**Supplemental Online Material:** The Physiological Basis of Psychological Disgust and Moral Judgments

**SOM1. Additional study to test whether ginger reduces feelings of fear in response to fear-eliciting stimuli.** Although in Study 1 we tested for the effect of ginger on several different emotions and observed effects for disgust only, the stimuli themselves were expected to elicit disgust only, which prevented us from giving the other emotions measured (anger, sadness, happiness) a fair chance at being affected by the manipulation, because their degree of activation in response to the disgusting stimuli was relatively low. To better test for the alternative explanation that ginger is not disgust-specific, but rather acts more broadly on negative affect or high-arousal emotions, we conducted an additional study (briefly described in Footnote 2) in which we examined whether ginger reduces feelings of fear in response to fear-inducing stimuli. We chose to target fear as a comparison case because, like disgust, fear is a high-arousal withdrawal-oriented negative emotion that can be readily elicited in the lab (in contrast, the other regularly manipulated negative emotions – anger and sadness —are approach-oriented and low-arousal, respectively). The methods of this new study (final *N* = 271, comparable to Study 1’s *N* of 242), were nearly identical to Study 1 except that rather than rating disgusting stimuli, participants rated feelings of fear toward fear inducing stimuli (GIFs). Additionally, this study was conducted at the end of a larger separate study examining the effects of ginger, so prior to viewing fearful stimuli participants also responded to eight moral vignettes describing harm-based moral violations (e.g., committing theft, lying); this larger study is reported in detail in SOM7.

As in Study 1, prior to data collection we pre-tested a set of (fear-inducing) stimuli for their severity. Pre-testing occurred in two rounds. In the first round, fear-inducing photos (drawn from the internet) were found to elicit very low levels of fear among a small sample of undergraduate research assistants [*n* = 9; *M* fear rating across photos = 2.69, SD = 1.38, on a scale from 1 (*Not at all afraid*) to 4 (*Somewhat afraid*) 7 (*Very afraid*)]. Several researchers have suggested that stimulus movement is an important factor for the elicitation of fear (e.g., Courtney, Dawson, Schell, Iyer, & Parsons, 2010), so we next pre-tested a set of 26 fear-inducing GIFs (images with small amounts of movement) as potential stimuli; these were also drawn from internet searches. Five undergraduate research assistants viewed these 26 GIFs and rated their response to each on a 7-point Likert-scale ranging from 1 (*Not at all afraid*) to 4 (*Somewhat afraid*) to 7 (*Very afraid*). They were also asked whether the emotion of fear or some other emotion best captured their reaction to each image. Based on their ratings, three GIFs were selected for the highly frightening stimulus set (a shadowy figure in a hallway, a spooky face in the dark, a ghost who suddenly appears), and were found to be significantly more frightening than three other GIFs that were determined to be moderately frightening (a mannequin head with beaming eyes, a girl sleeping with a doll whose eyes are blinking, an “out of focus” boy standing over someone sleeping): *M*high = 5.20 (.99); *M*moderate = 3.40 (.43), paired-sample *t(*4) = 3.14, *p* = .035.

As in Study 1, prior to data collection, we planned to separately examine the impact of ginger on each set of images; analyses are therefore presented separately for these two sets of images. Interspersed among the fear stimuli were 5 neutral photos: a lightbulb, an umbrella, a ferryboat, a chair, and a spoon. All stimuli (GIFs and photos) were shown to participants in a within-subjects counterbalanced order. We expected that, because the effects of ginger are likely to be specific to disgust, ginger would not reduce feelings of fear in response to either the highly or moderately scary stimuli.

As in the pre-testing, participants judged the highly severe fear stimuli to be significantly more frightening than the moderately severe stimuli, *M*high = 4.98, *SD* = 1.53; *M*moderate = 4.35, *SD* = 1.66; paired-sample *t(*270) = 9.34, *p* <.0001. As expected, we found no evidence for an effect of ginger on fear, for either 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. This result suggests that ginger’s impact on purity violating stimuli is likely to be strictly due to its impact on disgust, and unlikely to be the result of generalized negative emotion reduction, or to any kind of relaxation or calming effect.

**SOM2. Interim Study Description.** After conducting Study 1 and prior to conducting Study 2, we conducted an interim study with a small sample (final *N* = 96), in an initial exploratory attempt to test whether ginger reduced the severity of various kinds of moral judgments. This study was described in our original pre-registration document as “Study 2” (see <https://osf.io/pbqn5/>). In this study, we included *only* highly severe purity violations (i.e., no moderately severe purity violations were included) and moral vignettes that violated harm concerns (including two trolley dilemmas: the switch and footbridge cases), as described below.

**SOM3. Harm-based Vignettes used in Interim study**

1. James is going to work and considers whether to walk the 1½ miles or to drive in. He is feeling lazy and decides to drive in. How moral or immoral do you, personally, find James’s decision to be? 1 (*Perfectly OK*) to 9 (*Extremely Wrong*)
2. Controversy has erupted over a documentary film about Mexican immigrants. The film has received excellent reviews, but several of the people interviewed in it have objected that their rights were violated. The filmmaker deliberately had his camera crew stand back 15 feet in a crowd so that some interviewees did not realize they were being filmed. Because the camera was not hidden, the procedure was legal. What do you think about the studio’s decision to release this film, despite the aforementioned allegations? 1 (*Strongly approve of film release*) to 9 (*Strongly disapprove of film release*)
3. You are walking down the street when you come across a wallet lying on the ground. You open the wallet and find that it contains several hundred dollars in cash as well the owner’s driver’s license. From the credit cards and other items in the wallet it’s very clear that the wallet’s owner is wealthy. You, on the other hand, have been hit by hard times recently and could really use some extra money. You consider sending the wallet back to the owner without the cash, keeping the cash for yourself. How wrong is it for you to keep the money you found in the wallet in order to have more money for yourself? 1 (*Perfectly OK*) to 9 (*Extremely Wrong*)
4. You have a friend who has been trying to find a job lately without much success. He figured that he would be more likely to get hired if he had a more impressive resume. He decided to put some false information on his resume in order to make it more impressive. By doing this he ultimately managed to get hired, beating out several candidates who were actually more qualified than he. How wrong was it for your friend to put false information on his resume in order to help him find employment? 1 (*Perfectly OK*) to 9 (*Extremely Wrong*)
5. Your plane has crashed in the Himalayas. The only survivors are yourself, another man, and a young boy. The three of you travel for days, battling extreme cold and wind. Your only chance at survival is to find your way to small a village on the other side of the mountain, several days away. The boy has a broken leg and cannot move very quickly. His chances of surviving the journey are essentially zero. Without food, you and the other man will probably die as well. The other man suggests that you sacrifice the boy and eat his remains over the next few days. How wrong is it to kill this boy so that you and the other man may survive your journey to safety? 1 (*Perfectly OK*) to 9 (*Extremely Wrong*)

**Interim study results for harm-based moral vignettes.** Moral judgment severity across all 4 harm vignettes was unaffected by the ginger manipulation, *M*ginger = 5.71 (*SD* = 1.30), *M*sugar = 5.64 (*SD* = 1.22), independent sample *t(*94) = .28, *p* =.78. Scenario E was not included in these analyses because it contained elements of both harm and purity violations; excluding it did not change the results in any meaningful way. Given the small size of the sample included in this study, we are hesitant to draw any firm conclusions from these null results.

**SOM4. Trolley dilemma vignettes used in Interim Study**

1. 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? 1 (*Perfectly OK*) to 9 (*Extremely Wrong*)
2. 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? 1 (*Perfectly OK*) to 9 (*Extremely Wrong*)

**Interim Study Results for trolley dilemmas.** Participants in the ginger condition were more utilitarian in their moral judgments than those in the control condition; collapsing across the footbridge and switch cases, *Mginger* = 4.78 (*SD*=1.99), *Msugar* = 6.01 (*SD*=1.89), *t*(94) = 3.10, *p* = .003. Breaking the results down by trolley case, the effect was stronger for the switch case, *Mginger* = 3.56 (*SD*=2.18), *Msugar* = 5.35 (*SD*=2.14), *t*(94) = 4.06, *p* < .0001, relative to the footbridge case, *Mginger* = 6.00 (*SD*=2.57), *Msugar* = 6.67 (*SD*=2.17), *t*(94) = 1.38, *p* = .17. Deontological judgments (i.e., non-utilitarian) are thought to be caused by emotional responses (Greene et al., 2001), so this result is consistent with this account, as it suggests that feelings of disgust are causally related to these types of moral judgments – especially when of a moderate severity (i.e., the switch case, in which people view sacrificing 1 to save 5 as more permissible when it involves merely flipping a switch that moves the trolley to another track compared to pushing a man to his death to save the 5, as in the footbridge case).

However, in an attempt to replicate this result in with a larger sample (i.e., the sample reported for Study 2 in text), we failed to find the same result (see main text for details).

**SOM5. Highly severe purity violations included in the Interim Study.** The highly severe purity violations included in the interim study were identical to the highly severe purity violations included in Studies 2 and 3, described in the main text.

**Interim Study Results for highly severe purity violations.** Replicating results reported in Studies 2 and 3 (see main text), moral judgment severity of the highly severe purity vignettes (the mean of responses to all 4 vignettes) was unaffected by the ginger manipulation, *M*ginger = 7.10 (*SD* = 1.56); *M*sugar = 6.89 (*SD* = 1.74), independent sample *t(*94) = .62, *p* =.53.

**SOM6. Additional items included in Study 3 and Results.** After completing all other dependent measures in Study 3, participants rated several photos depicting individuals who belonged to various outgroups. Specifically, they were asked to indicate their feelings toward these individual(s) using a “feeling thermometer” adapted from past research (e.g., Inbar, Pizarro, & Bloom, 2012), on a scale from 1 (*Cold*) to 5 (*Neutral*) to 9 (*Warm*). We explored whether ginger might reduce prejudice toward certain groups of individuals, particularly those for whom prejudice has been linked to disgust, such as gay men (e.g., Inbar, Pizarro, Knobe, & Bloom, 2009). In particular, we examined prejudice responses toward gay men, obese men and women, elderly men and women, and disabled men and women. For comparison, we also included groups that are not thought to be targets of disgust-based prejudice: African Americans, Caucasians, East Asians, First Nations, and Muslims. However, no significant effects emerged in any case: ginger did not decrease (or increase) coldness ratings towards any group examined (all *ps* >.30).

**SOM7. Additional Study Examining Responses to Harm-Violating Vignettes.**

*Method*

*Participants and Procedure.* 502 undergraduate students participated in exchange for course credit. 13 participants were excluded due to procedural errors, for a final sample of 489 (74% women, *Mage* = 20.17, *SD* = 3.07). Participants followed a procedure identical to that used in Study 3. Sample size was determined in part from a power analysis based on 75% power to detect a small interaction effect, 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. Halfway through data collection, several items were added to the end of this study to test whether ginger affected feelings of fear in response to a fear-inducing stimulus; 271 of the participants in this study completed these secondary measures, as described above in SOM1 and in Footnote 1 of the main text.

*Materials.* Prior to data collection we pre-tested a set of harm infractions for their severity. These vignettes were modified slightly from past research (i.e., Knutson et al., 2010). To pre-test the severity of these 12 vignettes, seven undergraduate research assistants read and rated each on a 9-point Likert-scale ranging from 1 (*Perfectly OK*) to 9 (*Extremely Wrong*). We then selected 4 highly severe and 4 moderately severe moral violations for inclusion (ICC for all items = .68; ICC for selected items = .51): *MHigh* = 7.64 (*SD* = .63); *MModerate* = 4.25 (*SD* = 1.59), paired-sample *t(*6) = 5.44 *p* = .002. All items are listed below. We again separately analyzed responses to highly and moderately severe moral harm violations and predicted that ginger would be most effective for reducing responses to moderately severe infractions.

*Highly severe harm violations*

1. 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 thought the man was kind of a jerk during the whole transaction, so he decided not to send the poster and just kept the money.
2. Will used to drink and drive a lot. One time he borrowed his brother’s car, was drunk and had taken Valium. He sideswiped another car that had its door open. Will got scared and kept driving.
3. When Jacob was graduating from high school, he had a friend whom he wasn’t really getting along with anymore. He was coming to see Jacob when he got into a car accident. Jacob chose that time at the hospital to tell him their friendship was over.
4. Mary was in a store and found something she wanted, but it was expensive. She took it and put it in the box of an item that was cheaper, and paid for the cheaper item.

*Moderately severe harm violations*

1. Derek had a good friend James who was a really nice guy. Then James got married and kind of changed. Derek didn’t like James’s new personality so when James called to hang out Derek would lie and say he was busy.
2. Jim used to work for the federal government. He used a calculator from work at home for some audits. When he left government services, he kept the calculator.
3. The other day Cindy got into an argument with her mom on the phone. She really doesn’t like having to face the reality of her dysfunctional relationship with her mom. She was really mad at her mom so Cindy just hung up the phone.
4. 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 that she wasn’t friends with Dave even though she hung out with him regularly.

*Results*

Participants judged the highly severe harm violations to be significantly more wrong than the moderately severe harm violations, *M*high = 7.80, *SD* = .83; *M*moderate = 5.27, *SD* = 1.29; paired-sample *t(*488) = 46.05, *p* < .0001. We again separately examined results for moderately and highly severe violations. For moderately severe violations, neither an interaction between bodily sensation awareness and experimental condition, *b* = .20, *t*(485) = 1.43, *p* = .15, nor a main effect of condition, *b* = -.06, *t*(485) = .50, *p* = .62, emerged; *M*ginger = 5.24 (*SD* = 1.31); *M*sugar = 5.29 (*SD* = 1.26), independent sample *t(*487) = .43, *p* = .67. Similarly, no main effect of bodily sensation awareness emerged on judgments of moderately severe harm violations, *b* = .08, *t*(485) = 1.12, *p* = .26.

Turning to the highly severe violations, neither an interaction between bodily sensation awareness and experimental condition, *b* = .018, *t*(485) = .20, *p* = .84, nor a main effect of condition, *b* = -.06, *t*(485) = .75, *p* = .45, emerged; *M*ginger = 7.95 (*SD* = .85); *M*sugar = 8.00 (*SD* = .82), independent sample *t(*487) = .67, *d* = .06, 95% CI [-.24, .12], *p* = .51. Similarly, no main effect of bodily sensation awareness emerged on these judgments, *b* = .06, *t*(485) = 1.28, *p* = .20. Importantly, there was no main effect of condition on participants’ ratings of their trait bodily sensation awareness, *M*ginger = 4.30 (*SD* = .84); *M*sugar = 4.18 (*SD* = .84), independent sample *t(*487) = 1.55, *p* =.12.

**Table S1. Additional results for Study 4: Non-significant main effects for moral foundations other than purity.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Sugar Condition** | **Ginger Condition** | **Test of Differences (Sugar vs. Ginger)** |
| **Moral Domain and Items (grouped by severity)** |  |  |  |
| *Care/Harm* Moderate Severe All items | 5.88 (1.50)7.93 (1.11)6.90 (1.15)  | 5.79 (1.69)8.06 (0.96)6.92 (1.12) | *t*(502) = 0.64, *d* =.06, *p* =.52*t*(502) = 1.39, *d* =.13, *p* =.17*t*(502) = 0.18, *d* =.02, *p* =.86 |
|  |  |  |  |
| *Fairness* Moderate Severe All items | 5.80 (1.53)7.73 (1.24)6.77 (1.24)  | 5.70 (1.59)7.83 (1.28)6.77 (1.27) | *t*(502) = 0.72, *d* =.07, *p* =.47*t*(502) = 0.85, *d* =.08, *p* =.40*t*(502) = 0.02, *d* = 0.0, *p* =.98 |
|  |  |  |  |
| *Loyalty* Moderate Severe All items | 5.45 (1.44)7.76 (1.19)6.61 (1.07)  | 5.34 (1.43)7.78 (1.12)6.56 (1.05) | *t*(502) = 0.86, *d* =.08, *p* =.39*t*(502) = 0.21, *d* =.02, *p* =.84*t*(502) = 0.47, *d* =.05, *p* =.64 |
| *Authority* Moderate Severe All items | 6.21 (1.34)7.00 (1.42)6.60 (1.24)  | 6.29 (1.40)7.20 (1.33)6.74 (1.21) | *t*(502) = 0.67, *d* =.06, *p* =.50*t*(502) = 1.67, *d* =.15, *p* =.10*t*(502) = 1.31, *d* =.11, *p* =.19 |

*Note*. Numbers for sugar and ginger conditions are means with standard deviations in parentheses. Moderate refers to the three moderately severe items, Severe refers to the three highly severe items, and All items refers to the moderately and highly severe items aggregated together.

**Table S2. Additional results for Study 4: Non-significant interactions between experimental condition and BSA for moral foundations other than purity.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Moderate Violations** | **Severe Violations** | **All Items** |
| **Moral Foundation** |  |  |  |
| Care/Harm | *b* = -.11, *p* = .45 | *b* = -.16, *p* = .08 | *b* = -.13, *p* = .18 |
|  |  |  |  |
| Fairness | *b* = -.11, *p* = .44 | *b* = .02, *p* = .84 | *b* = -.04, *p* = .71 |
|  |  |  |  |
| Loyalty | *b* = .05, *p* = .68 | *b* = -.12, *p* = .24 | *b* = -.03, *p* = .72 |
| Authority | *b* = .02, *p* = .87 | *b* = .11, *p* = .35 | *b* = .07, *p* = .54 |

Note. Reported betas are unstandardized. Moderate refers to the three moderately severe items, severe refers to the three highly severe items, and All items refers to the moderately and highly severe items aggregated together.

**Table S3. Examining demographic differences between the samples included in Studies 2, 3, and 4.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Study 2**  | **Study 3** | **Study 4** | **Test of** **Differences** **Study 2 vs. 3** | **Test of Differences Study 3 vs. 4** |
| **Demographics and Individual Difference Variables Assessed** |  |  |  |  |  |
| Age | 20.42 (3.33)  | 20.01 (2.30) | 22.47 (6.77) | *t*(483) = 1.91, *d* =.15, *p* =.057 | *t*(998) = 7.67, *d* = .55, *p* < .001 |
| BSA | 4.36 (.78) | 4.34 (.78) | 4.15 (.85) | *t*(801) = .24, *d* =.03, *p* =.81 | *t*(998) = 3.68, *d* = .72, p < .001 |
| Time Since Last Meal | 3.65 (3.94) | 3.70 (4.55) | 4.77 (5.36) | *t*(717) = .15, *d*=.12, *p* =.88 | *t*(998) = 3.40, *d* = .22, *p* < .001 |
| Gender | 80% women  | 75% women | 71% women | *X*2 = .006, *p* = .94 | *X*2 = 1.69, *p* = .19 |

Note. Numbers for Age, BSA, and Time Since Last Meal are means with standard deviations in parentheses. No robust differences emerged between samples means correcting for multiple comparisons. BSA refers to bodily sensation awareness, also called Public Body Consciousness; it is an individual difference measure capturing the extent to which individuals are sensitive to their internal bodily sensations.