



Gross values: Investigating the role of disgust in bioethics

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Abstract

What is the role of disgust in moral judgements? Previous research found that disgust increases the severity of judgments; but other more recent work has cast doubt on these findings. Here we investigate roles of induced and trait disgust on moral judgments of controversial biological and medical technologies – bioethics – an area rife with proto-typical disgust cues. Participants ($N=600$) viewed disgusting, frightening, or neutral pictures, rated the moral acceptability of biotechnologies, and completed questionnaire measures of trait disgust. We found a small negative effect of *induced* disgust (but not fear) on the acceptability of ‘existing’ biotechnology, but not ‘future’, ‘agricultural’, or ‘termination’ biotechnologies. But this effect was too small to change pre-existing opinions and would not have survived a correction for multiple tests. Although *trait* disgust had mostly negative relationships with the moral acceptability of biotechnologies, it did not moderate the effect of observing disgusting photos on biotechnology judgments. The larger, more consistent effects for trait disgust suggest that either (a) measures of trait disgust and moral attitudes share a source of method variance or (b) incidental, visual manipulations are too weak to capture the true effect of disgust on moral judgments.

Keywords Disgust · Morality · Moral emotions · Bioethics

Introduction

Imagine you are waiting for your results at a doctor’s office. Your eyes wander over posters depicting smoke-damaged lungs, lurid skin diseases, and dissected brains. You feel queasy. Then the doctor returns with your results – they are not good – and recommends a novel invasive procedure. You are repulsed by the idea, it seems unnatural, disgusting... wrong. You are about to reject the idea... but should you trust your gut reaction?

Recent research in moral psychology has argued that the emotion of disgust plays a substantial role in moral judgement. According to this theory, disgust evolved in humans to motivate avoidance of pathogens, parasites, and other disease-vectors (Schaller & Park, 2011). This psychological system also motivates avoidance of social hazards – ‘unclean’

people and practices. It has been argued this has given rise to a distinct domain of morality concerned with defending and maintaining bodily and spiritual ‘purity’ (Haidt & Joseph, 2004). This theory predicts that inductions of disgust and variation in ‘trait’ disgust should influence moral judgments.

Does Disgust Influence Moral Judgment?

A series of early experiments suggested that experimentally inducing disgust or feelings of cleanliness increases and decreases moral condemnation, respectively (Schnall et al., 2008; Wheatley & Haidt, 2005). Later experiments (Horberg et al., 2009; Olatunji et al., 2016) and correlational studies (Inbar et al., 2009; Wagemans et al., 2018) have shown that disgust primarily predicts condemnation of disgusting (‘impure’) moral violations such as counter-normative sexual behavior.

However, a meta-analysis found that the effect of experimentally induced disgust on moral judgements is small ($d=0.11$) and, after accounting for publication bias, possibly nil ($d=-0.01$; Landy & Goodwin, 2015). Since then, large replications of key studies in the meta-analysis have also failed to replicate, even among groups thought to be especially sensitive to disgust (Ghelfi et al., 2018; Johnson et al., 2016). Recent positive effects of induced disgust have been limited to particular types of moral

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scenarios (Tracy et al., 2019; van Dijke et al., 2018; Wisneski & Skitka, 2017). The mixed picture painted by experiments suggests that the more robust association between trait disgust and moral judgments is partly spurious. Indeed, one recent study suggests that associations between trait disgust and negative moral judgments merely reflects generalized negativity (Landy & Piazza, 2019).

How Does Disgust Affect Moral Judgments?

Even if disgust does affect moral judgments, it need not follow that emotions like disgust are necessary or sufficient to generate moral condemnation, as some commentators have theorized (Nichols, 2002; Prinz, 2007). Even landmark incidental disgust experiments did not produce strong enough effects to change participants' opinions from the "approval" or "neutral" side of rating scales to the "disapproval" side, implying that disgust at most amplified preexisting attitudes (May, 2014). Furthermore, such amplification could be mediated by non-emotional processes, in which case disgust would be best characterized as one factor among indefinitely many that can affect the *antecedents* of moral judgments. For example, disgust inductions may change people's understanding of the act they are evaluating, perhaps by drawing their attention to its potential harm (Huebner et al., 2009). Alternatively, participants may resent being intentionally exposed to noxious stimuli, and express their bad mood by making more negative moral judgments (Landy & Goodwin, 2015). On these views, asking people to pay attention to a certain aspect of an act while evaluating it or insulting participants before having them judge scenarios would bring about the same effects as disgust inductions via the same psychological processes. Thus, significant effects of disgust inductions on moral judgments are not evidence that disgust has an integral role in moral judgments unless one can rule out the possibility that participants' mood, and their understanding of the acts they are judging, are responsible for the effect. One step towards ruling out these confounds is establishing *measurement invariance* across disgust and control conditions. Measurement invariance would hold if disgust inductions reduced reports of moral acceptability by changing people's attitudes towards moral biotechnologies rather than merely changing the relationships between people's attitudes and how they report those attitudes (Gregorich, 2006).

The Present Study

The present study investigates the roles of induced and trait disgust on judgments of controversial biological and medical technologies — the province of bioethics. Bioethical issues provide a good test case for the effects of disgust because most

of them involve prototypical disgust cues, such as: body-envelope violations, bodily fluids, 'unnatural' technologies, and environmental pollution (Clifford & Wendell, 2016; De Witt et al., 2017). Whether disgust influences the perceived acceptability of biotechnologies also has important practical implications. Disgust may influence healthcare provision, which is set in locations (for example, hospitals, clinics) in which disgust elicitors abound. And disgust may stall debates about whether to legalize or subsidize biotechnologies insofar as emotional reactions are immune to cost-benefit arguments.

Research on the role of disgust in biotechnology opposition has yet to reach definitive conclusions. One study found that state and trait level disgust predict "absolutist" (that is, insensitive to risks and benefits) opposition to GMOs (Scott et al., 2016). Follow-up studies show that participants use the word "disgust" metaphorically to express a wariness of unforeseen negative consequences of novel biotechnologies (Royzman et al., 2017). Clifford and Wendell (2016) found significant associations between trait disgust and a handful of biotechnologies. However, main effects of induced disgust were non-significant across the board. There was inconsistent evidence that induced disgust caused more condemnation of GMOs among those more sensitive to pathogen disgust.

The current experiment has a similar protocol to Study 3 of Clifford and Wendell (2016) but introduces several improvements. First, Clifford and Wendell (2016) compared their disgust induction only to an affect-neutral control. We followed Horberg et al. (2009) in also including a fear condition to test whether disgust affects moralization simply by inducing negative affect (thereby having a similar effect to fear) or through some unique property (thereby having a different effect than fear). Second, Clifford and Wendell (2016) treated each biotechnology as a separate dependent variable and examined the effects of trait disgust, induced disgust, and their interaction on each outcome. In spite of the large number of tests, the authors made no attempt to control the family-wise error rate. We planned a limited number of tests and report the family-wise error rate. The unplanned sensitivity tests we conducted were also designed to minimize false positives. Third, we recruited a sample that was larger ($N = 600$) than their two experiments combined (Study 1 $N = 210$, Study 3 $N = 311$; Study 2 did not include an experimental manipulation). Fourth, Clifford and Wendell (2016) did not correct for measurement error. In contrast, we modeled biotechnologies as latent variables, which have perfect reliability.

Our latent variable approach also enabled us to test for measurement invariance across experimental conditions. This approach addresses concerns that skeptical commentators often raise when interpreting positive results. In particular, tests of measurement invariance allow for an explicit test of whether disgust inductions reduce judgments of moral acceptability by changing the measurement process rather than directly changing people's

attitudes towards moral biotechnologies (Gregorich, 2006). If the biotechnology items possess *configural invariance*, then we can infer that the same constructs underlying judgments of biotechnologies are being measured across experimental conditions. We test this assumption using multi-group confirmatory factor analysis, which fits the same factor structure in each condition, but allows factor loadings and items to be freely estimated within each condition. Configural invariance is achieved if the multi-group model has good model fit. If the moral judgment items possess *metric invariance*, then participants in different conditions likely possess the same understanding of the acts that they are judging. Thus, condition differences in moral judgments would not be attributable to disgust simply focusing participants' attention on features other than those to which they would normally attend. We test metric invariance by constraining the factor loadings equal across conditions in a multi-group model that possesses configural invariance. We infer metric invariance when equalizing factor loadings does not degrade model fit relative to the configural model. If the items also possess *scalar invariance*, then condition-mean differences reflect genuine changes in the moral judgment process rather than mere changes in how participants respond to questionnaire items. We test scalar invariance by observing whether model fit declines after constraining item intercepts to be equal across conditions in the metric invariant model.

Methods

Preregistration

Our planned sample size, protocol, and analysis plan were preregistered and are available here: <https://osf.io/j36ex>. Some details of our analyses were not pre-registered but were consistent with conventional applications of structural equation modeling, such as using cut-offs of approximate fit indices (RMSEA \leq .06, TLI \geq .95, and SRMR \leq .08 are adequate; RMSEA \leq .10, TLI \geq .90, and SRMR \leq .10 are mediocre) to evaluate model fit adequacy (Hu & Bentler, 1999). However, some methodologists find conventional practices too lax. In the "Sensitivity Analysis" section of the supplemental analyses (<https://osf.io/d49mk/>), we present results from unplanned analyses in which we (a) aggregate biotechnologies without making assumptions about their latent structure, (b) treat each biotechnology as an independent outcome, and (c) test hypotheses only after addressing model misfit. Because none of the sensitivity analyses generated significant results that were not also found in the primary analyses, we do not report on them further here.

Recruitment

600 participants (459 women, 141 men; $M_{\text{age}} = 48.84$, $SD_{\text{age}} = 17.31$) based in the United States, were recruited via Qualtrics, in exchange for £4.25, to complete a questionnaire. Our sample size gave us 80% power to detect condition effects as small as $d = .24$ and correlations as small as $r = .11$, assuming two-tailed tests with an alpha of .05. We calculated statistical power using G*Power (Faul et al., 2009). Sample size was determined before any data analysis.

Procedure

No other measures or manipulations beyond those described below were administered. First, participants observed in sequence 20 pictures sourced from the International Affective Picture System (IAPS), a well-established picture set of emotional stimuli for exclusively scholarly interests (Libkuman et al., 2007). There were three conditions. Participants saw either twenty examples of disgusting pictures (for example, vomit and wounds), frightening pictures (for example, guns and snakes), or neutral pictures (for example, cups and furniture).¹ The items within this and each subsequent section of the procedure were presented in random order.

After observing each picture, participants rated their reaction on a 7-point rating scale, (1 = "Extremely unpleasant", 2 = "Very Unpleasant", 3 = "Unpleasant", 4 = "Neutral", 5 = "Pleasant", 6 = "Very Pleasant", 7 = "Extremely pleasant"). These ratings were averaged and served to verify whether the disgust and fear conditions elicited more negative affect than the neutral conditions. Although ratings of pleasantness cannot verify that the disgust pictures primarily elicited disgust and the fear pictures primarily elicited fear, IAPS photos have been validated for eliciting specific emotions, including disgust and fear (Mikels et al., 2005). Moreover, checking that the intended emotional response occurred can make transparent the hypotheses under study to the participants (Ejelöv & Luke, 2020). In contrast, having participants report on the pleasantness of the photos does not confound the unique effects of the disgust or fear condition.

Second, participants rated the moral acceptability of twenty biotechnologies on a 5-point rating scale (1 = Completely unacceptable; 2 = Unacceptable; 3 = Neither acceptable nor unacceptable; 4 = Acceptable; 5 = Completely acceptable). (See Table 1 for descriptive statistics grouped by condition.) We defined "moral acceptability" for participants as "something that, from your moral viewpoint, a person can do without being wrong." Items were collated from a review of previous studies of bioethics (Graham et al.,

¹ As noted by Landy and Goodwin (2015), using the IAPS, rather than stimuli involving people performing disgusting acts, allows us to discount the possibility that disgust increases condemnation of specific people who engage in the act under consideration rather than of the act per se.

Table 1 Means and Standard Deviations for the Moral Acceptability of Biotechnology Attitude Ratings in Each Condition

	Disgust Prime <i>N</i> =202		Fear Prime <i>N</i> =208		Neutral Prime <i>N</i> =190	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Biotechnology						
Vaccine	4.40	0.96	4.46	0.95	4.49	0.88
Eating Meat	4.31	0.84	4.27	0.90	4.28	0.79
Alternative Medicine	3.98	1.04	4.12	0.88	4.14	0.91
Acupuncture	4.23	0.91	4.29	0.98	4.38	0.76
Stem Cell Therapy	3.89	1.03	4.02	0.91	4.03	0.98
Robots in Surgery	3.44	1.35	3.41	1.30	3.35	1.22
Testing Risky Drugs	3.26	1.31	3.49	1.24	3.40	1.26
GMOs to Replace Gasoline	3.45	1.18	3.76	1.03	3.72	1.10
Artificial Organs	3.30	1.16	3.70	1.15	3.54	1.12
Animal Organ Transplant	2.77	1.28	2.93	1.29	2.82	1.82
Animal Testing	2.70	1.25	2.78	1.27	2.67	1.18
Gene Edits to Reduce Disease	2.72	1.16	2.88	1.17	2.78	1.19
Three-Parent Baby	2.20	1.22	2.32	1.14	2.17	1.16
Head Transplant	2.00	1.17	1.95	1.16	1.97	1.21
Cloning Humans	1.80	1.00	1.95	1.14	1.80	1.03
GMO to Improve Food	2.73	1.25	2.77	1.24	2.76	1.18
Pesticides	2.40	1.16	2.44	1.17	2.25	1.14
Physician-Assisted Suicide	2.86	1.39	3.17	1.41	2.91	1.21
Abortion	2.92	1.39	3.04	1.45	2.86	1.42
Vaccine	4.40	0.96	4.46	0.95	4.49	0.88
Obese Paying More	1.90	1.08	2.10	1.21	1.92	1.06

Participants 5-point rating scale (1 = Completely acceptable; 2 = Unacceptable; 3 = Neither acceptable nor unacceptable; 4 = Acceptable; 5 = Completely acceptable). We defined “moral acceptability” for participants as “something that, from your moral viewpoint, a person can do without being wrong”

2011; Haidt, 2007; Horberg et al., 2009; National Science Foundation, 2012; Pew Research Center, 2015; Schnall et al., 2008). See the supplementary materials (<https://osf.io/agky9/>) for exact wording of the instructions and items.

Third, participants completed the “Pathogen Disgust” ($\omega = .85$; $M = 4.17$, $SD = 1.22$) and “Sexual Disgust” ($\omega = .86$; $M = 3.58$, $SD = 1.53$) sub-scales of the Three Domain Disgust Scale (TDDS), a widely-used questionnaire measure of trait disgust (Tybur et al., 2009). Participants were asked to rate how disgusting they found the concepts described in the questionnaire from “Not at all disgusting” to “Extremely disgusting” on a 7-point rating scale.

Fourth, participants completed the Judgment scale of the Morality as Cooperation Questionnaire (MAC-Q; Curry et al., 2019), as well as demographic questions about political identity, age, gender, religious affiliation, marital status, nationality, number of children and grandchildren, and education. These variables were not analysed in the present study.

Finally, participants were invited to provide open-ended feedback about the survey. We coded feedback for pejorative comments about the IAPS photos ($n = 11$ out of 190

participants in the disgust condition) to empirically examine whether anger at exposure to noxious stimuli could explain significant effects of the disgust condition (Landy & Goodwin, 2015). There were no complaints about the fear photos or neutral photos.

Results

All tests of hypotheses were conducted in R version 3.5.1 (R Core Team, 2019) using the lavaan (Rosseel, 2012) and psych (Revelle, 2018) packages. Full Information Maximum Likelihood was used to handle missing data, and robust standard errors were used to handle violations of multivariate normality. There were no data exclusions. We treated rating scale items as continuous because they all had at least five categories (Rhemtulla et al., 2012). All tests were two-tailed with an alpha of .05. Data (<https://osf.io/7yb4w/>) and syntax (<https://osf.io/b5xah/>) are available on the Open Science Framework.

Factor Structure

We used exploratory factor analysis with an oblimin rotation to determine the factor structure of biotechnology judgments. We settled on four factors, and then affirmed measurement invariance across experimental conditions. For full statistical details see the supplemental analyses (<https://osf.io/d49mk/>).

We labeled the first factor *Existing*; it comprises biotechnologies that are already available: acupuncture, alternative medicine, artificial organs, vaccines, eating meat, stem cell research, using genetically modified plants to create a replacement for gasoline, using robots to assist with surgery, and treating very sick patients with experimental drugs (with their consent).

We labeled the second factor *Future*; it comprises biotechnologies that are not yet widely available: babies made from the genetic material of three persons, head transplants, human cloning, and changing a baby's genetic characteristics to reduce the risk of serious diseases. We labeled the third factor *Agricultural*; it comprises biotechnologies that exert power over the environment: animal testing, genetically modified foods, and pesticides.

Finally, we labeled the fourth factor *Termination*; it comprises biotechnologies the ethics of which turn on the consent of a relevant party to a procedure that may lead to termination of potential life: abortion and physician-assisted suicide.

Manipulation Check

Next, we examined how the disgust and fear conditions increased negative affect relative to the control condition. We averaged pleasantness ratings of the twenty IAPS pictures and regressed them on the condition factor; the neutral condition served as the reference group. The model explained substantial variance, $F(2, 597) = 497.2, p < .001$, Adjusted $R^2 = .62$. The disgust pictures were rated as very unpleasant ($M = 1.94, SD = 0.86$), and were significantly less pleasant than the neutral pictures ($M = 4.38, SD = 0.54$), $b = -2.43, se = .08, t(598) = 31.13, p < .001, 95\%CI [-2.58, -2.27], d = -3.15$, which participants on average found mildly pleasant. The fear pictures were also more unpleasant ($M = 2.76, SD = .86$) than the neutral pictures, $b = -1.59, se = .08, t(598) = -20.52, p < .001, 95\%CI [-1.74, -1.43], d = -2.06$, though less so than the disgust pictures.

Induced Disgust

We examined how fearful and disgusting photos affected the moral acceptability of biotechnology relative to observing neutral photos using a structural equation model in which two dummy-coded (disgust = 1, fear = 0, neutral = 0; disgust = 0, fear = 1, neutral = 0) variables predicted each of the four

biotechnology factors (see Table 2 for full unstandardized results).

Observing disgusting pictures caused a small, significant reduction in the acceptability of *Existing* biotechnologies relative to the neutral condition ($d = -0.23, p = .04$). Disgust did not have a significant effect on the acceptability of *Future* biotechnologies ($d = -0.01, p = .91$), *Agricultural* ($d = 0.10, p = .43$), or *Termination* biotechnologies ($d = -0.01, p = .87$). Adding whether participants reported being bothered by exposure to the disgust condition as a predictor of *Existing* biotechnologies did not change the size or significance of the effect of disgust.

Observing fearful pictures caused a nonsignificant reduction in the moral acceptability of *Existing* biotechnologies relative to the neutral condition ($d = -0.04, p = .75$). Attitudes toward *Future* biotechnologies $d = 0.07, p = .19$, *Agricultural* ($d = 0.15, p = .22$), and *Termination* ($d = 0.10, p = .07$) biotechnologies were non-significantly higher in the fear condition. The probability of a false positive when conducting eight significance tests is 0.34. Thus, the significant effect of disgust on attitudes toward *Existing* biotechnologies would not have survived a correction for multiple comparisons (for example, a Dunn-Sidak adjustment would have set alpha to .006).

Trait Disgust

Next, we estimated the associations between *trait* disgust and the moral acceptability of biotechnologies (see full model results in Table 3). After establishing measurement invariance of pathogen disgust across experimental conditions (see the supplemental materials), we fit a structural equation model in which the four biotechnology factors were regressed on

Table 2 Latent mean differences in the moral acceptability of biotechnology between emotion and neutral conditions

	<i>b</i>	<i>se</i>	<i>Z</i>	<i>p</i>	95% CI	<i>d</i>
Disgust vs. Neutral						
Existing	-0.13	0.06	-2.01	.044	[-0.25, -0.00]	-0.23
Future	-0.01	0.10	-0.12	.908	[-0.21, 0.18]	-0.01
Agricultural	0.09	0.11	0.80	.426	[-0.13, 0.30]	0.10
Termination	-0.02	0.13	-0.17	.867	[-0.28, 0.24]	-0.01
Fear vs. Neutral						
Existing	-0.02	0.06	-0.32	.750	[-0.13, .010]	-0.04
Future	0.13	0.10	1.31	.191	[-0.07, 0.33]	0.07
Agricultural	0.13	0.10	1.22	.221	[-0.08, 0.33]	0.15
Termination	0.24	0.13	1.83	.067	[-0.02, 0.50]	0.10

Model fit: $\chi^2(161) = 288.47, p < .001$; RMSEA = .036, 90% CI [.030, .043]; SRMR = .036; TLI = .941. Results are from a structural equation model in which two dummy-coded (disgust = 1, fear = 0, neutral = 0; disgust = 0, fear = 1, neutral = 0) variables predicted each of the four biotechnology factors

Table 3 Latent effect of trait disgust on the moral acceptability of biotechnology

	<i>b</i>	<i>se</i>	<i>Z</i>	<i>p</i>	95% CI	<i>r</i>
Pathogen Disgust						
Existing	−0.03	0.03	−1.12	.262	[−0.09, 0.02]	−.07
Future	−0.10	0.05	−2.17	.030	[−0.19, −0.01]	−.12
Agricultural	−0.13	0.04	−2.89	.004	[−0.21, −0.04]	−.17
Termination	−0.13	0.06	−2.21	.027	[−0.25, −0.02]	−.13
Model fit: $\chi^2(274)=524.36, p<.001$; RMSEA=.039, 90% CI [.033, .044]; SRMR=.043; TLI=.928						
Sexual Disgust						
Existing	−0.04	0.02	−2.07	.038	[−0.08, −0.00]	−.11
Future	−0.17	0.04	−5.02	<.001	[−0.24, −0.11]	−.28
Agricultural	−0.04	0.03	−1.31	.189	[−0.10, 0.02]	−.07
Termination	−0.28	0.04	−6.40	<.001	[−0.37, −0.19]	−.36
Model fit: $\chi^2(274)=574.45, p<.001$; RMSEA=.043, 90% CI [.038, .047]; SRMR=.042; TLI=.919						

Results are from structural equation models in which the biotechnology factors, pathogen disgust, and sexual disgust were all treated as latent variables. In the first model, the four biotechnology factors were regressed on pathogen disgust; in the second model, the biotechnology factors were regressed on sexual disgust

pathogen disgust. Pathogen disgust had a significant negative relationship with the acceptability of *Future*, *Agricultural*, and *Termination* biotechnologies, but not *Existing* biotechnologies.

After establishing measurement invariance of sexual disgust across experimental conditions (see <https://osf.io/d49mk/>), we ran the same model but replaced pathogen disgust with sexual disgust. Sexual disgust had a significant negative relationship with the moral acceptability of *Existing*, *Future*, and *Termination* biotechnologies, but not *Agricultural* biotechnologies.

Interaction between Induced and Trait Disgust

Some researchers emphasize that not all individuals are equally affected by disgust inductions (Schnall, 2017). For instance, disgust inductions may have a greater effect on the judgments of those higher in disgust sensitivity, that is, trait disgust (Ong et al., 2014). To test whether our null experimental results hold across all levels of disgust sensitivity, we conducted a set of unplanned analyses in which we tested for an interaction between trait disgust and the condition assignment. The simplest way to test an interaction between a latent variable and dummy variable is to create a (metric invariant) multi-group CFA with the dummy variable as the group factor and observe whether the strength of the association between the latent variable and outcome variable differs across levels of the group factor. We created metric invariant multi-group (with condition assignment as the group factor) versions of the models in

which the biotechnology factors were regressed on pathogen disgust ($\chi^2(894)=1319.01, p<.001$; RMSEA = .049, 90% CI [.043, .054]; SRMR = .066; TLI = .895) and sexual disgust ($\chi^2(894)=1301.77, p<.001$; RMSEA = .048, 90% CI [.042, .053]; SRMR = .063; TLI = .903), respectively. For pathogen disgust, constraining the regression coefficients equal across groups did not significantly reduce fit for the model in which pathogen disgust was the exogenous variable, $X^2(8)=5.98, p=.650$. Similarly, constraining the regression coefficients equal across groups did not significantly reduce model fit when sexual disgust was the exogenous variable, $X^2(8)=3.17, p=.924$, implying no significant interactions between induced disgust and trait disgust. These findings suggest that the small and largely null results of the disgust induction are not qualified by trait disgust.

Discussion

We investigated whether experiencing disgust reduces the moral acceptability of biotechnologies, relative to experiencing fear or no particular emotion. The results suggest that induced disgust (but not fear) had a small negative causal effect on acceptance of *Existing* biotechnologies, but not on other types of biotechnology, and that this observed small negative effect disappears after (an unplanned) correction for multiple comparisons. We are not aware of any theory which predicts that disgust will change attitudes towards *Existing*, but not other, biotechnologies.

Trait disgust had more significant associations with the moral acceptability of biotechnologies. Pathogen disgust was negatively correlated with the acceptability of *Future*, *Agricultural*, and *Termination* biotechnologies, but not *Existing* biotechnologies. Sexual disgust was negatively associated with the acceptability of *Existing*, *Future*, and *Termination* biotechnologies, but not *Agricultural* biotechnologies.

What are the implications of these findings? Induced disgust might amplify preexisting attitudes towards *Existing* biotechnologies, but does not appear powerful enough to change minds. Observing disgusting photos reduced the acceptability of *Existing* biotechnologies by only 0.13 rating scale points (on a 1–5 scale), which is insufficient to shift responses from the “acceptable” side of the rating scale to the “unacceptable” side (May, 2014). Indeed, no item had a mean that was both lower than 3 in the disgust condition and higher than 3 in the neutral condition (see Table 1). Moreover, there was a 0.34 probability we would observe at least one significant effect of the condition assignment even if neither fear nor disgust have any effects on biotechnology attitudes.

Many commentators took early research on incidental manipulations of disgust to show that emotions *cause or even constitute all* moral judgments (Nichols, 2002; Prinz, 2007). Our results add to the more recent consensus that induced

disgust, at most, *amplifies* condemnation of *some* controversial issues. We counsel caution in drawing any positive conclusions from our data until the effect of induced disgust on *Existing* biotechnologies is replicated in new samples.

Of course, we should keep in mind the limitations of the present study. One could point to the more reliable associations between trait disgust and condemnation of biotechnologies as evidence that the true effect of disgust is underestimated by the manipulation of disgust. On one version of this view, visual primes do not evoke enough disgust to affect moral judgments. Yet, recent large experiments using stronger primes such as gustatory and olfactory stimuli have also yielded null effects (Ghelfi et al., 2018; Johnson et al., 2016). Alternatively, disgust might only increase condemnation when it is evoked by the act under consideration (Wisneski & Skitka, 2017). This is possible, but we note that rejecting the relevance of incidental disgust manipulations would require discarding most of the experimental evidence showing that disgust influences moral judgments.

Common method variance could also explain why questionnaire measures of trait disgust may have stronger associations with self-reports of moral judgments than disgust inductions. Landy and Piazza (2019) found that trait disgust predicts self-reported attitudes towards not only moral violations but also imprudent behavior and even art. Controlling for response styles or supplementing self-reports with physiological markers of trait disgust would enable unbiased estimates of its relationship with biotechnology attitudes. The biotechnology topics we used were based on previous studies. Their breadth is consistent with recommendations for early stages of scale development (Clark & Watson, 2019). Our structural equation models failed tests of exact fit, though, and misspecification can bias regression coefficients. The sensitivity tests we report in the supplemental materials did not uncover any additional significant effects, which provides some assurance that underfitting the data is not responsible for our negative findings. Nevertheless, it remains possible that a more valid model of biotechnology attitudes that we did not consider would have uncovered stronger effects of disgust.

In conclusion, our results reinforce growing doubts that the emotion of disgust is fundamental to moral judgments. Nevertheless, it could be that emotion-driven amplifications of preexisting attitudes have practical effects on policy or health outcomes. Further research studying how disgust affects decisions of actual patients and consumers would allow healthcare providers and advocates to assess how to best communicate the benefits and risks of biotechnologies. Meanwhile, clinicians can rest assured that the graphic posters in their waiting rooms are unlikely to be giving patients cold feet about procedures that may be in their best interests.

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Data Availability The materials used, and the datasets generated and analysed, in the current study are available in the OSF repository: <https://osf.io/n4az9>. A pre-registration of the study is available here: <https://osf.io/j36ex>.

Declarations

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the School of Anthropology and Museum Ethnography Departmental Research Ethics Committee (#15–008) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Conflict of Interest Mohima Sanyal declares that she has no conflict of interest. William H.B. McAuliffe declares that he has no conflict of interest. Oliver Scott Curry declares that he has no conflict of interest.

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