it possible that moral thinking in all three domains is partly shaped by physiological disgust, and thus affected by our ginger manipulation. We laid out this exploratory hypothesis in our preregistration document, along with the alternative exploratory hypothesis that ginger would affect judgments relevant to the purity domain only (see <https://osf.io/43tuw/>). In both cases, we made clear that we expected to observe effects of ginger only on moderately severe violations, in any domain, consistent with the results of Studies 1-3.

A third possibility is that physiological disgust is not related to any specific moral foundation but rather shapes moral thinking uniformly across domains (Cameron, Lindquist, & Gray, 2015; Schein, Ritter, & Gray, 2016). Indeed, several studies found that manipulations of incidental disgust and dispositional disgust sensitivity were associated with harsher moral judgments across domains (Jones & Fitness, 2008; Karinen & Chapman, in press; Schnall et al., 2008; Wheatley & Haidt, 2005). Convergent studies have found that people regularly express disgust in response to moral violations outside the purity domain (Cannon et al., 2011; Chapman, Kim, Susskind, & Anderson, 2009; Chapman & Anderson, 2013; 2014; Giner-Sorolla & Chapman, 2016; Hutcherson & Gross, 2011), and one widely used measure of disgust sensitivity directly posits a form of moral disgust based on feelings occurring in response to fairness

violations (Tybur, Lieberman, & Griskevicius, 2009). It therefore seemed plausible that, counter to our exploratory hypotheses, ginger might reduce judgment severity of moral violations across all five foundations (but see SOM7); Study 4's design allowed us to address this question, as well.

Method

Participants and procedure. Five-hundred and twelve undergraduate and graduate students participated in exchange for course credit or payment (in contrast to our prior studies, some participants in this study were recruited through paid human-subjects pools in a Psychology Department and a Business School; as a result, this study obtained a slightly older sample compared to our prior studies; see Table S3). Five participants were excluded due to procedural errors, and three participants were excluded for correctly guessing the goal of the study (i.e., to examine the effect of ginger on moral thinking), for a final sample of 504 (71% women, $M_{age} = 22$, $SD = 6.77$).⁶ Sample size was determined based on the goal of replicating the size of the sample included in Study 3, which would allow for 75% power to detect a small two-way interaction between ginger and bodily sensation awareness.

Participants followed a procedure almost identical to that of Study 3, with several exceptions. The first difference from Study 3 is that we took a new methodological precaution to reduce error variance. After filling capsules with ginger (in all studies, we bought ginger powder in bulk and filled capsules ourselves), the third author weighed each pill by hand, to ensure that

⁶ The key main effect observed in this study held when no exclusions were made, $F(1, 510) = 5.76$, $p = .02$.

every participant in the ginger condition ingested as close to 1.5 grams as possible.⁷ Second, in addition to reporting when they had last eaten a meal, participants also estimated how frequently they eat ginger, on a scale ranging from 1 (“Never or very rarely”) to 3 (“A couple times a week”) to 5 (“Several times a week”). This new item was included to ensure that results were not affected by variation in frequency of ginger ingestion; our thinking was that participants who more regularly eat ginger might be more immune to its psychological effects. Third, whereas in Studies 2 and 3 we had included two highly severe purity vignettes referring to cousin incest, in Study 4 we modified these two vignettes to avoid including two vignettes about incest. We opted to instead include only one incest vignette, this time about sibling incest to ensure a high level of severity, and an additional vignette about a teenager urinating in a public pool (see Materials and Appendix A for details).

Fourth, after providing responses to the eight purity violating vignettes (presented in a randomized order), participants judged the moral wrongness of 24 other moral vignettes, six for each of the four moral domains other than purity. In each group of six, three of the vignettes were pre-tested to be highly severe and three to be moderately severe (see Materials; Appendix A; also our preregistration document, <https://osf.io/43tuw/>). These 24 vignettes were intermixed and presented in a randomized order. After completing all moral judgments, participants completed the measure of bodily sensation awareness used in prior studies.

⁷ Prior to conducting Study 4, we conducted an attempted version of that study, using un-weighed pills filled by a research assistant, and realized only later that all ginger capsules had been drastically underfilled (i.e., such that each experimental-condition participant ingested approximately .9g of ginger total, rather than the intended 1.5g; see <https://osf.io/43tuw/>), requiring us to view those data as corrupted. In Studies 1-3 the second author filled all capsules and weighed randomly selected samples to ensure weights close to .5g each.

Materials. Prior to data collection we pre-tested sets of vignettes describing harm/care, fairness, loyalty, authority, and purity moral infractions. These vignettes were taken either directly from past research (i.e., Clifford, Iyengar, Cabeza, Sinnott-Armstrong, 2015; Schnall et al., 2008), amended slightly from past research (i.e., Rozin et al., 1999), or constructed anew in their entirety for the present research. To assess the severity of these 32 vignettes, we: (a) used existing severity ratings provided by the researchers who developed the items (i.e., personal communication; Clifford et al., 2015; items 1, 11, 12, 13, 14, 16, 18, 19, 24, 28, 29, and 30 in Appendix A), (b) used ratings made by participants in the placebo condition in Studies 2 and 3 (items 3, 4, 5, 6, 7, and 8 in Appendix A), (c) used ratings made by participants in the placebo condition of a previous version of this study (see Footnote 7; items 2, 9, 10, 15, 17, 20, 21, 22, 25, 26, 31, and 32 in Appendix A), or (d) for the two newly constructed items (items 23 and 27 in Appendix A), obtained ratings from 23 undergraduate research assistants and graduate students who read and rated how wrong each item was on a 9-point Likert-scale ranging from 1 (*Perfectly OK*) to 9 (*Extremely Wrong*; ICC = .81).

Based on these ratings we selected sets of items that, together, had average severity ratings close to or above 8.5 for the highly severe items and close to or below 6.5 for moderately severe items (out of 10.0), based on mean ratings of the two sets of purity items observed in the prior studies; mean ratings by category were: for purity items, $M_{High} = 8.48$ ($SD = .25$) and $M_{Moderate} = 6.60$ ($SD = .64$); for care/harm items, $M_{High} = 9.02$ ($SD = .20$); $M_{Moderate} = 6.53$ ($SD = .23$); for fairness, $M_{High} = 8.99$ ($SD = .23$); $M_{Moderate} = 6.60$ ($SD = .53$); for loyalty, $M_{High} = 8.91$ ($SD = .80$); $M_{Moderate} = 6.36$ ($SD = .91$); for authority, $M_{High} = 8.33$ ($SD = .64$); $M_{Moderate} = 6.59$ ($SD = .56$). All items are listed in Appendix A; see <https://osf.io/43tuw/> for pre-registered predictions for all sets of items.

We again planned to separately analyze responses to highly and moderately severe violations, and pre-registered our prediction that ginger would be most effective for reducing the perceived moral wrongness of moderately severe purity infractions specifically, either as a main effect or in interaction with bodily sensation awareness (see <https://osf.io/43tuw/>). We also pre-registered a secondary set of exploratory hypotheses, addressing the role of ginger in other domains of moral thinking, as described above.

Results

Main analyses. Confirming pre-testing, participants judged the highly severe moral violations to be significantly more wrong than the moderately severe violations, in each of the five domains examined: for purity, $M_{\text{high}} = 7.25$, $SD = 1.42$; $M_{\text{moderate}} = 5.64$, $SD = 1.83$; paired-sample $t(503) = 24.52$; for harm/care, $M_{\text{high}} = 7.99$, $SD = 1.04$; $M_{\text{moderate}} = 5.83$, $SD = 1.60$; paired-sample $t(503) = 33.32$; for fairness, $M_{\text{high}} = 7.78$, $SD = 1.26$; $M_{\text{moderate}} = 5.75$, $SD = 1.56$; paired-sample $t(503) = 34.39$; for loyalty, $M_{\text{high}} = 7.78$, $SD = 1.15$; $M_{\text{moderate}} = 5.39$, $SD = 1.43$; paired-sample $t(503) = 35.80$; and for authority, $M_{\text{high}} = 7.10$, $SD = 1.38$; $M_{\text{moderate}} = 6.25$, $SD = 1.37$; paired-sample $t(503) = 15.56$; all $ps < .001$.

In addition, consistent with Studies 1-3, a main effect of bodily sensation awareness emerged on judgments of moderately severe purity violations, such that participants higher in bodily sensation awareness perceived these transgressions to be more wrong, $b = .34$, $t(503) = 3.58$, $p < .001$. For highly severe purity violations, there was also a main effect of bodily sensation awareness, with participants higher in this trait also judging these violations as more wrong, $b = .24$, $t(503) = 3.27$, $p = .001$. For the other four domains of moral thinking, very similar effects emerged, with bodily sensation awareness leading to increased wrongness

judgments across both severity levels of all five moral domains; $b = .26$, $t(503) = 4.93$, $p < .001$, for Harm_{severe}; $b = .32$, $t(503) = 3.82$, $p < .001$, for Harm_{moderate}; $b = .26$, $t(503) = 3.94$, $p < .001$, for Fairness_{severe}; $b = .38$, $t(503) = 4.79$, $p < .001$, for Fairness_{moderate}; $b = .25$, $t(503) = 4.27$, $p < .001$, for Loyalty_{severe}; $b = .16$, $t(503) = 2.20$, $p = .03$, for Loyalty_{moderate}; $b = .30$, $t(503) = 4.22$, $p < .001$, for Authority_{severe}; and $b = .27$, $t(503) = 3.79$, $p < .001$, for Authority_{moderate}. These results are consistent with the suggestion that judgments of moral wrongness for all five domains stem, in part, from subtle bodily symptoms that are more perceptible to some individuals than others. However, given that this conclusion is based on correlational data, it is also possible that a third factor variable—for example, trait sensitivity—contributes to both heightened bodily sensation awareness and increased judgment severity across moral domains, and is the cause of the observed associations. Importantly, although bodily sensation awareness was measured toward the end of the experiment, mean levels of this trait did not vary as a function of condition, $M_{\text{ginger}} = 4.18$ ($SD = .86$); $M_{\text{sugar}} = 4.13$ ($SD = .84$), independent sample $t(502) = .65$, $p = .52$.

Turning to our experimental manipulation, consistent with pre-registered hypotheses, ginger reduced the severity of participants' judgments of moderately severe purity violations, $M_{\text{ginger}} = 5.44$ ($SD = 1.82$) vs. $M_{\text{sugar}} = 5.83$ ($SD = 1.83$), independent sample $t(502) = 2.40$, $d = .21$, 95% CI [.07, .71], $p = .02$. In contrast, as was the case in Studies 1, 2, and 3, ginger did not have a significant effect on judgments of highly severe purity violations, $M_{\text{ginger}} = 7.13$ ($SD = 1.51$); $M_{\text{sugar}} = 7.36$ ($SD = 1.30$), independent sample $t(502) = 1.80$, $d = .16$, 95% CI [-.02, .47] $p = .07$, although in this case the effect was marginally significant (and in the predicted direction), and there was a significant main effect of ginger collapsing across purity violation severity, $t(502) = 2.38$, $p = .02$. In addition, as in the prior studies, the effect of ginger on judgments of moderately severe purity violations held controlling for time since participants last ate, $F(1, 501)$

= 5.65, $p = .02$. This result also held controlling for how frequently participants reported eating ginger, $F(1, 501) = 5.60, p = .02$, and ginger ingestion frequency did not significantly moderate the result, either when treated as a continuous variable, $b = .01, p = .55$, or as a dichotomous split between those who eat ginger more and less frequently (i.e., 1-2 vs. 3-5 on the rating scale), $F(1, 500) = .84, p = .36$.⁸

In contrast to the main effect that emerged on responses to moderately severe purity violations, no significant effects of ginger emerged on responses to moderately or highly severe violations in any other moral domain; $t_s(502) = .02 - 1.67, p_s = .10 - .84$; see Table S1 for all means and results of t -tests for each domain. To test whether the effect of ginger on responses to moderate purity violations differed from its effect on responses to all other violations, we conducted a 2 (moderate purity violations vs. moderate other violations) x 2 (ginger vs. sugar) mixed-design ANOVA on the severity of participants' judgments, and found the predicted interaction, $F(1, 502) = 4.14, p = .04$, indicating that the effect of ginger varied depending on the moral domain of the violation examined. To test whether this difference could be attributed, in part, to a broader distinction between the binding and individuating moral foundations, we next conducted a similar analysis, but defining the within-subjects factor as responses to moderate purity, loyalty, and authority violations (i.e., binding foundations) versus responses to moderate harm/care and fairness violations (i.e., individuating foundations). No interaction emerged, $F(1, 502) = .16, p = .69$, further confirming the results of the t -tests examining effects of ginger within

⁸ The analysis using the dichotomized variable was an exploratory test of whether, even though the continuous frequency variable did not moderate results, there might nonetheless be a difference between people who eat ginger fairly regularly ($n = 369$) and those who only rarely or never eat ginger ($n = 135$).

each moral foundation separately, and suggesting that ginger influences moral thinking for moderate purity violations only.

We next tested whether ginger moderated the relationship between bodily sensation awareness and moral judgment severity, as was found in Study 3. For both moderately and highly severe purity violations, no interaction emerged, $b = -.16$, $p = .34$, for moderate violations; $b = .08$, $p = .50$, for highly severe violations. There was also no interaction between bodily sensation awareness and judgment severity for any other moral domain, for either moderately or highly severe violations, $bs = -.16 - .11$, $ps = .08- .86$; see Table S2 for full results for each domain.

Testing for demand effects. As in the prior studies, we next examined whether participants in the ginger condition were aware of being in that condition. One-hundred, thirty-four participants (53% of those in the ginger condition) guessed correctly, and 70 incorrectly (28% of those in the sugar condition), that they had ingested ginger. By contrast, 45 participants (18%) guessed correctly, and 29 (12%) incorrectly, that they had ingested sugar. The remainder of participants in both conditions reported not knowing which condition they were in. We next re-ran the main analysis, testing for an effect of ginger on moderately severe stimuli, for three separate subsamples of participants: (1) excluding those who correctly guessed that they had ingested ginger, (2) excluding those who correctly guessed that they had ingested ginger *and* those who believed they had ingested ginger but were incorrect, and (3) excluding all participants who correctly guessed which condition they were in. In contrast to the results of the prior studies, the effect of ginger on judgments of moderate stimuli did not remain statistically significant when examining each of these subsamples, probably because a greater proportion of

participants correctly guessed that they were in the ginger condition and therefore had to be excluded for these subsidiary analyses, reducing statistical power. Nonetheless, all effects were in the expected direction; for Subsample 1, $M_{\text{ginger}} = 5.60$ ($SD = 1.81$) vs. $M_{\text{sugar}} = 5.83$ ($SD = 1.83$), independent sample $t(368) = 1.32$, $d = .13$, $p = .26$; for Subsample 2, $M_{\text{ginger}} = 5.60$ ($SD = 1.81$) vs. $M_{\text{sugar}} = 5.70$ ($SD = 1.76$), independent sample $t(298) = .49$, $d = .06$, $p = .63$; and for Subsample 3, $M_{\text{ginger}} = 5.60$ ($SD = 1.81$) vs. $M_{\text{sugar}} = 5.89$ ($SD = 1.86$), independent sample $t(323) = 1.34$, $d = .16$, $p = .18$.

Although these results do not rule out the possibility of demand concerns contributing to observed effects, that suggestion is countered by our failure to find evidence for demand effects in any of the three prior studies, and the fact that only 12 participants (2% of the full sample) in Study 4 had any idea that ginger has an impact on stomach functioning or nausea (all participants were queried about ginger's effects and responded in an open-ended fashion). Furthermore, the main effect of ginger on responses to moderately severe purity violations held when excluding those few people, $t(490) = 2.22$, $p = .03$. It is also noteworthy that although these ancillary analyses of targeted subsamples may be informative, they were not included in our preregistered analysis plan for this study, so it may be appropriate to view their results with less confidence than our primary pre-registered analyses. Nonetheless, we subsequently conducted internal meta-analyses across all four studies (see below), and further addressed this issue by meta-analyzing the data separately for each of the three subsamples.

Summary of Results. Together, the results of Study 4 provide confirmatory support for the finding from the prior three studies—and especially Studies 1 and 2—that, by inhibiting physiological nausea, ginger reduces the severity of judgments about moderately severe purity

violations. In contrast, ginger appears to have no effect on judgments about moderately (or highly) severe violations in the moral domains of harm/care, fairness, loyalty, or authority. These results therefore imply that the perceived moral wrongness of purity-based violations is at least partly attributable to the physiological sensations of nausea that individuals experience in response to them, whereas the perceived wrongness of other kinds of moral infractions may not be based on this physiological experience. In other words, when people say they find a moral infraction reprehensible because it disgusts them, they likely mean that literally—but only if the infraction violates their sense of purity.

Internal Meta-Analyses

It is noteworthy that the pattern of effects observed in Study 3 is different from that observed in Studies 1, 2, and 4. We believe that the results of Study 3 provide tentative additional support for the conclusion from Studies 2 and 4 that physiological feelings of nausea are causally related to moral judgments of moderately (but not highly) severe purity violations, by demonstrating that biologically interfering with these feelings reduces perceptions of moral wrongness. In Studies 2 and 4, this finding emerged as a main effect that was predicted in a preregistered document, whereas in Study 3 it emerged as an interaction that supported an exploratory prediction only. This interaction, between the ginger interference manipulation and participants' varying levels of bodily sensation awareness, may suggest that ginger disrupted the link between people's awareness of their bodily sensations and their moral evaluations, such that they became less able to use physiologically based affective information to inform their moral judgments when that information was inhibited. However, it is also possible that Study 3 instead

represents a failure to find the predicted main effect, and the observed interaction a false positive.

Given this inconsistency across studies, we conducted an internal meta-analysis across all four studies to examine the robustness of the overall main effect of ginger on responses to moderately severe disgust-eliciting stimuli. Although the dependent variable across the four studies was superficially different – in Study 1 we assessed feelings of disgust toward purity-offending images (i.e., core disgust elicitors) whereas in Studies 2, 3, and 4 we assessed judgments of moral wrongness regarding purity violating vignettes—it nonetheless may be informative to examine these results together meta-analytically, to determine the overall impact of ginger on responses to moderately severe violations (below, we also examine results meta-analytically excluding Study 1; see also Table 1). Prior studies have used a similar approach to examine the impact of widely researched independent variables (e.g., religious primes) on a range of distinct dependent variables (e.g., different forms of pro-social behaviors, along with numerous other outcome measures; Shariff, Willard, Andersen, & Norenzayan, 2016). Given that all four of the present studies aimed to uncover an effect of pharmacologically inhibiting the physiological substrate of disgust on consequent disgust feelings and corresponding moral judgments, we thought this approach might be similarly useful here.

To that end, we calculated a meta-analytic effect using inverse-variance weighted *ds* (Johnson & Eagly, 2000). To be clear, this meta-analysis includes *all* data we have collected addressing the question of how the ingestion of ginger influences responses to moderately severe purity infractions, of a moral or non-moral nature (For the sake of comparison, Table 1 presents meta-analytic results for responses to both moderately and highly severe purity infractions). This

analysis indicated an overall small but significant effect of ginger on responses to moderately severe purity violations, $d = .14$, $p = .005$, 95% CI [.04, .24]. This result suggests that, across the four studies, ginger had a small but robust impact on feelings of disgust and corresponding moral judgments. We next conducted a similar meta-analysis excluding Study 1; in other words, examining the main effect of ginger on responses to moderately severe purity violations of a moral nature only, rather than across purity violations of a moral and non-moral nature. This analysis indicated a very similar small but significant effect, $d = .12$, $p = .005$, 95% CI [.01, .23]. This result confirms that the overall significant effect that emerged across the four studies was not unduly driven by Study 1, in which we examined responses to purity-violating images rather than moral infractions.

Next, we conducted similar meta-analyses for each of the subsamples we created in each study to address the possibility of demand effects. In other words, we meta-analyzed the main effect of ingesting ginger on responses to moderately severe purity violations across Studies 1, 2, 3, and 4: (a) excluding participants who correctly guessed that they were in the ginger condition (Subsample 1); (b) excluding participants who correctly and incorrectly guessed that they were in the ginger condition (Subsample 2); and (c) excluding participants who correctly guessed that they were in the ginger or the sugar condition (Subsample 3). We then performed the same analyses across just Studies 2, 3, and 4 (i.e., only those studies examining responses to moral transgressions). Interestingly, in all cases meta-analytic d s were larger than those observed when including all participants. Specifically, when examining all four studies, $d = .20$, $p < .001$, 95% CI [.08, .32] for Subsample 1; $d = .20$, $p = .002$, 95% CI [.08, .32] for Subsample 2; and $d = .20$, $p = .002$, 95% CI [.08, .32] for Subsample 3. When examining only Studies 2, 3, and 4, $d = .17$, $p = .01$, 95% CI [.04, .30] for Subsample 1; $d = .16$, $p = .02$, 95% CI [.03, .30] for Subsample 2;

and $d = .16$, $p = .02$, 95% CI [.03, .30] for Subsample 3. These results suggest that the significant effects that emerged in this research are unlikely to be due to demand characteristics of the studies' design. Together, findings from these meta-analyses allow for greater confidence in the overall main effect of ginger on moral judgments of moderately severe infractions in the purity domain, despite the failure to find this specific effect in Study 3 (it may be noteworthy, in this vein, that in all three subsamples examined in Study 3 effects were in the predicted direction, though not statistically significant; see Table 1).

In addition, although Study 3 was designed to be a direct replication of Study 2, we subsequently tested whether any differences between the samples included in the two studies might account for the observed inconsistency in the specific pattern of results. As is shown in Table S3, the samples did not differ significantly in gender, age, mean bodily sensation awareness, or time since their last meal (which could affect the rate of ginger digestion). Comparing the samples included in Studies 3 and 4, we did find several small but significant differences, in age (Sample 4 was slightly older), mean bodily sensation awareness (Sample 4 scored slightly lower), and time since last meal (Sample 4 had last eaten about an hour earlier than Sample 3). The former two differences seem unlikely to be the cause of the different observed experimental effects, given that it is unclear how a 2-year age difference would matter for these results, and we might expect to see weaker—not stronger—effects of ginger in the sample with lower average BSA. However, the third difference between samples – in the time since participants' last meal – could be relevant; it is possible that experimental-condition participants in Study 4 more quickly metabolized the ginger they ingested, leading to stronger effects. Although this was clearly not the case for participants in Study 2, who had last eaten

most recently of all three samples, time of last meal is a potential moderator to closely consider in future research.⁹

Overall, given the general consistency among the three samples, and particularly Samples 2 and 3, the inconsistent results across studies may indicate that feelings of disgust at times affect moral judgments in a broad way that generalizes across individuals, and at other times most notably for individuals who are particularly attuned to their bodily sensations. Nonetheless, this is an important open question for future research; we hope that others who build on this research continue to measure BSA and test for interactions between this individual difference variable and experimental manipulations expected to affect disgust.

General Discussion

This research represents the first attempt to pharmacologically inhibit the primary physiological component of disgust (nausea) and measure downstream consequences on feelings of disgust and moral judgments. It also provides the first experimental evidence that feelings of disgust which spontaneously occur in response to both moral and non-moral purity violations are rooted in physiological nausea, and are causally related to judgments of those violations. These findings therefore make several novel contributions to our understanding of disgust and its role in moral thinking.

First, they suggest that psychological feelings of disgust are at least partly caused by physiological nausea. Prior research has shown that nausea and disgust are both associated with neurological responses in the insula (Napadow et al., 2013; Wicker et al., 2003), a brain region

⁹ Follow-up comparisons found no significant differences by experimental condition in time since participants last ate, for Studies 2, 3, or 4.

activated by unpleasant tastes and odors (Small et al., 1999; Wicker et al., 2003). However, the insula is also associated with anger (Damasio et al., 2000), anxiety (Critchley et al., 2004), and somatosensory awareness (Critchley et al., 2004), limiting firm conclusions about the precise relationship between physiological and psychological disgust on the basis of these findings (see also Chapman et al., 2009). The current Study 1, in contrast, is the first to demonstrate that nausea is causally connected to psychological disgust feelings and not to other negative emotions—and, in doing so, to validate existing self-report measures of disgust. At least when used to assess responses to core disgust elicitors, these measures appear to tap into a physiological response.

Indeed, although prior studies found an association between gastric precursors to nausea and self-reported feelings of disgust in response to non-moral purity violating stimuli (i.e., core disgust elicitors like dirty toilets; Harrison et al., 2010; Shenhav & Mendes, 2014), these studies did not test whether nausea was the cause of reported disgust feelings. By inhibiting nausea via ginger, and observing consequent reductions in reported disgust to core elicitors, the present Study 1 demonstrates that physiological nausea causes psychological disgust, and that psychological disgust is therefore not merely the cognitive perception of a stimulus as potentially nausea-inducing. This result provides new support for somatic theories of affect suggesting that emotions are, in part, subjective feelings of our physiological symptoms (Damasio, 1994). Disgust feelings in response to core elicitors are, it seems, at least partly emergent from the physiological sensation of nausea.

Second, these findings are the first to show that biologically interfering with spontaneously occurring nausea in response to moral infractions in the purity domain reduces the

severity of judgments about those infractions, providing the first evidence that integral disgust—that is, disgust regarding a particular moral violation, as opposed to incidental disgust resulting from an unrelated stimulus—influences judgments of that violation. These results therefore provide an intriguing answer to the oft-raised question about whether the disgust reported in response to moral infractions is a psychological manifestation of an actual physiological experience (i.e., nausea), or is more likely to be a useful metaphor; a way of conveying one's extreme disapproval or other negative emotions regarding the violation (Gutierrez, Giner-Sorolla & Vasiljevic, 2012; Nabi, 2002). For purity-based moral violations, at least, it seems that the disgust is *real*, in the sense of emerging from physiological nausea, because interfering with that nausea reduces the reported disgust. Furthermore, the present results also suggest, for the first time, that this same physiological experience is part of what makes people judge those violations as immoral. Apparently, when we witness a purity-based moral infraction of some ambiguity (i.e., a moderately severe violation), we feel nauseous, and this feeling tells us that what we are seeing is wrong.

Interestingly, though, this conclusion appears to be restricted to violations of the purity moral foundation; in Study 4 we observed no effect of ginger on violations in the four other moral domains, nor any effect in interaction with bodily sensation awareness. Furthermore, an interaction between experimental condition and moral foundation demonstrated that the effect of ginger on moral thinking differs for purity compared to other foundations. What this difference suggests is that, for violations related to the other moral domains, reported disgust may not refer to the same physiological nausea experience as it does for purity violations. Instead, when people say they are disgusted by the infliction of harm to others, unfair treatment of different people or groups, demonstrations of disloyalty, or disrespect for an authority figure, they may be using that

word metaphorically; based on the present results, these kinds of violations do not elicit actual disgust feelings. This conclusion is consistent with prior studies showing that for violations outside the purity domain, reports of disgust tend to be highly correlated with reports of anger—suggesting that in these contexts reported disgust may reflect a more general outrage and condemnation (Guitierrez et al., 2012; Russell & Giner-Sorolla, 2013). In contrast, in these same studies purity violations reliably elicited reported disgust that was independent of reported anger. The present results are also consistent with the prior finding that disgust sensitivity is more strongly associated with purity violations than with violations in other domains (Wagemans et al., 2018). However, given that in the present research this difference was directly documented in only one study (but see also SOM7), future work is needed to replicate this distinction among the various domains of moral thinking.

The present findings also raise other important questions for future research. Most notably, the precise pattern of results in Study 3 was inconsistent with that of the other three studies; although we observed main effects of ginger in Studies 1, 2, and 4, in Study 3 we instead found an interaction between ginger and bodily sensation awareness. Although we cannot provide any definitive explanation for this pattern, it aligns with an inconsistency present in the prior literature on incidental disgust and moral judgments. This literature reports similarly mixed results, sometimes observing a main effect (e.g., Horberg et al., 2009) and other times no main effect but an interaction between bodily sensation awareness and disgust on judgments (e.g., Schnall et al., 2008; but see Johnson et al., 2016). In fact, in one of the first sets of studies documenting an effect of incidentally induced disgust on moral judgments, Schnall and colleagues (2008) found a main effect of their manipulation in Study 1, but no main effect—and instead an interaction with bodily sensation awareness—in Studies 2, 3, and 4. Furthermore,

other research on incidental disgust and moral evaluations has documented additional moderators, such as emotional differentiation (Cameron, Payne, & Doris, 2013) and mindfulness (Sato & Sugiura, 2014). Other factors like current mood, and—in the present case—individual differences in the digestive system—are also likely to influence results.

In other words, as was observed in the present research, the prior literature linking (incidental) disgust with moral judgments has sometimes indicated that (incidental) disgust directly influences moral judgments, and other times that the influence of disgust is conditional on bodily sensation awareness. Given these discrepancies, we strongly believe that future studies are needed to seek the boundary conditions of these effects (see also Schnall et al., 2015). Nonetheless, in light of this prior research, the broader theory underlying our work would suggest that we should expect to observe either a main effect of ginger or an interaction between ginger and bodily sensation awareness. Given that all four of our studies examining moderately severe purity violations each supported one of these two specific predictions, and we are fully reporting all data we have collected on this issue, it seems unlikely that this pattern of results could be explained as a series of Type 1 errors. Our interpretation is, instead, that there is a meaningful effect relating real, stimulus-driven disgust to moral judgments—but future work is needed to determine the robustness of this effect, especially as it emerges in interaction with BSA.

More broadly, we view the present research as fitting well within a “theory-driven cumulative science” (Fiedler, 2017). According to this perspective, psychological science should not be restricted to conducting studies that are either highly novel but therefore based on few priors (in which case robust evidence for consistency of results is essential) or lack novelty but

have a strong prior evidentiary basis. Instead, we should emphasize innovative and diagnostic methods to test hypotheses that emerge from well-supported prior theories. According to Fiedler, these hypotheses “can be derived logically... What matters in theory-driven science is whether a pattern follows from the theory, which speaks for itself, independent of individual authors’ motives and beliefs” (2017, pp. 54, 55). In the present case, we used a novel methodological approach to test hypotheses that emerge from a clearly articulated and well-established theoretical account, and from a large body of prior empirical findings on incidental disgust and moral thinking. Nonetheless, future research on this issue is very much warranted; and this work will need, at the very least, to examine why, at times, effects emerge only in interaction with bodily sensation awareness while at other times this individual-difference variable is not relevant.

Future studies are also needed to uncover the specific biological mechanisms underlying ginger’s effects. Although considerable evidence suggests that ginger reduces nausea and the tendency to vomit, the precise way in which this works is unknown (Singh, Yoon, & Kuo, 2016). In the present research, we found no evidence for effects of ginger on any emotions other than disgust (see also Footnote 2; SOM1), supporting the suggestion that these results are specifically due to ginger’s influence on nausea and nausea-based disgust. The evidence for mediation of the effect by post-task disgust in Study 2 further supports this conclusion, as does the failure to find evidence for mediation by any other emotion assessed. Furthermore, ginger is used medicinally in place of other antiemetics such as dimenhydrinate both because other antiemetics can increase drowsiness whereas ginger’s side effects are minimal, and because ginger is more nausea-specific (Ernst & Pittler, 2000; Lien et al., 2003; Pongrojpraw, Somprasit, & Chanthasenanont, 2007). However, future research that examines moral thinking while employing the present

approach should seek ways of unobtrusively measuring disgust alongside moral judgments, to more directly test whether such feelings mediate the effects of ginger on judgments.

Another limitation of the present work, which should be addressed in future research, is that all four studies relied on samples drawn exclusively from the population of undergraduates at a large North American university. It is therefore possible that the present findings would not generalize to other cultural contexts. However, purity concerns tend to be a larger component of moral thinking and decision making in non-Western cultures than Western ones; our results might therefore be more robust in certain other populations, such as India (Graham et al., 2011). In fact, by conducting this research among highly liberal North American university students, we may have limited from the outset our likelihood of finding strong effects on purity-based moral judgments, given that liberals and Westerners tend to accord less weight to the purity moral domain (Graham, Haidt, & Nosek, 2009). However, it is also possible that the present effects would be weaker among individuals from cultures that regularly cook with ginger (e.g., East Asian populations) and might therefore be more accustomed to its antiemetic properties and less responsive to them. Finally, an additional limitation that should be addressed in future work is our inclusion of only 10 purity-violating vignettes (across studies). Valuable future work will examine whether these effects hold across a broader range of violations and moral dilemmas.

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Table 1. Summary of Main Effects of Experimental Condition on Responses to Purity Violations, Studies 1-4.

Data Included	Moderate severity			High severity	
	<i>d</i> (<i>SE</i>) Full sample	<i>d</i> (<i>SE</i>) Subsample 1	<i>d</i> (<i>SE</i>) Subsample 2	<i>d</i> (<i>SE</i>) Subsample 3	<i>d</i> (<i>SE</i>) Full sample
Study 1	0.26 (.13)*	0.39 (.15)**	0.38 (.16)*	0.38 (.16)*	0.13 (.13)
Study 2	0.23 (.11)*	0.36 (.13)**	0.33 (.14)*	0.35 (.14)*	-0.03 (.11)
Study 3	-0.03 (.09)	0.08 (.11)	0.15 (.11)	0.05 (.11)	-0.11 (.09)
Study 4	0.21 (.09)*	0.13 (.11)	0.06 (.12)	0.16 (.12)	0.16 (.09) ^t
Meta-analytic effect, Studies 1-4	0.14 (.05)**	0.20 (.06)***	0.20 (.06)**	0.20 (.06)**	0.03 (.05)
Meta-analytic effect, Studies 2-4	0.12 (.06)**	0.17 (.07)*	0.16 (.07)*	0.16 (.07)*	0.01 (.06)

Note. Moderate severity refers to responses to moderately severe purity violations. High severity refers to responses to highly severe purity infractions. Subsample 1 excludes participants in the ginger condition who correctly guessed that they were in that condition. Subsample 2 excludes participants who correctly or incorrectly guessed that they were in the ginger condition. Subsample 3 excludes participants who correctly guessed whichever condition they were in.

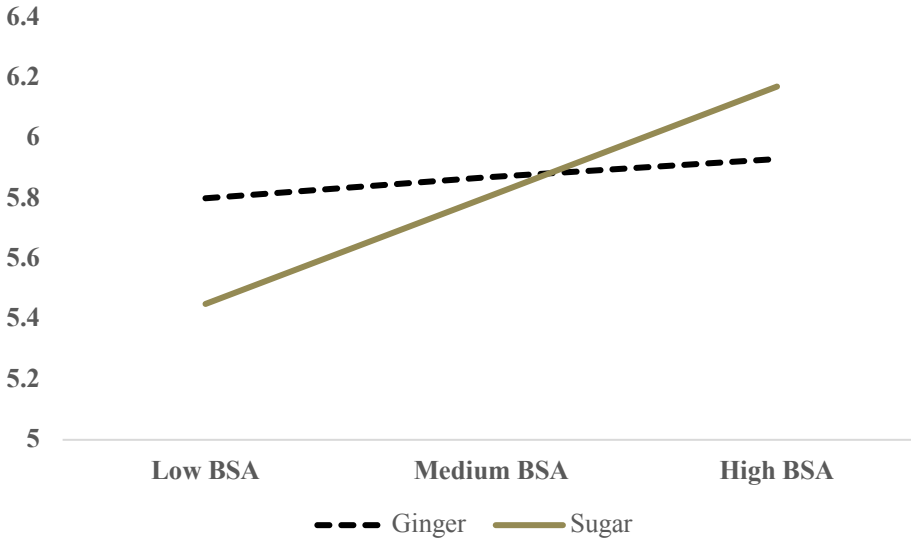
^t < .10

**p* < .05

***p* < .01

****p* < .001

Figure 1 – Interaction between Experimental Condition and Bodily Sensation Awareness
 Predicting Moral Judgments in Study 3.



Note. The Y-axis represents judgment severity of moderate purity-based moral infractions. The X-axis represents effects of bodily sensation awareness at -1 SD, Mean, and +1 SD. In the sugar condition, bodily sensation awareness positively predicted moral judgment severity ($b = .46$, $p = .0006$). In contrast, in the ginger condition this relationship was substantially reduced ($b = .09$, $p = .53$), suggesting that by inhibiting the physiological component underlying disgust (i.e., nausea), ginger disrupted the link between individuals’ awareness of their disgust feelings and the severity of their moral judgments.

Appendix A

Moral Transgression Vignettes Included in Study 4

Highly severe purity items:

1. A teenager urinates in the wave pool at a crowded amusement park. How wrong is this?
[newly added for Study 4]
2. How moral or immoral do you, personally, find protected (i.e., contraception is used) consensual sex between a brother and sister to be? [newly added for Study 4]
3. Frank's dog was killed by a car in front of his house. Frank had heard that in China people occasionally eat dog meat, and he was curious what it tasted like. So he cut up the body and cooked it and ate it for dinner. How wrong is it for Frank to eat his dead dog for dinner?
4. Matthew is playing with his new kitten late one night. He is wearing only his boxer shorts, and the kitten sometimes walks over his genitals. Eventually, this arouses him, and he begins to rub his bare genitals along the kitten's body. The kitten purrs, and seems to enjoy the contact. How wrong is it for Matthew to be rubbing himself against the kitten?

Moderately severe purity items (also used in Studies 2 and 3):

3. A man who is not in a romantic relationship orders an inflatable sex doll that looks like his secretary. How wrong is this?
4. A chemist has used special purifier materials to completely sanitize a person's feces. A man decides to eat a spoonful of the feces. How wrong is this?
5. A man decides to drink water out a toilet bowl that has never been used. How wrong is this?

6. When no one is looking, a morgue worker touches the open eye of a corpse. How wrong is this?

Highly severe harm/care items:

9. Will used to drink and drive a lot. One time he borrowed a friend's car, was drunk and had taken Valium. He sideswiped another car that had its door open. Will got scared and kept driving. How wrong is this?
10. Tanya despised another girl at her school. One day, in an unprovoked fit of rage, she walked up to the girl, slapped her hard on the face and pulled some of her hair out
11. Anthony chuckles at an amputee he passes by while on the subway.

Moderately severe harm/care items:

12. Everett makes fun of his brother Alan for getting dumped by his girlfriend.
13. Michelle snatches her dog's food away after it makes a mess in the living room.
14. Madison laughs at another student who forget her lines in a school play.

Highly severe fairness items:

15. Jeremy put a poster that he had on EBay. There was a man who bid on it and paid with a system that sent the money directly to Jeremy. Jeremy decided not to send the poster and just kept the money. How wrong is it for Jeremy to do this?
16. Shaun copies a classmate's answer sheet on a makeup final exam. How wrong is this?
17. Natasha planned out a perfect financial pyramid scheme and made hundreds of thousands of dollars at the expense of those she tricked into joining her 'business'. How wrong is Natasha's behavior in this situation?

Moderately severe fairness items:

18. Joe, a soccer player, pretends to be seriously fouled by an opposing player. How wrong is this?
this?
19. Zachary skips to the front of the line because his friend is an employee. How wrong is it for Zachary to do this?
20. Tiffany and her friend went to lunch. Although the service was great, Tiffany decided not to leave a tip. How wrong is this?

Highly severe loyalty items:

21. Sally and her mom were generally close, but one day they got into a heated argument. Soon after, Sally's mom died of natural causes. Sally decided not to attend her mom's funeral. How wrong is it for Sally not to attend her mom's funeral?
22. Rafael's wife told him that she is uncomfortable with him spending so much time with his ex-girlfriend – especially because she could use more help at home caring for their newborn son. Rafael sometimes lies and says he is doing something else, when really he continues to spend time with his ex-girlfriend. How wrong is it for Rafael to lie to his wife in this situation?
23. During a trip overseas, Tom, a member of the Canadian National Security Service, gave away top-secret information to a high-ranking foreign politician. How wrong is it for Tom to do this?

Moderately severe loyalty items:

24. An employee, Jonathon, jokes with competitors about how bad his company did last year. How wrong is it for Jonathon to do this?
25. Owen's brother committed a minor crime (shoplifting an item worth less than \$10). Without any prompting, Owen decided to call the police to tell them what his brother did,

which ultimately got his brother arrested. How wrong is it for Owen to turn his brother into the police in this situation?

26. Sarah was friends with Dave, whom her sister was dating. Sarah's sister didn't want Sarah to be friends with Dave because Sarah had dated him once. Sarah lied to her sister and told her that she wasn't friends with Dave even though she hung out with him regularly. How wrong is it for Sarah to lie to her sister in this situation?

Highly severe authority items:

27. Mark, a teenager, finds a police officer's car and slashes its tires. How wrong is this?
28. Megan spray paints graffiti across the steps of the local courthouse. How wrong is it for Megan to do this?
29. A group of women have a long and loud conversation during a church sermon. How wrong is this?

Moderately severe authority items:

30. Joshua repeatedly interrupts his teacher as she explains a new concept. How wrong is this?
31. A soldier directly disobeys his commanding officer's commands. How wrong is this?
32. Anna thinks her boss is incompetent so at work she tunes out and never listens to what he has to say nor follows his lead in the rare moments that she does pay attention. How wrong is it for Anna to act like this?