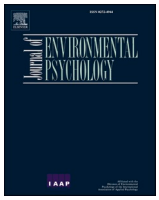
Journal of Environmental Psychology 80 (2022) 101758

Contents lists available at ScienceDirect

Journal of Environmental Psychology

journal homepage: www.elsevier.com/locate/jep



Would you eat a burger made in a petri dish? Why people feel disgusted by cultured meat☆

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ARTICLE INFO

Handling Editor: Sebastian Berger

Keywords:
Cultured meat
Food preference
Consumer behavior
Disgust

ABSTRACT

Cultured meat—real animal flesh produced from *in vitro* cell cultures, without the need to raise animals—is now poised to become publicly available. Compared to conventional meat, cultured meat offers environmental benefits in its production using less water and yielding fewer greenhouse gas emissions. However, many people find cultured meat too disgusting to eat. Through three preregistered studies (total $N = 1587$), we investigated disgust toward cultured meat. An estimated 35% of meat-eaters and 55% of vegetarians felt too disgusted by cultured meat to try eating it. Perceiving cultured meat as unnatural predicted more disgust among both vegetarians and meat-eaters. Meanwhile, perceiving cultured meat as resembling animal flesh predicted less disgust among meat-eaters but more disgust among vegetarians. Experimentally framing cultured meat as resembling animal flesh decreased disgust among meat-eaters but not among vegetarians. These findings can guide efforts to improve consumer acceptance of cultured meat.

Producing meat via conventional animal agriculture poses one of the greatest threats to environmental sustainability (Wynes & Nicholas, 2017). Largely in response to this concern, conventional methods for producing meat are changing profoundly, and meat that comes from farmed animals could one day be a relic of the past. Consumers will soon be able to eat "cultured meat": real animal flesh that comes not from a slaughtered animal, but from extracted muscle cells grown *in vitro*. First referenced in utopian literature in the 1800s, cultured meat is part of a proposed industry that uses cell-based biotechnology to replace traditionally animal-derived foods (Post et al., 2020). As a novel food that humans have never encountered before, cultured meat may evoke hesitation for seeming so unnatural and unfamiliar—and potentially so *disgusting*.

Many social, psychological, economic, and technological factors could fuel consumer resistance to cultured meat, such as perceived norms about eating conventional meat, distrust of food scientists, product pricing of cultured meat, taste expectations, and disbelief in benefits of eating cultured meat (Bryant & Barnett, 2020; Tomiyama et al., 2020; Wilks et al., 2019). Evolutionary perspectives suggest that disgust may be a particularly meaningful factor, and one that may fuel resistance even if consumers' concerns about other factors are resolved. Disgust evolved to regulate behaviors that may risk exposure to pathogens (e.g., interpersonal contact, sexual behavior, eating behavior) and operates at an instinctive, automatic level (Curtis et al., 2004, 2011; Oaten et al., 2009; Rozin & Fallon, 1987). Feelings of disgust may thus often be misguided, existing in the absence of any real pathogen threat, yet still remain influential for cognition and behavior. For example, as people tend to feel disgusted by insects, people have been found to resist consuming perfectly safe foods simply because those foods contain insects or merely had come into contact with a sterilized insect (Berger et al., 2018; Rozin et al., 1986).

Thus not surprisingly, disgust is a leading barrier to consumer acceptance of cultured meat (Bryant & Barnett, 2020). Understanding the basic appraisals eliciting this disgust response is critical for promoting sustainable consumption. Shifting from conventionally produced meat to cultured meat offers immense environmental, health, and ethical benefits (Post et al., 2020). First, cultured meat offers numerous advantageous for sustainability, as its production uses less water and produces fewer greenhouse gas emissions relative to conventional meat (Post et al., 2020). Of all foods, moreover, conventional meat is the most

☆ This material is based upon work supported by the National Science Foundation Graduate Research Fellowship Program under Grant No. DGE-2034835. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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https://doi.org/10.1016/j.jenvp.2022.101758
Received 30 August 2021; Received in revised form 3 December 2021; Accepted 11 January 2022
Available online 14 January 2022

common source of life-threatening infections such as *Salmonella* and *Listeria* (Painter et al., 2013). Conventional animal agriculture is also a hotbed for infectious disease outbreaks, and increased reliance on cellular agriculture for cultured forms of meat is vital for avoiding future pandemics (Greger, 2021; Jones et al., 2013). Nevertheless, all of these potential gains would go unrealized if consumers are too disgusted by cultured meat to eat it. Understanding the roots of disgust toward cultured meat could illuminate basic affective processes to be harnessed for societal benefits.

To reap the benefits of cultured meat, consumers who currently eat meat have to replace their conventional meat with cultured alternatives. We posit that while both meat-eaters and vegetarians are inclined to view cultured meat as disgusting, distinct appraisals might underlie each group's feeling of disgust. Understanding these group differences can support efforts to change consumer attitudes and behaviors most effectively. We theorize that whereas meat-eaters may experience disgust predominantly from perceiving cultured meat as unnatural, vegetarians may feel particularly disgusted by the fact that cultured meat comes originally from the body of a living animal. In this sense, we posit that perceptions of cultured meat as too unnaturally *different* from conventional meat and, ironically, too *similar* to it may both underlie disgust toward cultured meat, albeit for different groups of consumers. Although persuading vegetarians to eat cultured meat is not the key to resolving environmental issues, understanding their disgust alongside meat-eaters' disgust can paint a fuller picture of the psychological landscape and ultimately support efforts to replace conventional meat with cultured meat at large.

1. Why might vegetarians Be disgusted by cultured meat?

Intuitively, the prospect of eating cultured meat might seem like a vegetarian's paradise. By bypassing the need to slaughter animals and by reducing the environmental tolls of conventional agriculture, cultured meat is essentially a paragon of the vegetarian cause. Most vegetarians eschew conventional meat for ethical issues (Rosenfeld, 2018) and thus should be delighted to consume meat that evades these harms. Indeed, compared to meat-eaters, vegetarians are more likely to see cultured meat as having benefits over conventional meat (Wilks & Phillips, 2017). Yet despite their more favorable attitudes, vegetarians are paradoxically *less* willing to try cultured meat than are meat-eaters (Bryant & Dillard, 2019; Wilks & Phillips, 2017).

Vegetarians' aversions to cultured meat make sense in light of theoretical perspectives on disgust, which highlight the high potential of animal products to elicit disgust (Angyal, 1941; Hartmann & Siegrist, 2018; Rozin & Fallon, 1987). Animal-derived products may be common triggers of disgust because they traditionally carry higher risks of disease-causing microorganisms. Reminders of a food's animal origin may evoke disgust particularly strongly among vegetarians. Because they abstain personally from meat consumption and feel more moral concern for animals, vegetarians appear sensitized to the connection between the meat people eat and the animals from which meat comes (Fessler et al., 2003; Rosenfeld, 2019; Rozin et al., 1997). The striking resemblance of cultured meat to conventionally produced animal flesh may therefore evoke in vegetarians a strong sense of repulsion. Although cultured meat clearly has a much different symbolic meaning and cultivation history than does conventional meat, sensory-affective processes may be blind to this distinction. Disgust evolved as an instinctive defense strategy and thus drives attitudes and behavior without much conscious reflection (Curtis et al., 2004, 2011; Oaten et al., 2009; Rozin & Fallon, 1987). Affective systems underlying disgust did not evolve to deal with a technology like cellular agriculture. Even if vegetarians recognize the distinction between cultured and conventional meat consciously, the same disgust they feel toward conventional meat may nevertheless apply to cultured meat.

2. Why might meat-eaters Be disgusted by cultured meat?

For meat-eaters, on the other hand, cultured meat may be disgusting not because of its perceived animal origins but due to precisely the opposite: because cultured meat *lacks* conventional animal origin and thus seems unnatural. Many studies highlight that meat-eaters express resistance to trying cultured meat because of its perceived unnaturalness (Siegrist & Hartmann, 2020; Siegrist & Sütterlin, 2017; Tomiyama et al., 2020; Verbeke et al., 2015; Wilks et al., 2021). This resistance exemplifies a naturalistic fallacy, whereby individuals equate unnaturalness with undesirability (Moore, 1903). Judgments about a food's naturalness, notably, stem strongly from the food's production process (Roman et al., 2017; Rozin, 2006), suggesting that cultured meat's laboratory origins may make it seem less natural than conventional meat with farm origins. Compared to vegetarians, meat-eaters are more inclined to believe that humans evolved to consume the flesh of other animals in nature (Piazza et al., 2015). Thus, meat-eaters may be particularly likely to perceive lab-grown cultured meat as violating the natural order. Perceiving a food as unnatural may make it seem disgusting (Siegrist et al., 2018), presumably because unnatural foods seem inherently less desirable, less familiar, and potentially pathogenic; feeling disgusted by unnatural foods may be an adaptive means of inhibiting risky consumption behavior (Curtis et al., 2011).

3. Research aims

Ultimately, we hypothesize that both meat-eaters and vegetarians are inclined to feel disgusted by cultured meat but for different reasons. For vegetarians, disgust likely stems predominantly from animal reminders—associating any type of meat, whether conventional or cultured, with its animal origin. For meat-eaters, disgust likely stems predominantly from perceived unnaturalness—perceiving cultured meat as a violation of how food ought to exist in nature. Divergent cognitive appraisals of cultured meat, we propose, may induce in vegetarians and meat-eaters the same affective disgust response. Identifying the bases of this disgust response may be critical to understanding why people reject cultured meat: a product poised to create a more humane, healthy, and sustainable future.

4. Study 1

Because cultured meat is so novel, we first sought to identify what proportion of people find it too disgusting to eat. We expected a substantial proportion of both vegetarians and meat-eaters to view cultured meat as too disgusting but set no predictions about how disgust might differ between these groups.

4.1. Method

This study's sample size, materials, conditions, exclusion criteria, hypotheses, and analyses were preregistered at https://osf.io/vya2d/?view_only=332040e3854a4d5580ef22aa05b88f53.

4.1.1. Participants

In determining this study's sample size, we considered any disgust difference between vegetarians and meat-eaters of greater than small-medium effect to be meaningful. Accordingly, a power analysis using WebPower specifying a small-medium effect of $h = 0.35$ and equal group sizes revealed that a total sample of 256 participants would provide 80% power at $\alpha = 0.05$, two-tailed. To increase power further and account for attention-check exclusions, we recruited 400 participants (200 vegetarians, 200 meat-eaters) via Prolific. To obtain a valid and balanced sample of vegetarians and meat-eaters, participants were prescreened based on dietary status automatically through Prolific (unknowingly to participants) and reported their dietary status at the end of the survey for confirmation. Given that vegetarians are a very limited demographic,

we recruited participants from two countries—the United Kingdom (n = 377) and the United States (n = 23)—in this study and all subsequent studies in order to achieve our target sample sizes. After excluding two participants who failed an attention check in the survey, 398 remaining participants (95 men, 297 women, 6 other) between the ages of 18 and 79 (M_{age} = 34.32, SD = 11.97) were retained for analyses.

4.1.2. Materials

Cultured Meat Description. The following text provided a brief description of cultured meat, based on descriptions used in previous research (Bryant & Dillard, 2019; Wilks & Phillips, 2017): "Cultured meat is meat grown from animal muscle cells in isolation without the need to raise animals. The world's first cultured meat hamburger was created in 2013. Currently, cultured meat is not publicly available, though it will likely become available in the near future."

Disgust Toward Cultured Meat. Disgust as a barrier to trying cultured meat was assessed by the item, "Cultured meat is too disgusting for me to try eating it," with response options of "agree" or "disagree."

4.1.3. Procedure

After providing informed consent, participants read the description of cultured meat and then completed the disgust measure. At the end of the survey, participants confirmed their dietary status as a vegetarian or meat-eater. This study protocol received Institutional Review Board approval, and informed consent was obtained from all study participants.

4.2. Results

Data and analysis scripts are available at https://osf.io/k3j7b/?view_only=73f6fd03ad494dd896988826c6a8958a.

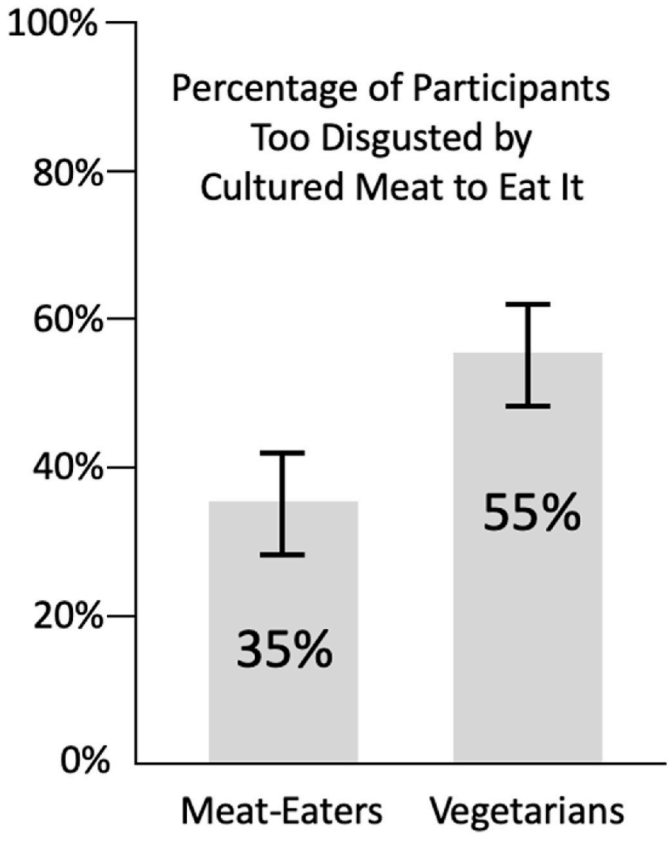

Fig. 1. Percentage of Meat-Eaters vs. Vegetarians Reporting That Cultured Meat is Too Disgusting to Try Eating in Study 1 (Error Bars Indicate 95% Confidence Intervals).

More than one-third of meat-eaters (35%) and more than half of vegetarians (55%) felt too disgusted by cultured meat to try eating it (see Fig. 1). Vegetarians were significantly more likely than were meat-eaters to feel too disgusted, χ^2 (1) = 16.33, p < .001, h = 0.41.

5. Study 2

Results of Study 1 suggest that a substantial proportion of both meat-eaters and vegetarians are too disgusted by cultured meat to try eating it, with vegetarians much more likely to be disgusted than are meat-eaters. Next, we set out to identify the appraisals underlying each of these two groups' feelings of disgust. We hypothesized that participant dietary status would moderate the effects of perceived unnaturalness and animal reminders on disgust, with the effect of perceived unnaturalness larger for meat-eaters (vs. vegetarians) and the effect of animal reminders larger for vegetarians (vs. meat-eaters).

5.1. Method

This study's sample size, materials, conditions, exclusion criteria, hypotheses, and analyses were preregistered at https://osf.io/5hrtg/?view_only=2c0110472e2b4855a1a22286beedd853.

5.1.1. Participants

In determining this study's sample size, we accounted for medium effects of each appraisal on disgust. A power analysis using G*Power 3.1 specifying a medium correlation coefficient of r = 0.30 revealed that a total sample of 84 participants would provide 80% power at α = 0.05, two-tailed. We expected, furthermore, that each appraisal would predict disgust significantly among one group of dieters but not among the other group. Based on guidelines by Giner-Sorolla (2018), which suggest multiplying the estimated main-effect sample size by 4 to detect this type of interaction effect, we estimated an optimal minimum sample of 336. To increase power further in the case of a weaker interaction effect and to account for attention-check exclusions, we recruited a generously powered sample of 600 participants (300 vegetarians, 300 meat-eaters). Participants resided in the U.S. (n = 18) and U.K. (n = 582) and were recruited via Prolific. After excluding 10 participants who failed an attention check in the survey, 590 remaining participants (126 men, 455 women, 9 other) between the ages of 18 and 79 (M_{age} = 34.94, SD = 11.68) were retained for analyses. We followed the same recruitment procedure as in Study 1 to obtain a valid and balanced sample of vegetarian and meat-eaters.

5.1.2. Materials

Cultured Meat Description and Disgust. The description of cultured meat and assessment of disgust toward it were the same as in Study 1, but with a continuous response scale from 1 (not at all) to 7 (extremely much) for disgust.

Perceived Unnaturalness. Perceived unnaturalness of cultured meat was assessed by the following 3-item scale (α = 0.87), developed based on previous research (Piazza et al., 2015; Siegrist et al., 2018): "Cultured meat seems unnatural," "Cultured meat seems artificial," and "Cultured meat is more of a scientific invention than an agricultural product," with responses ranging from 1 (not at all) to 7 (extremely much).

Animal Reminders. Animal reminders of cultured meat were assessed by the following 5-item scale (α = 0.97), developed based on previous research (Rothgerber, 2013): "If I were to eat cultured meat, I would feel like I am eating something from an animal," "Eating cultured meat would feel just like eating part of an animal's body," "If I were to eat a cultured meat burger, I would feel like I am eating something from a cow," "If I were to eat a cultured meat pork chop, I would feel like I am eating something from a pig," "Eating cultured meat would feel like eating the flesh of an animal," with responses ranging from 1 (not at all) to 7 (extremely much).

5.1.3. Psychometric properties of scales

Before collecting data for this study, we conducted a pilot study evaluating the psychometric properties of the perceived unnaturalness and animal reminders scales. Results supported the intended 2-factor structure of the reported scales with strong item performance. Factor loadings are available in Supplementary Material at https://osf.io/4y8vd/?view_only=25c132032e914a028af0a5d765dd5694.

5.1.4. Procedure

After providing informed consent, participants read the description of cultured meat and then completed the measures of perceived unnaturalness and animal reminders in a randomized order. Then, participants completed the disgust measure. At the end of the survey, participants confirmed their dietary status as a vegetarian or meat-eater. This study protocol received Institutional Review Board approval, and informed consent was obtained from all study participants.

5.2. Results

Data and analysis scripts are available at https://osf.io/c9sd4/?view_only=0d81416de4f248179bf786c81fd7107a.

For perceived unnaturalness, our hypothesis was unsupported (see Fig. 2): The interaction effect between perceived unnaturalness and participant dietary status on disgust was not significant, $b = -0.01$, $SE = 0.10$, 95% CI [−0.20, 0.18], $\beta = -0.01$, $t(586) = 0.10$, $p = .918$. Perceiving cultured meat as unnatural was a strong predictor of disgust toward it among both vegetarians and meat-eaters, $b = 0.89$, $SE = 0.05$, 95% CI [0.79, 1.00], $\beta = 0.58$, $t(588) = 17.09$, $p < .001$.

For animal reminders, meanwhile, our hypothesis was supported (see Fig. 3). A significant interaction effect emerged between animal reminders and participant dietary status on disgust, $b = -1.14$, $SE = 0.10$, 95% CI [−1.33, −0.95], $\beta = -0.90$, $t(581) = 11.72$, $p < .001$, such that perceiving cultured meat as having strong cues of its animal origin predicted greater disgust toward cultured meat among vegetarians, $b = 0.69$, $SE = 0.06$, 95% CI [0.09, 0.32], $\beta = 0.53$, $t(296) = 10.62$, $p < .001$, but less disgust among meat-eaters, $b = -0.46$, $SE = 0.07$, 95% CI [−0.60, −0.31], $\beta = -0.35$, $t(285) = 6.28$, $p < .001$.

6. Study 3

Results of Study 2 suggest that perceiving cultured meat as unnatural is likely an underpinning of disgust among both vegetarians and meat-eaters alike. Perceiving cultured meat as having salient animal origin cues, meanwhile, was associated with greater disgust toward cultured meat among vegetarians but less disgust among meat-eaters. These findings mesh with Study 1's results; while perceived unnaturalness may elicit a similar amount of disgust across vegetarians and meat-eaters, that animal reminders may lessen meat-eaters' disgust but amplify vegetarians' disgust could explain why vegetarians on the whole are far more disgusted by cultured meat than are meat-eaters.

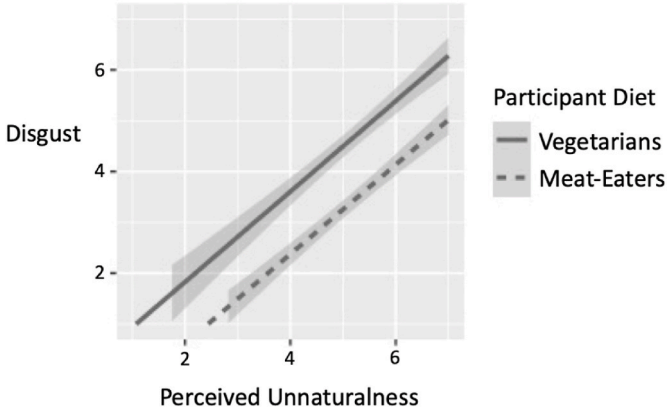

Fig. 2. The relationship between perceived unnaturalness of cultured meat and disgust toward eating it, stratified by participant dietary status, in study 2 (shadows indicate 95% confidence intervals).

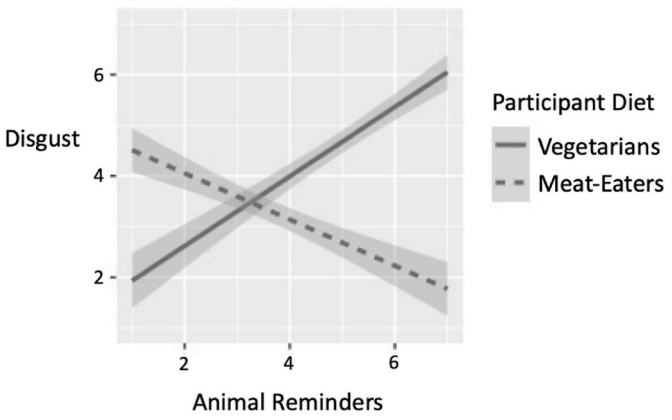

Fig. 3. The relationship between animal reminders of cultured meat and disgust toward eating it, stratified by participant dietary status, in study 2 (shadows indicate 95% confidence intervals).

As Study 2 was correlational, causal inferences from its findings are limited. Accordingly, we manipulated animal reminders in Study 3. We hypothesized that, compared to a control frame, exposure to an animal-reminder frame of cultured meat—a frame depicting cultured meat as perceptually identical to animal flesh—would increase disgust among vegetarians but decrease disgust among meat-eaters.

6.1. Method

This study's sample size, materials, conditions, exclusion criteria, hypotheses, and analyses were preregistered at https://osf.io/7xftv/?view_only=c50c8032e5434c91bfaefd69868c02e0.

6.1.1. Participants

We determined this study's sample size based on the effect sizes observed in Study 2. The interaction effect between dietary status and animal reminders on disgust was an extremely large effect of $\beta = -0.90$, while the simple effect of animal reminders on disgust was a large effect of $\beta = 0.53$ among vegetarians and a medium-large effect of $\beta = -0.35$ among meat-eaters. To maximize our ability to detect all effects of interest, we powered Study 3 based on this smallest observed effect in Study 2 of $\beta = -0.35$. A power analysis using G*Power 3.1 specifying an equivalent effect of $f = 0.37$, numerator $df = 1$, and four study conditions revealed that a total sample of 60 participants would provide 80% power at $\alpha = 0.05$, two-tailed.

We suspected, though, that an experimental manipulation of cultured meat's animal resemblance might have an attenuated effect relative to that observed cross-sectionally. Many meat-eaters feel emotionally attached to eating conventionally animal-based meat and are defensive of this habitual behavior (Graça et al., 2015; Piazza et al., 2015; Rothgerber, 2013), expressing skepticism about cultured meat's taste rivaling that of conventional meat (Wilks & Phillips, 2017). Thus, even though cultured meat is not yet publicly available, consumer attitudes may already be anchored by motivated cognitions, and attempts to convince meat-eaters that cultured meat perceptually resembles animal flesh might have limited persuasion capacity. An animal-reminder frame of cultured meat might likewise yield attenuated effects among vegetarians. Given that most vegetarians eschew meat to support animal rights (Rosenfeld, 2018), vegetarians may already construe meat as the flesh of a formerly living animal instinctively at baseline, leaving limited room for an animal-reminder frame to shift this construal further.

Accordingly, to maximize this study's power so as to detect

approximately small effects ($f = 0.12$), we recruited a generously powered sample of 600 participants (300 vegetarians, 300 meat-eaters). Participants resided in the U.S. ($n = 44$) and U.K. ($n = 556$) and were recruited via Prolific. After excluding one participant who failed an attention check in the survey, 599 remaining participants (142 men, 444 women, 13 other) between the ages of 18 and 79 ($M_{age} = 34.07$, $SD = 12.68$) were retained for analyses. We followed the same recruitment procedure as in Studies 1 and 2 to obtain a valid and balanced sample of vegetarian and meat-eaters.

6.1.2. Materials

Cultured Meat Frame. This study included a control frame and an animal-reminder frame of cultured meat, matched in length to be three sentences each.

The *control frame* was the cultured meat description used in Studies 1 and 2, which read, "Cultured meat is meat grown from animal muscle cells in isolation without the need to raise animals. The world's first cultured meat hamburger was created in 2013. Currently, cultured meat is not publicly available, though it will likely become available in the near future."

The *animal-reminder frame* read, "Cultured meat is meat grown from animal muscle cells in isolation without the need to raise animals. Cultured meat is 100% pure animal flesh, so eating a hamburger made from cultured beef feels like eating something that came directly from a cow. Every single bit of any cultured meat originates entirely from a real living animal."

Disgust. Disgust toward cultured meat was assessed in the same manner as in Study 2.

6.1.3. Procedure

After providing informed consent, participants were randomly assigned to read either the control or animal-reminder frame. After reading one of these frames, completed the disgust measure. At the end of the survey, participants confirmed their dietary status as a vegetarian or meat-eater. This study protocol received Institutional Review Board approval, and informed consent was obtained from all study participants.

6.2. Results

Data and analysis scripts are available at https://osf.io/zm26n/?view_only=498a5fbedd1a495396ab16a280132677.

A two-way analysis of variance (ANOVA) revealed a significant interaction effect between framing condition and participant dietary status on disgust, $F(1, 595) = 4.82$, $p = .029$, $\eta_p^2 = 0.01$ (see Fig. 4). As hypothesized, meat-eaters who read the animal-reminder frame of cultured meat reported less disgust toward cultured meat ($M = 3.03$, $SD = 1.88$) than did meat-eaters who read the control frame ($M = 3.52$, $SD = 1.93$), $F(1, 297) = 4.76$, $p = .030$, $\eta_p^2 = 0.02$ ($d = 0.26$). Meanwhile, vegetarians who read the animal-reminder frame reported slightly more disgust toward cultured meat ($M = 5.08$, $SD = 2.02$) than did vegetarians who read the control frame ($M = 4.83$, $SD = 2.30$), though this difference was not significant $F(1, 298) = 1.00$, $p = .317$, $\eta_p^2 = 0.003$ ($d = 0.12$).

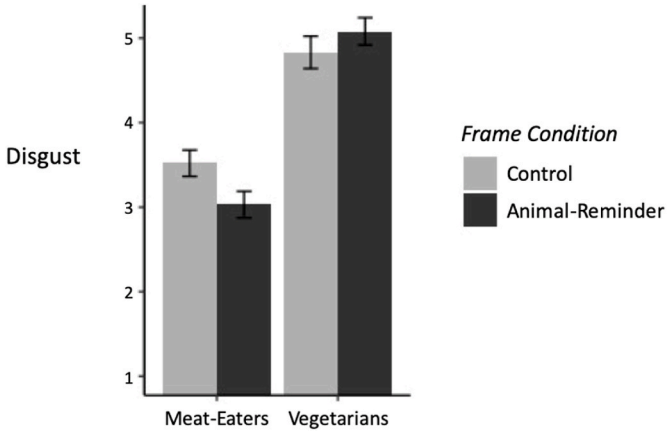

Fig. 4. The effect of animal-reminder framing of cultured meat on disgust toward eating it, stratified by participant dietary status, in study 3 (error bars indicate standard errors; disgust was assessed on a scale of 1–7).

7. General discussion

Producing meat via conventional animal agriculture poses critical threats to humanity and the environment—demanding unsustainable amounts of water, releasing excessive greenhouse gasses, and increasing the risk for future pandemics (Greger, 2021; Jones et al., 2013; Post et al., 2020). Cultured meat—real animal flesh produced via cellular agriculture—offers a promising remedy for these issues and is expected to become widely available to the public in as early as 2023 (Whiting, 2020). Yet a leading barrier to consumer acceptance of cultured meat is that many people perceive it as disgusting (Bryant & Barnett, 2020), undermining the potential for cultured meat to benefit society. As consumer acceptance vs. rejection of cultured meat will ultimately determine its lasting impacts, understanding basic processes surrounding disgust toward cultured meat is vital.

We found evidence suggesting that appraisals underlying disgust operate partially divergently between vegetarians and meat-eaters. Perceiving cultured meat as unnatural was strongly associated with disgust toward it among both vegetarians and meat-eaters, with perceived unnaturalness explaining 34% of variance in disgust. This effect reflects a common naturalistic fallacy of equating unnaturalness with undesirability (Moore, 1903). Normative sentiments prescribe that humans evolved naturally to eat other animals (Piazza et al., 2015), and eating meat from a laboratory seems to violate this law. With an eye toward improving consumer acceptance of cultured meat, we echo other scholars' calls to combat the belief that cultured meat is unnatural (e.g., Siegrist & Hartmann, 2020; Siegrist & Sütterlin, 2017; Verbeke et al., 2015; Wilks et al., 2021), suggesting further that such efforts have potential for efficacy across a wide range of vegetarian and meat-eating consumers.

Whereas perceived unnaturalness was a shared correlate of disgust across dietary groups, vegetarians and meat-eaters differed in their responses to an opposing appraisal: the perception of cultured meat as originating from an animal. Stronger animal-origin reminders of cultured meat predicted less disgust among meat-eaters but more disgust among vegetarians. Moreover, manipulating the animal-origin salience of cultured meat decreased disgust among meat-eaters but had no effect among vegetarians. Vegetarians may be aversely sensitive to the perceived animal origins of food and feel repulsed by this quality (Fessler et al., 2003; Rosenfeld, 2019; Rozin et al., 1997). It was surprising that emphasizing animal-origin qualities of cultured meat did not make vegetarians more disgusted by cultured meat. We suspect that, because most vegetarians eschew meat for animal rights reasons (Rosenfeld, 2018), many vegetarians may instinctively construe meat—whether conventional or cultured—as the flesh of an animal, creating a potential ceiling effect on disgust when it comes to emphasizing animal origins or resemblance.

Meat-eaters, meanwhile, are not simply indifferent to eating something that blatantly stems from animal carcasses but actually appear favorable toward it, feeling less disgust at higher animal-reminder appraisals of cultured meat. Based on these findings, emphasizing the resemblance of cultured meat to animal flesh offers a promising strategy for improving consumer acceptance among meat-eaters. Further research should examine which methods for emphasizing animal resemblance are optimal, such as stressing that all cultured meat originates from the tissue of a living animal, clarifying that cultured meat's

physical properties (e.g., protein structures, iron) are identical to those of conventional meat, or reporting that cultured meat's sensory properties (e.g., flavor, smell, mouthfeel) resemble those of conventional meat. To maximize practical implications, researchers should compare effects of these framing strategies to frames targeting other consumption barriers (e.g., pricing, taste, distrust in scientists, perceived norms) and benefits (e.g., for human health, animal suffering, environmental sustainability) (Bryant & Barnett, 2020; Tomiyama et al., 2020; Wilks et al., 2019).

In manipulating frames of cultured meat, researchers and marketers should be mindful of their target population. Whereas combating beliefs about unnaturalness might improve attitudes across consumer groups, emphasizing cultured meat's animal resemblance could potentially make some vegetarians feel more disgusted and less open to its consumption. From a consequentialist perspective, however, this externality is likely trivial: Vegetarians already eschew meat, and thus there is likely no substantial environmental benefit to be gained from them incorporating cultured meat into their diets. To improve the sustainability of food systems, a goal should be to encourage people who do currently eat meat to replace conventional meat with cultured meat. Beyond vegetarian status, other individual differences may be of interest in studying disgust toward cultured meat, as acceptance of cultured meat varies by consumer gender, age, political ideology, and socioeconomic status (Bryant & Barnett, 2020).

7.1. Strengths and limitations

Strengths of this research include its highly powered designs, use of preregistration, and psychometric evaluation of measures (in Study 2). Another strength of this research is its timeliness, with the possibility to be disseminated before cultured meat becomes widely available for public consumption. By intervening on feelings of disgust while consumer attitudes are still forming, there is likely high capacity to improve consumer acceptance of cultured meat.

A limitation of research on cultured meat in general is that, because cultured meat is a novel food product not yet mainstream, it is impossible to frame cultured meat in a truly neutral way to participants. This issue makes it difficult to estimate experimental framing effects or to gauge baseline consumer attitudes. Simply describing what cultured meat is at the most basic level will likely necessitate some mention of cultured meat's animal origin (e.g., it is animal flesh) and/or convey probable sentiments of unnaturalness (e.g., it is from a lab, Petri dish, or cell culture; it is part of cellular agriculture, etc.). In manipulating animal reminders in Study 2, our control description of cultured meat still mentioned that cultured meat is "animal muscle cells" in order to clarify the basic idea that cultured meat is truly animal-based meat (and not plant-based meat). However, this procedure may have dampened the effect of our manipulation. Moreover, as cultured meat is not yet publicly available, our studies entailed participants imagining how they would feel about cultured meat hypothetically based on written descriptions of what cultured meat is; participants may have reported different attitudes had they been exposed to actual cultured meat.

An additional limitation of our studies pertains to their operationalization of disgust toward cultured meat. Our assessment of disgust captured a combination of two different attitudes: (1) feeling disgusted by cultured meat and (2) willingness to try cultured meat. As a result, when participants indicated being too disgusted to try eating cultured meat, it is difficult to know with full precision whether they (a) found cultured meat disgusting, (b) were unwilling to eat cultured meat, or (c) were unwilling to eat cultured meat *because* it is disgusting. Our aim was to capture the last of these possibilities. An alternative strategy for capturing the endorsement of disgust as a barrier to trying cultured meat is to first ask participants about their willingness to try cultured meat, and then assess possible underlying motives for their (un)willingness (e.g., disgust, unnaturalness, etc.).

Lastly, for generalizability, a limitation of our studies is that, as they consisted only of U.S. and U.K. participants, cross-cultural inferences beyond these countries are restricted. Testing generalizability to other populations is ripe for future research.

7.2. Conclusion

When former science fiction becomes current reality, will people eat meat that is cultured in a Petri dish? Cultured meat offers promising environmental benefits over conventional meat, yet these potential benefits will go unrealized if consumers are too disgusted by cultured meat to eat it. We found that approximately one-third of meat-eaters and more than half of vegetarians reported being too disgusted by cultured meat to try eating it. Perceptions of unnaturalness strongly explained disgust across dietary groups. Among meat-eaters, but not vegetarians, framing cultured meat as resembling animal flesh provides a promising strategy for decreasing disgust. By highlighting divergent correlates of disgust toward cultured meat between vegetarians and meat-eaters, our findings can support targeted efforts toward changing consumer attitudes and behavior. These findings can guide environmental campaigns that seek to encourage cultured meat consumption as an alternative to conventional meat.

Author statement

Author 1 developed the study concept. Both authors contributed to the study design. Author 1 collected and analyzed study data. Author 1 drafted the manuscript, and Author 2 provided critical revisions. Both authors approved the final version of the manuscript for submission.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2022.101758.

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