Effective strategies for overcoming the naturalistic heuristic

Experimental evidence on consumer acceptance of "clean" meat

Bobbie NJ Macdonald[1]
Stanford University
bmacdon@stanford.edu

Eva Vivalt
The Australian National University
eva.vivalt@anu.edu.au

Abstract

The naturalistic heuristic of "what is natural is good" poses a serious barrier to consumer adoption of genetically modified foods, childhood vaccinations, and related technologies. In this study, we examine three messaging strategies — direct debunking, embracing unnaturalness, and descriptive norms — for overcoming consumer resistance in the context of a new food technology: "clean meat" (also known as "cultured" or "in vitro" meat). We compare the effects of these three pro-clean meat appeals against the undermining effects of being exposed to anti-clean meat information from other potential consumers. We find persistent negative effects of anti-clean meat social information over 10 weeks. Of the three pro-clean meat appeals, only the embrace unnaturalness appeal successfully offset the undermining effects of anti-clean meat social information, suggesting that advocates wishing to enhance consumer acceptance of new food technologies should focus on how these technologies are similar to products that also seem "unnatural" but which are already widely adopted by consumers.

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1 Corresponding author. De-identified data and code for this project will be made available at: github.com/bnjmacdonald/antinaturalistic-fallacy. All experimental materials, including the text of the treatments and the survey questions, will also be made available here. This research was approved by the Stanford Institutional Review Board (protocol ID: 39306) and the Australian National University (protocol ID: 2016/613).

1. Introduction

"Clean meat" — i.e. meat products made from cultured animal tissues, also known as "cultured" or "in vitro" meat — has the potential to dramatically reduce the environmental footprint and animal suffering associated with conventional meat production, while also yielding health benefits.[2] However, since clean meat products conflict with the widespread heuristic among consumers that "what is natural is good", these products are at risk of being branded as "artificial" and "lab-grown" in the minds of consumers.[3] This "naturalistic heuristic" — where consumer attitudes are biased in favor of products that are more congruent with their notion of what is "natural" for humans to consume and what kinds of organisms/chemicals occur in the natural environment — is not unique to clean meat. Genetically modified (GM) foods, vaccines, and other technological advances have faced similar barriers to acceptance in the general public.[4] Making matters worse, the expected benefits of clean meat are temporally distant (e.g. avoiding catastrophic climate change) and spatially removed (e.g. reducing animal suffering in factory farms, preventing deforestation), making it difficult for consumers to incorporate these benefits into their decision-making calculus.[5]

In this study, we: (a) show that consumer wariness of clean meat is driven far more by concerns about whether clean meat products are natural and healthy — which are symptoms of the naturalistic fallacy — than how clean meat products taste or how much they cost; (b) examine whether a *debunking*

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2 For recent media coverage of clean meat products, see for instance, Garfield (June 27, 2017), Ferdman (May 20, 2015), Addady (February 02, 2016), Stone (May 27, 2016).

3 For a systematic review of research on the importance of "food naturalness" to consumers, see Roman et al. 2017.

4 For research on public acceptance of GM foods, see Lusk et al. 2015, Siegrist 2008, Costa-Font et al. 2008, Saher et al. 2006, Frewer et al. 1996. On vaccines, see Miton and Mercier 2015, Yaqub et al. 2014, Nyhan et al. 2014. On the use of nanotechnology in food packaging and production, see Siegrist et al. 2009, Siegrist et al. 2007. On other topics, see Runge et al. 2017, O'Keefe et al. 2016, Rollin et al. 2011, Frewer et al. 2011, Siegrist 2008.

5 For reviews of existing research on individual decision-making with temporally and/or spatially distant consequences, see Wade-Benzoni and Tost 2009, Markowitz and Shariff 2012.

unnaturalness appeal, *embracing unnaturalness* appeal, or *descriptive social norm* appeal is more effective at increasing consumer acceptance of clean meat products over a 10 week observation period; and (c) examine how susceptible consumer attitudes are when exposed to negative reactions from other potential consumers towards clean meat products. Based on a three wave survey experiment conducted over 10 weeks, we show that the *embrace unnatural* appeal led to a sustained increase in consumer willingness-to-pay and interest in clean meat over the entire study period, while the *debunking unnatural* and *descriptive social norm* appeals produced only short-term improvements in consumer attitudes. Importantly, the positive effects of the *embrace unnatural* appeal are strongest on consumers who were *least* interested in clean meat products at baseline, suggesting that this messaging strategy can be an effective tool for changing the minds of skeptical consumers. Finally, on a less encouraging note, we show that being exposed to negative reactions about clean meat from complete strangers significantly undermines acceptance of clean meat, with these effects persisting for the entire study period.

This study makes three contributions. First, we provide disconcerting evidence about the asymmetric effectiveness of pro- vs. anti-adoption appeals towards new technologies, such that extremely small amounts of anti-adoption information led to sustained reductions in consumer acceptance of clean meat, while two of the three pro-adoption appeals had no discernible effects after 10 weeks. Existing research has already cast a pessimistic light on the potential for correcting misinformation and improving public acceptance of vaccines and other technologies through informational appeals, particularly appeals aimed at debunking misperceptions (Nyhan and Reifler 2015, Nyhan et al. 2014, Lewandowsky et al. 2012). Yet results extend this literature by showing that the ineffectiveness of direct debunking strategies extends to novel technologies (such as clean meat) for which consumer attitudes have not yet crystallized. In addition, we add to this literature by demonstrating asymmetric information effects, such that consumer attitudes are particularly susceptible to small amounts of anti-adoption information that activates the naturalistic heuristic.

Second, on a more optimistic note, we provide evidence that an *embracing unnaturalness* messaging strategy can be effective at improving public acceptance of new food technologies. This messaging strategy leverages consumers' mental models and "cultural intuitions" (Miton and Mercier 2015, Ecker et al. 2011, Johnson and Seifert 1999) about what is healthy/safe to consume, effectively equating clean meat products with other products consumers have already become accustomed to. Third, this is one of the first studies to provide direct evidence that consumer acceptance of clean meat products is much more strongly related to concerns about the health and naturalness than conventional concerns about price and taste. As a result, the "naturalistic fallacy" is likely to be a serious barrier to public acceptance as clean meat products begin to enter the market.

2. Materials and methods

2.1 Data collection and experimental conditions

This study was organized as a randomized 2x4 full factorial design consisting of three survey waves over an 11 week period using respondents from Amazon Mechanical Turk (MTurk). The experimental conditions and survey waves are described below. This study was pre-registered with the American Economic Association (AEA) Randomized Controlled Trial (RCT) registry and a pre-analysis plan posted at the Open Science Framework (OSF).

Wave 1 (Baseline survey). First, participants were asked to complete a 10 minute survey containing questions on demographics, current levels of meat consumption, attitudes, and potential moderators. All participants were provided with information about what the term "clean meat" refers to, what makes clean meat different than conventional meat production, and what some of the purported environmental, health, and ethical benefits of consuming clean meat products are. This information was meant to familiarize participants with clean meat products, since the term is not yet common knowledge.

Wave 2 (Treatment exposure and immediate reactions). Approximately one week after completing the baseline survey, the same participants were recontacted and asked to complete a second online survey. At this stage, participants were randomly assigned to: (a) either receive anti-acceptance social infor-

mation or not; and (b) read one of four half-page appeals. Participants assigned to receive anti-acceptance social information were shown a web page listing five short quotes from previous survey respondents expressing negative sentiment about clean meat (e.g. "This seems very unnatural. I don't feel comfortable about this.", "Artificial meat sounds disgusting"). These quotes were extracted from a separate survey on clean meat attitudes and were the same for all participants assigned to read the quotes. Participants who were not assigned to receive anti-acceptance information were shown nothing instead.

All participants were then randomly assigned to read one of four articles: a *placebo* message, *debunking unnatural* appeal, *embrace unnatural* appeal, or a *descriptive norm* appeal. Each message was approximately 150-200 words in length, with three images that helped to convey the main message. The *placebo* message urged participants to walk more, making no mention of clean meat products or meat consumption. The *debunking unnatural* appeal is similar to the "mis-perception correction" messaging strategy commonly used to combat anti-vaccination beliefs.[6] Specifically, this appeal invokes the naturalistic heuristic in order to argue against its application in the case of clean meat products, pointing out that some seemingly "natural" compounds are clearly bad (e.g. arsenic) while other seemingly "unnatural" products clearly have positive benefits (e.g. antibiotics). Despite the widespread use of this messaging strategy, there is little evidence that such corrections are effective at countering negative attitudes/beliefs (Nyhan and Reifler 2015, Nyhan et al. 2014).[7] It is not clear, however, whether the ineffectiveness of this messaging strategy extends to new technologies — such as clean meat products — in which consumers have not had sufficient exposure to form crystallized opinions.

While the *embrace unnatural* also draws attention to the naturalistic heuristic, it is different in emphasis. Rather than debunking the naturalistic heuristic, the *embrace unnatural* appeal emphasizes how clean meat products are similar to many other seemingly "unnatural" foods that have already been widely accepted by consumers, thereby encouraging readers to add clean meat products to the set of prod-

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6 See, for instance: World Health Organization 2017, New York State Department of Health 2012.

7 cf. Dixon et al. 2015.

ucts they deem acceptable. Specifically, the *embrace unnatural* appeal describes how nearly all foods we eat today have been artificially engineered through selective breeding and other practices such that they no longer resemble their naturally occurring ancestors. This appeal is designed to more directly align clean meat products with consumers' intuitions about whether clean meat is likely to be beneficial to their health, thereby making it easier to accept the counter-intuitive conclusion that clean meat is a safe and healthy product despite its seemingly "unnatural" qualities.[8] From a cognitive dissonance perspective, this messaging strategy frames an individual's decision to orient their attitudes favorably towards clean meat as the path of least resistance in resolving the dissonance. In order to rationalize continued skepticism towards clean meat products when faced with this *embrace unnatural* messaging strategy, individuals would need to find a way of explaining their past consumption of many products that seem patently "unnatural", making it easier to instead add one more item to the set of "hard to view as 'natural', but probably still safe and healthy" products. In a similar vein, whereas the *debunking unnatural* appeal seeks to shatter readers' mental model of what is healthy/safe to consume without providing an alternative narrative, the *embrace unnatural* approach helps to maintain coherence in readers' mental models, asking readers to recognize that there are many exceptions to the naturalistic heuristic without asking them to abolish the heuristic altogether. [9]

Finally, the *descriptive norm* appeal conveys a descriptive social norm that many consumers are excited about clean meat and would like to try it once it becomes available in their area. This appeal makes no persuasive effort to debunk the naturalistic heuristic or to communicate the benefits of clean meat. The effectiveness of social norm appeals have been documented in a variety of domains. [10] In the case

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8 For a discussion of how "culturally shared intuitions" — such as the naturalistic heuristic — may affect beliefs towards vaccines and similar technologies, see Miton and Mercier 2015.

9 For a review of research on the importance of mental models in misinformation correction, see Lewandowsky et al. 2012.

10 See, for instance, Steg and Vlek 2009, Gerber et al. 2008, Goldstein et al. 2008.

of clean meat products, descriptive information about others' attitudes and behaviors should be especially important when considering new products and technologies that appear risky, since a large base of early adopters provides an important signal to other consumers that the products are healthy and safe.

Immediately after reading the article, all participants completed a short survey eliciting their reactions to the article, willingness to pay for clean meat products, interest in clean meat products, and other outcome measures as described in Section 2.2.

Wave 3 (Endline survey). Approximately 10 weeks after completing the treatment exposure survey, the same participants were recontacted and asked to complete a followup survey. The followup survey elicited participants' willingness to pay for clean meat products, interest in further information about clean meat products and vegetarian products, attitudes towards clean meat, and other outcome measures as described in Section 2.2.

Survey attrition. Following the baseline survey, we recontacted participants via email. We recruited 3200 participants (400 per cell for the 4x2 experiment), of which there were 3157 valid survey responses in the baseline survey wave. 2623 respondents completed the treatment survey wave (83.1%) approximately one week after baseline, while 1515 respondents completed the endline survey wave (48.0%) approximately ten weeks following treatment exposure. Figure 8 (Appendix) displays the balance across experimental arms among respondents who completed all three survey waves, showing that this attrition did not lead to any substantial imbalances between experimental arms on pre-treatment outcomes or other variables of interest.

2.2 Outcome measures

All variables described in this section were measured in the baseline, treatment, and endline survey waves, unless otherwise stated. For the analyses reported in Section 3, all dependent variables are standardized to have mean equal to zero and variance equal to one, with the exception of dichotomous variables which we leave unstandardized. We measure respondents' behavioral intentions and attitudes towards clean meat as follows:

Willingness to pay for clean meat. We infer participants' willingness to pay for clean meat from a discrete choice experiment at the end of the treatment survey. Respondents were presented with sets of descriptions of two or three different products, each consisting of a set of 2 attributes: (a) Product: clean meatballs, vegetarian meatballs, conventional meatballs; (b) Price per lb: $5, $10, $15, or $20. A full factorial design accounting for all interactions among those exposed to information about clean meat consists of 12 different combinations (3 products x 4 prices). We asked respondents to answer one of two alternative blocks of 6 questions (randomly assigned).

Interest in clean meat. We collect several attitudinal measures on attitudes towards clean meat: "how interested are you in purchasing the clean meat product you just read about?" (*interest purchase*, 1-5 scale from "not interested at all" to "extremely interested"), "Would you eat this product?" (*would eat*, 1-5 scale from "definitely not" to "definitely yes"), and "How do you feel about clean meat products?" (*feel*, 1-7 scale from "extremely negative" to "extremely positive").

Concerns about clean meat. We provided participants with a list of five potential concerns about clean meat products — unhealthy, unnatural, unsafe, taste, and price — and asked them to select all that apply. Participants were also permitted to select "I have no concerns" or to enter another concern not listed.

Perceived benefits of clean meat. We provided participants with a list of six potential benefits of clean meat products — healthier, safer, more environmentally sustainable, may reduce farm animal suffering, tastier, and cheaper — and asked them to select all that apply. Participants were also permitted to select "I foresee no benefits" or to enter another benefit not listed.

3. Results

3.1 Naturalistic reasoning undermines clean meat acceptance

Before examining effective strategies for overcoming consumer resistance to clean meat products, we must better understand the extent to which consumer concerns about the naturalness, safety, and health effects of clean meat products outweigh more conventional concerns such as taste and price. To do so, we

trace how changes in self-reported interest in clean meat products between waves 1 and 3 correlate with changes in concerns about the unnaturalness, safety, health effects, taste, and cost of these products over the same time period.

Figure 1 displays these results, showing that consumers who become concerned about clean meat's naturalness, health effects, and/or safety between waves 1 and 3 became substantially less interested in clean meat products over the same time period. Specifically, becoming concerned about the naturalness of clean meat is associated with a 0.3 standard deviation decrease in *would eat* ($p < 0.001$) and a 0.1 standard deviation decrease in *interest purchase* ($p < 0.01$). In contrast, changes in concerns about taste are only weakly related to interest in clean meat products, while individuals who reported becoming more concerned about cost between waves 1 and 3 became *more* interested in clean meat products.[11]

The importance of perceived naturalness, safety, and health consequences of clean meat products is also reflected in the open-ended responses of many study participants, such as:

> Respondent A: "Gross me out — no way will I eat this stuff."
>
> Respondent B: "I don't like the idea of artificially engineering food products."
>
> Respondent C: "I just can't get past the whole 'unnatural', 'eating a science experiment' brain block."

Despite these concerns, there were also a great deal of positive reactions to clean meat products. At the end of the baseline survey (wave 1), 32.7% of all respondents entered their email address in order to be notified when clean meat products become available in their area. In addition, 48.1% of respondents

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11 This counterintuitive finding may be an artifact of the survey question design, such that respondents with strong negative reactions towards clean meat would have been drawn towards the response options for "unnatural", "unsafe", and "unhealthy" (crowding out attention to "price" and "taste"), while respondents who either felt indifferent or positive towards clean meat may have gravitated towards price as a de facto concern when no other concerns were particularly salient.

answered "probably yes" or "definitely yes" to whether they would eat a clean meat product, while 45.4% of respondents said that they were "very interested" or "extremely interested" in purchasing clean meat products.[12]

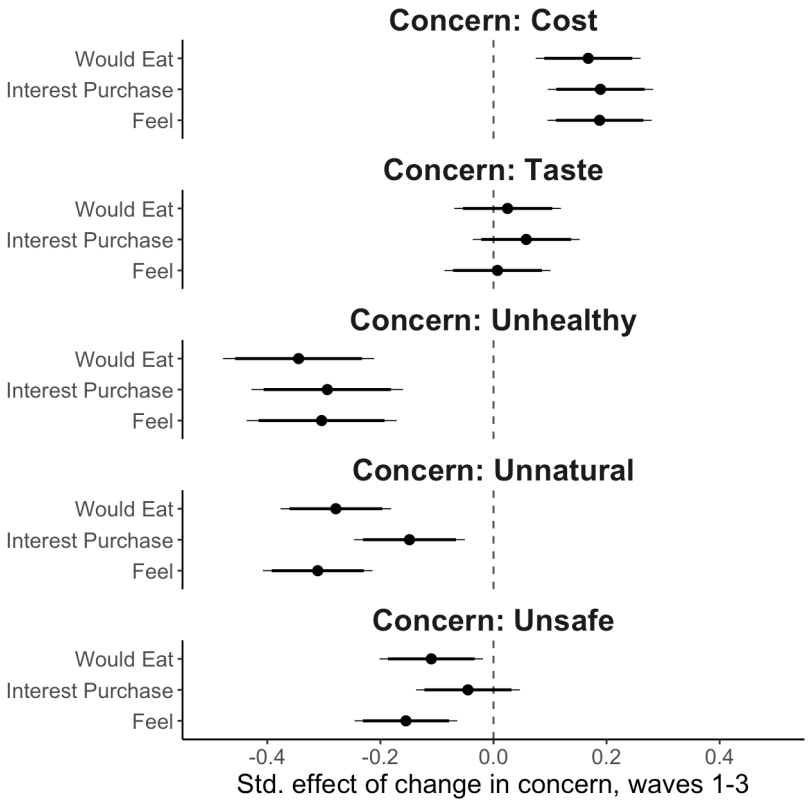

Figure 1. Link between concerns about clean meat and interest in clean meat. Displays estimated standardized effects of a change in concerns about clean meat between waves 1 and 3 on corresponding change in interest in clean meat. Estimates are produced from a simple linear regression of each measure of interest in clean meat on dichotomous indicators representing each concern, as well as controls for baseline demographics and self-reported meat consumption. Dependent variables include: *would eat* ("Would you eat this product?", 1-5 scale), *interest purchase* ("how interested are you in purchasing the clean meat product you just read about?", 1-5 scale), and *feel* ("How do you feel about clean meat products?", 1-7 scale). Dependent variables are standardized to have mean equal to zero and variance equal to one. Horizontal bars represent 90% and 95% confidence intervals.

12 Figure 9 in the Appendix contains further information on these descriptives.

3.2 Effects of pro-clean meat appeals

How effective are pro-clean meat appeals — either based on direct debunking, embracing unnaturalness, or conveying descriptive social norms — at generating sustained improvements in consumer acceptance of clean meat products? We show that while all three appeals led to encouraging short-term improvements in consumer acceptance of clean meat products, these effects only persisted over the full 10 week post-treatment period for the *embrace unnatural* appeal. Figure 2 displays the effects of the *debunking unnatural*, *embrace unnatural*, and *descriptive norm* appeals on respondents' marginal willingness-to-pay for clean meat products. We estimate marginal willingness-to-pay from the discrete choice experiment (see Section 2.2) using conditional logistic regression, in which the dependent variable is a dichotomous variable y_{ijk}, representing whether or not respondent i selected alternative k in choice task j. The model specification is:

$$g(y_{ijk}) = \beta_1 \text{clean} + \beta_2 \text{veg} + \beta_3 \text{cost} + \alpha_{ij} \quad (1)$$

in which $g(\cdot)$ is the inverse logit link, *clean* is a dichotomous indicator representing whether the alternative is clean meatballs, *veg* is a dichotomous indicator representing whether the alternative is vegetarian meatballs, *cost* is the cost of the alternative ($5, $10, $15, or $20), and α_{ij} represents a fixed intercept for each respondent-choice strata. We estimate the β's using maximum likelihood, and then construct marginal willingness-to-pay estimates for clean meat as the ratio β_1 / β_3 and marginal willingness-to-pay estimates for vegetarian meatballs as the ratio β_2 / β_3.[13]

Results for respondents' marginal willingness-to-pay for clean meatballs relative to conventional meatballs, as well as vegetarian meatballs versus conventional meatballs, are displayed in Figure 2 for both wave 2 (measured immediately after treatment exposure) and wave 3 (10 weeks following treatment exposure). The left panel displays marginal willingness-to-pay among respondents assigned to each of the three treatment appeals and the placebo appeal, while the right panel displays marginal willingness-to-

13 We estimate standard errors using the Delta method.

pay among respondents exposed versus not exposed to the anti-acceptance social information treatment. Each point estimate in Figure 2 represents respondents' estimated marginal willingness-to-pay for clean (or vegetarian) meatballs relative to conventional meatballs, where negative willingness-to-pay estimates indicate that the clean meatballs would need to be $*x* cheaper in order for respondents to select clean meatballs over conventional meatballs. Values closer to zero (i.e. to the right in Figure 2) represent a higher marginal willingness-to-pay.

The *embrace unnatural* significantly increased respondents' willingness-to-pay for clean meat products relative to placebo, which persisted over the entire 10 week followup period. This difference is substantively large: whereas participants who read the placebo article would, on average, need cultured meatballs to be $5.2 cheaper than conventional meatballs in order to prefer the former (95% CI: 6.1, 4.2), respondents who read the *embrace unnatural* appeal needed only $3.4 on average (95% CI: 4.2, 2.6). Moreover, given that the *embrace unnatural* appeal led to no detectable increase in willingness-to-pay for vegetarian meatballs (relative to readers of the placebo appeal), this finding is unlikely to be a product of social desirability alone.

In contrast, the *debunk unnatural* appeal had no significant effects on willingness-to-pay for clean meatballs, whether measured immediately after treatment exposure or 10 weeks later. Finally, while the *social norms* appeal led to the largest *initial* gains in willingness-to-pay (as measured in wave 2), these effects had largely dissipated by the followup survey 10 weeks later. Nevertheless, the *social norms* appeal continued to produce moderate improvements in willingness-to-pay over this time span.

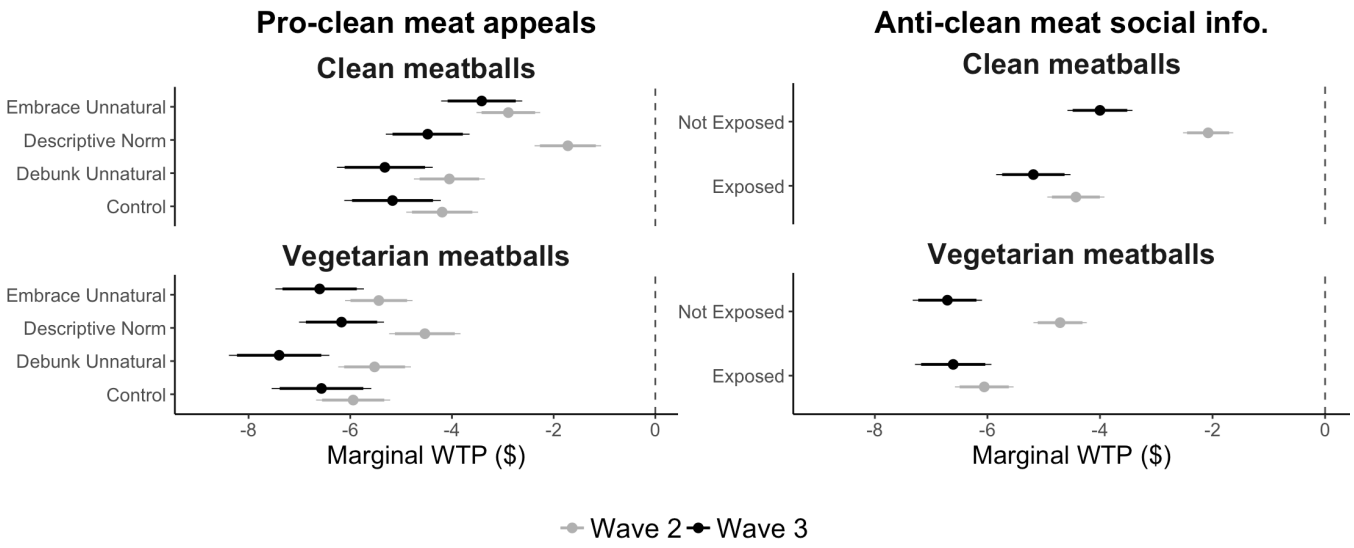

Figure 2. Treatment effects (willingness-to-pay). Displays the marginal willingness-to-pay relative to conventional meatballs for respondents in each experimental cell, with results shown separately for waves 2 and 3. A value of 0 on the x-axis indicates that respondents were indifferent between clean (or vegetarian) meatballs and conventional meatballs. Horizontal bars represent 90% and 95% confidence intervals. Results estimated using conditional logistic regression.

Figure 3 supplements these results with estimated effects of the three treatment appeals on three attitudinal measures of interest in clean meat — *would eat*, *interest purchase*, and *feel* — as well as five dichotomous concerns about clean meat and six dichotomous perceived benefits of clean meat. We estimate the average treatment effects (ATE) of each pro-clean meat appeal by comparing the *change* in each outcome variable y since wave 1 across respondents who read the treatment appeal versus respondents who read the placebo appeal. We estimate the effects of anti-acceptance social information in the same way. Results are shown separately for wave 2 and wave 3 measurements.

As shown in Panels 1-3 of Figure 3, all three pro-clean meat appeals led to initial improvements in consumer interest in clean meat between waves 1 and 2 (relative to the placebo article). As intended, the *debunk unnatural* and *embrace unnatural* appeals also led to decreases in concerns about whether clean meat products are unnatural.[14]

However, these encouraging effects of the *debunking unnatural* and *descriptive norms* appeals were short-lived. By the 10 week followup study, consumer interest in clean meat across all three measures was no higher among respondents reading either of these appeals relative to respondents who read the placebo appeal. In addition, respondents who read these two appeals were no longer any less likely to raise concerns about the naturalness, safety, or health consequences of clean meat products compared to respondents who read the placebo appeal.

Were the positive effects of the embrace unnatural concentrated among individuals who were already sympathetic towards clean meat products? In the supplementary materials (Figure 6), we estimate treatment effects separately for individuals who reported "low", "neutral", and "high" levels of interest in clean meat in the baseline survey. We find that the positive effects of *embrace unnatural* are concentrated among the respondents who were *least* interested in clean meat products at baseline. This result adds support to the idea that the *embrace unnatural* appeal works by offering a low dissonance solution to accepting clean meat products, since we would expect the least interested consumers to experience the most dissonance from being encouraged to consume clean meat products. In addition, this result is encouraging, suggesting that the *embrace unnatural* appeal is best suited for combating the pernicious effects of anti-acceptance social information, given that anti-acceptance social information had the largest effects on the least interested consumers.

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14 The *social norms* appeal also led to a non-trivial reduction in the number of respondents raising the "unnatural" concern, yet this effect does not reach conventional levels of statistical significance. The *embrace unnatural* and *social norms* appeals may have also led to sizable reductions in concerns about the safety of clean meat, which should be expected given that the former emphasizes that clean meat is not very different from many other safe food products and the latter normalizes clean meat products by emphasizing widespread consumer excitement about their availability. However, these effects do not reach conventional levels of statistical significance.

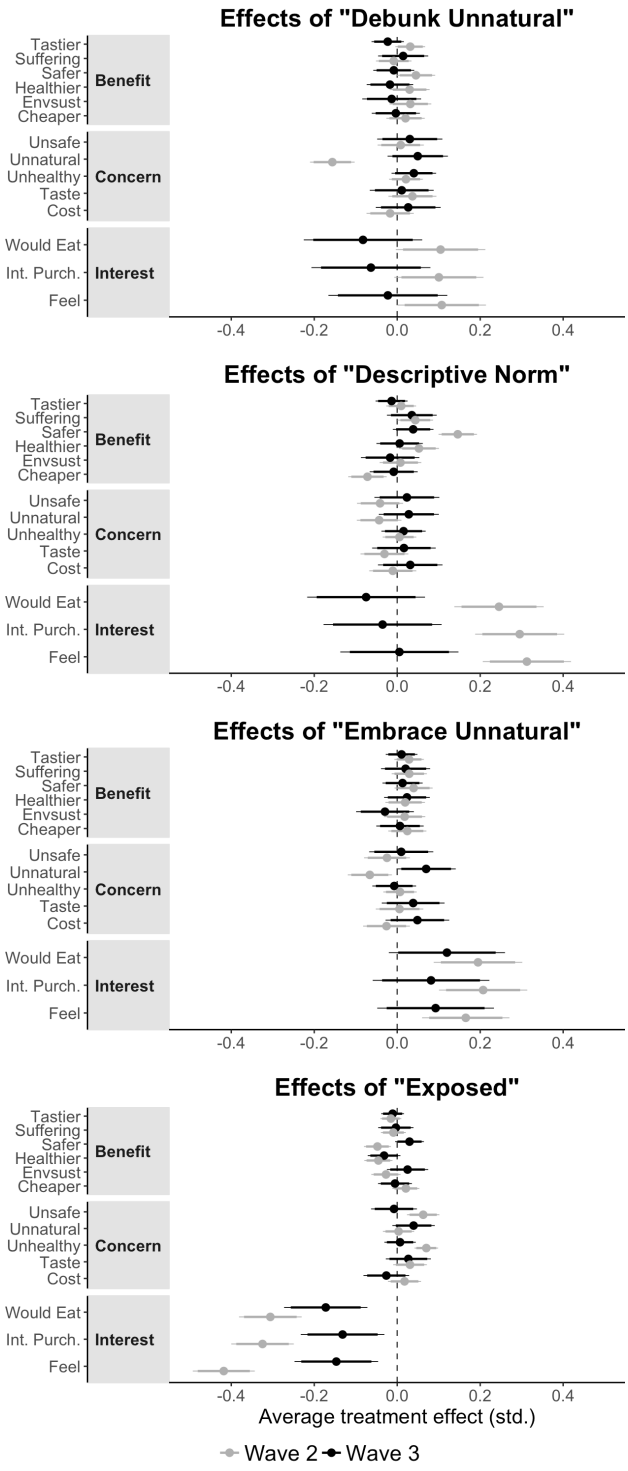

Figure 3. Treatment effects on interest, concerns, and perceived benefits. Displays average treatment effects (ATEs) for each treatment arm relative to control across three groups of outcomes: interest in clean meat, concerns about clean meat, and perceived benefits of clean meat. Panel 1 (top) displays treatment effects of the *debunk unnatural* appeal; Panel 2 displays treatment effects of the *descriptive norm* appeal; Panel 3 displays treatment effects of the *embrace unnatural* appeal;

Panel 4 (bottom) displays treatment effects of exposure to negative social information. The "concerns" and "benefits" variables are dichotomous, representing whether a respondent raised the concern/benefit (*y=1*) or not (*y=0*). Interest variables include: *would eat* ("Would you eat this product?", 1-5 scale), *interest purchase* ("how interested are you in purchasing the clean meat product you just read about?", 1-5 scale), and *feel* ("How do you feel about clean meat products?", 1-7 scale). The three interest variables are standardized to have mean equal to zero and variance equal to one. All dependent variables are measured in terms of the change since wave 1. Treatment effects are shown for wave 2 (immediately after treatment exposure) and wave 3 (10 weeks after exposure) separately. Points represent ATEs, surrounded by represent 90% and 95% confidence intervals.

In contrast, respondents exposed to the *embrace unnatural* appeal remained somewhat more likely to report increases in interest in clean meat after 10 weeks relative to the placebo group, whether measured in terms of *feel*, *would eat*, or *interest purchase*.[15] While these effects do not reach conventional levels of statistical significance at the 10 week followup period, they are consistent with the willingness-to-pay results reported above.[16]

In short, the *embrace unnatural* appeal is the only appeal for which we find consistent evidence of a persistent improvement in consumer acceptance of clean meat products for as long as 10 weeks following treatment exposure. While the *descriptive norms* appeal had encouraging enduring effects on marginal

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15 At the same time, the *embrace unnatural* appeal's dampening effects on concerns about the naturalness of clean meat in wave 2 reversed sign by wave 3, such that respondents became more likely to cite naturalness as a concern. It is possible that the *embrace unnatural* appeal partly severed the negative relationship between concerns about naturalness and interest in clean meat, however this possibility requires more careful scrutiny in future work.

16 In the supplementary materials, we explore whether the effectiveness of the three pro-clean meat appeals varies according to whether or not respondents were exposed to anti-acceptance information immediately before reading the pro-clean meat appeal. As in the findings reported here, we find that the *embrace unnatural* is the only appeal to lead to enduring effects regardless of whether we restrict the analyses to respondents that were exposed or not exposed to anti-acceptance information.

willingness-to-pay, these positive effects were not mirrored in our attitudinal measures of interest in clean meat. Finally, the *debunk unnatural* appeal failed to have any enduring effects on consumer acceptance of clean meat.

3.3 Effects of negative social information

How contagious are the anti-clean meat attitudes of wary consumers? As described in Section 2.1, respondents were randomly assigned to be exposed or not exposed to anti-acceptance social information at the beginning of the treatment wave, consisting of five short quotes from respondents to a previous survey expressing negative sentiment towards clean meat (e.g. "Our guts are not meant to digest unnatural things"). We examine the effects of anti-clean meat social information on willingness-to-pay, interest, concerns, and perceived benefits using the same methods described in Section 3.2 above. The results are displayed alongside the appeal effects in Figure 2 (right column) and Figure 3 (bottom panel).

Overall, there is strong evidence that negative social information undermined respondents' marginal willingness-to-pay for clean meat and interest in clean meat, with these effects persisting over the 10 week post-treatment study period. In wave 2, negative social information decreased respondents' marginal willingness-to-pay for clean meatballs versus conventional meatballs from –$2.1 (95% CI: 2.5, 1.6) to –$4.4 (95% CI: 4.9, 3.9). These effects remained large in the 10 week followup survey: respondents exposed to negative social information in wave 3 would have needed clean meatballs to be $5.2 less expensive than conventional meatballs in order to prefer the former (95% CI: 5.8, 4.5), while unexposed respondents only needed clean meatballs to be $4.0 less expensive on average (95% CI: 4.6, 3.4). Negative social information also led to a significant reduction in respondents' interest in clean meat after 10 weeks, whether measured in terms of *feel*, *interest purchase*, or *would eat*. These results are disconcerting, showing that extremely weak forms of anti-acceptance social information — as in the form of five short quotes from completely anonymous individuals — can lead to enduring downward shifts in consumer acceptance of new food technologies. Even worse, these negative effects persist despite the fact that most respondents in our study were asked to read a pro-clean meat appeal immediately after exposure to the anti-acceptance social information.

Finally, in the supplementary materials, we show that anti-acceptance social information has little persistent effect on individuals who were already very interested in clean meat at baseline (bottom row of Figure 6). Instead, anti-acceptance social information undermines interest in clean meat among respondents with low to moderate levels of existing interest in clean meat products. On the one hand, this result is encouraging, suggesting that once consumers have been won over, then they are more resilient to negative coverage of new food technologies. On the other hand, high levels of susceptibility to anti-acceptance social information among consumers with low to moderate interest in clean meat amplifies the challenge of converting skeptics into regular consumers of clean meat products.

4. Concluding remarks

While clean meat products are likely to be available in stores in the next five years, very little research has examined how consumer attitudes towards clean meat products are shaped by short snippets of information exchanged in social networks and what kinds of pro-clean meat messaging campaigns can be effective at generating sustained increases in consumer acceptance. In this study, we have introduced three main sets of findings, which are of broad relevance to scholars studying how individuals form opinions and make choices regarding new products and technologies. First, we showed that consumers' wariness about clean meat is driven far more by concerns about whether clean meat is natural and healthy than how clean meat products taste or how much they cost. Second, we showed that the *embracing unnatural* appeal led to sustained increases in consumers' willingness-to-pay and interest in clean meat over a 10 week period, while the positive effects of the *debunking unnatural* and *descriptive norms* appeals were short-lived. Third, in stark contrast to the ineffectiveness of these two latter appeals, we showed that small snippets of negative social information about clean meat from complete strangers undermines consumer acceptance of clean meat products substantially, and that these effects persist for at least 10 weeks.

On the one hand, these findings are disconcerting. The ineffectiveness of “misperception correction” and “direct debunking” appeals at shifting public attitudes has been well-documented in a variety of domains where attitudes are crystallized and/or deeply polarized, yet our findings go a step further by

showing that this approach is ineffective even in domains where many individuals have not had sufficient exposure to form strong opinions. Making matters worse, we show that potential consumers are susceptible to extremely small amounts of negative information from complete strangers. Hence, while successfully debunking the naturalistic heuristic remains a significant challenge, fueling it apparently does not. This finding is particularly disconcerting in light of the dramatic increase in consumers' access to negative social information through social media and other online sources. For new technologies such as clean meat that appear risky in the minds of many consumers, this access to anti-acceptance social information can easily undermine concerted informational campaigns by pro-acceptance advocates.

On the other hand, our results provide optimism that an *embrace unnatural* messaging strategy can be effective at generating sustained improvements in public acceptance for clean meat products. By leveraging the fact that individuals already consume a wide range of products that they would struggle to rationalize as “natural”, this messaging strategy nudges potential consumers towards adding clean meat products to their mental category of safe and healthy products as the easiest way to resolve internal dissonance. It is unclear whether the efficacy of this messaging strategy is limited to new technologies for which consumers have had little previous exposure. Nevertheless, these findings should be of broad interest to advocates of childhood vaccinations, GM foods, and other technologies that face substantial public resistance via the naturalistic heuristic.

Appendices

Appendix A: Supplementary figures

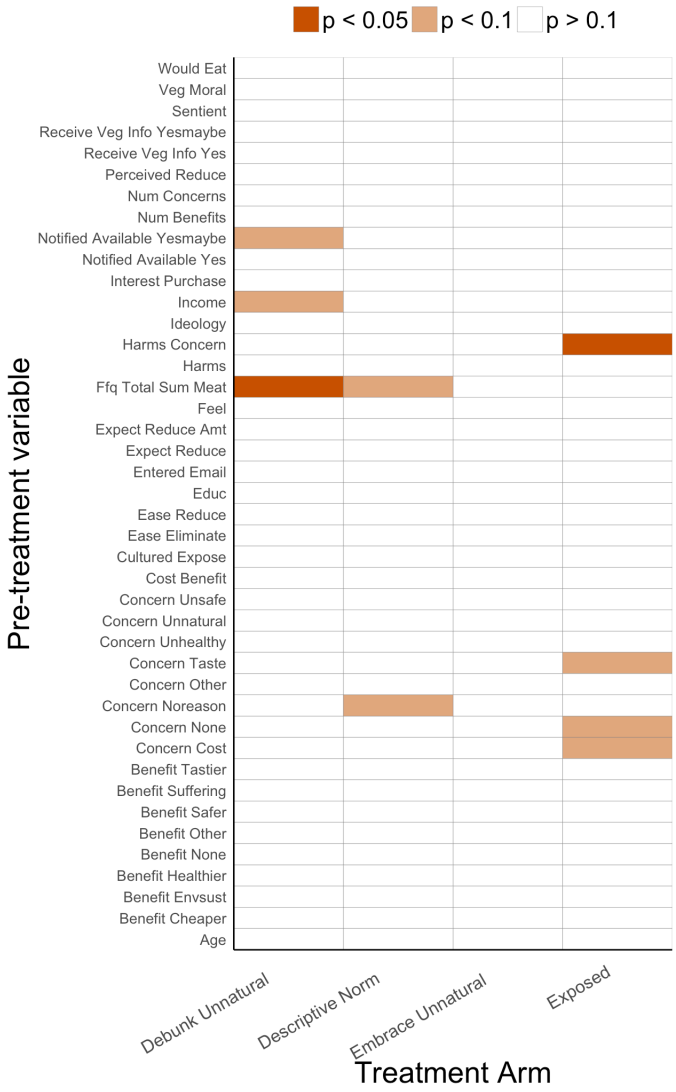

Figure 4. Experimental balance on pre-treatment variables. Displays pre-treatment balance on variables measured in wave 1 among respondents who completed all three survey waves (n=1515). Each cell represents the p-value for a t-test in the difference in means between the control group and the experimental arm (x-axis) on a particular variable measured at baseline (y-axis). As shown, the experimental arms are well balanced with the control group on nearly all pre-treatment co-variates. While there is some imbalance in self-reported servings of meat at baseline in the *debunk unnatural* and *descriptive norm* arms, correcting for this difference does not change the results reported above in any substantive way.

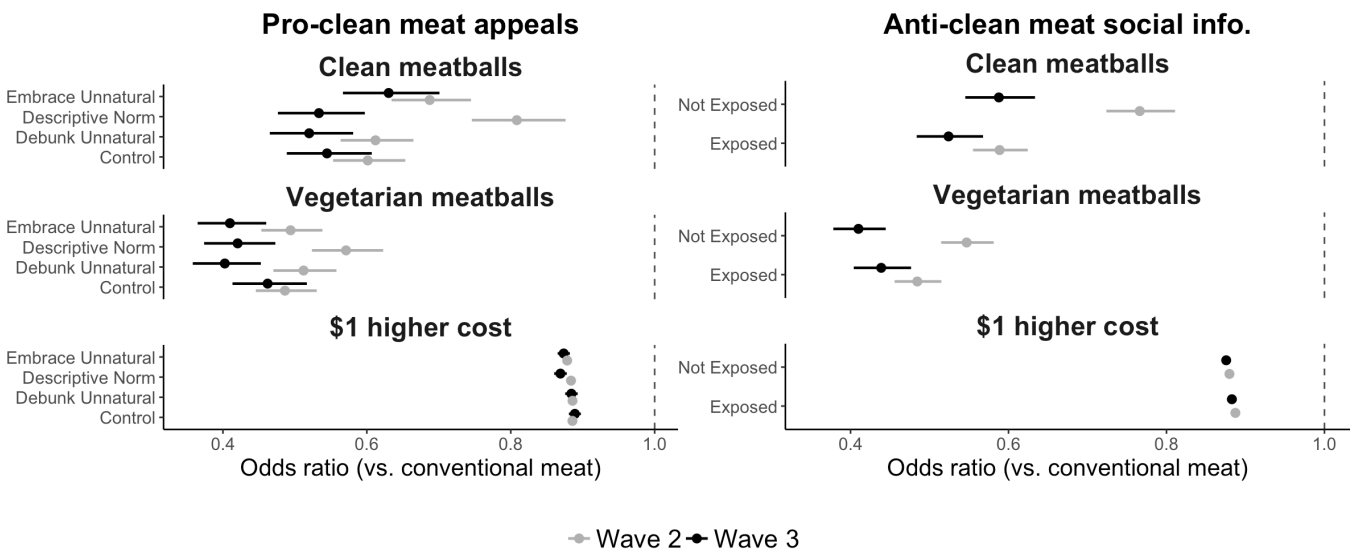

Figure 5. Treatment effects (discrete choice, odds ratio). Displays odds ratios of selecting clean (or vegetarian) meatballs relative to conventional meatballs among respondents in each experimental cell, with results shown separately for waves 2 and 3. A value of 1.0 on the x-axis indicates that respondents were indifferent between clean (or vegetarian) meatballs and conventional meatballs. A value of 0.6 indicates that respondents were only 60% as likely to choose clean (or vegetarian) meatballs relative to conventional meatballs. Horizontal bars represent 90% and 95% confidence intervals. Results estimated using conditional logistic regression. See for further details.

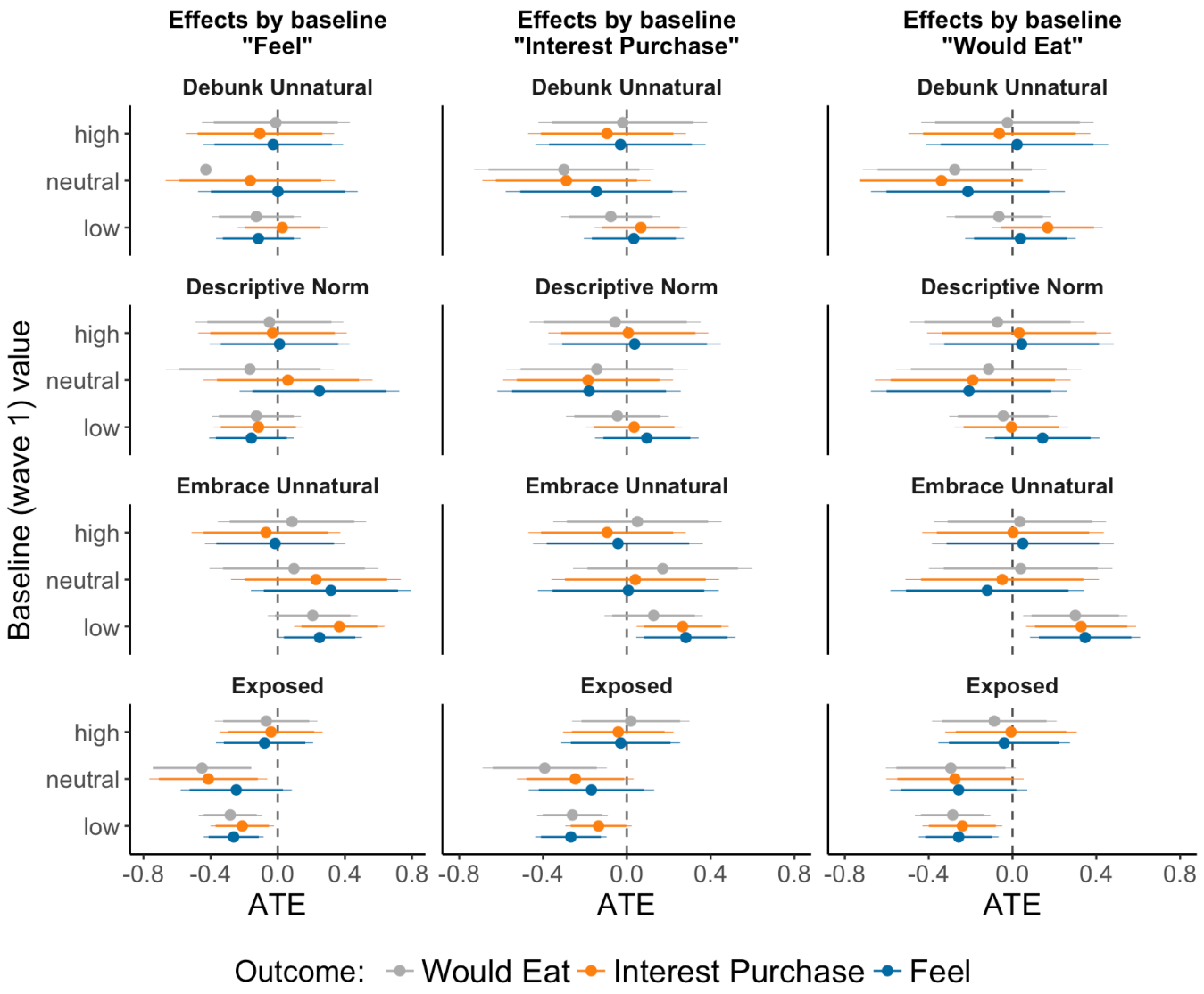

Figure 6. Heterogeneity in treatment effects by baseline interest in clean meat. Displays ATEs of each treatment appeal and negative social information ("exposed") on interest in clean meat. Results are estimated separately conditional on low vs. neutral vs. high levels of baseline interest in clean meat. Column 1 displays treatment effects of the three treatment appeals (and the effects of negative social information) on three measures of interest in clean meat — *would eat* ("Would you eat this product?", 1-5 scale), *interest purchase* ("how interested are you in purchasing the clean meat product you just read about?", 1-5 scale), and *feel* ("How do you feel about clean meat products?", 1-7 scale) — where results are estimated separately for respondents with low vs. neutral vs. high levels of baseline *feel*. Columns 2 and 3 display the same effects, except that results are broken down by baseline *interest purchase* and baseline *would eat*, respectively. All dependent variables are measured as the change between waves 1 and 3. Points represent ATEs, surrounded by represent 90% and 95% confidence intervals.

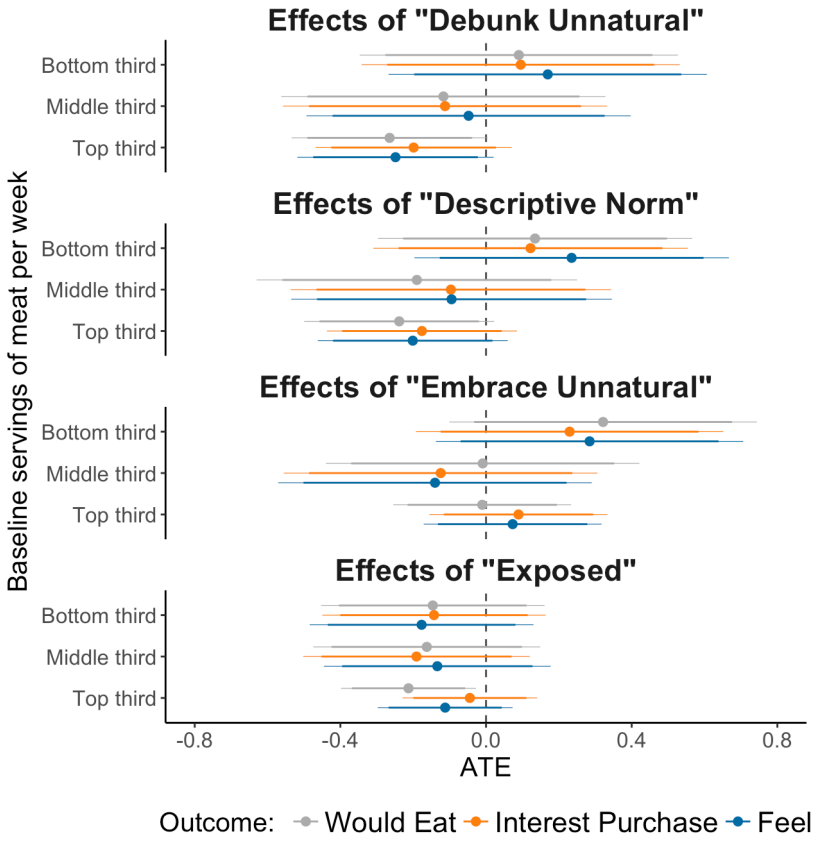

Figure 7. Heterogeneity in appeal effects by number of servings of meat consumed per week at baseline. Displays ATEs of each treatment appeal and negative social information ("exposed") on interest in clean meat. Results are estimated separately conditional on low vs. moderate vs. high levels of baseline self-reported servings of meat consumed per week. Dependent variables are: *would eat* ("Would you eat this product?", 1-5 scale), *interest purchase* ("how interested are you in purchasing the clean meat product you just read about?", 1-5 scale), and *feel* ("How do you feel about clean meat products?", 1-7 scale). All dependent variables are standardized to have mean equal to zero and variance equal to one, and are measured as the change between waves 1 and 3. Panel 1 (top) displays treatment effects of the *debunk unnatural* appeal; Panel 2 displays treatment effects of the *descriptive norm* appeal; Panel 3 displays treatment effects of the *embrace unnatural* appeal; Panel 4 (bottom) displays treatment effects of exposure to negative social information. Points represent ATEs, surrounded by represent 90% and 95% confidence intervals.

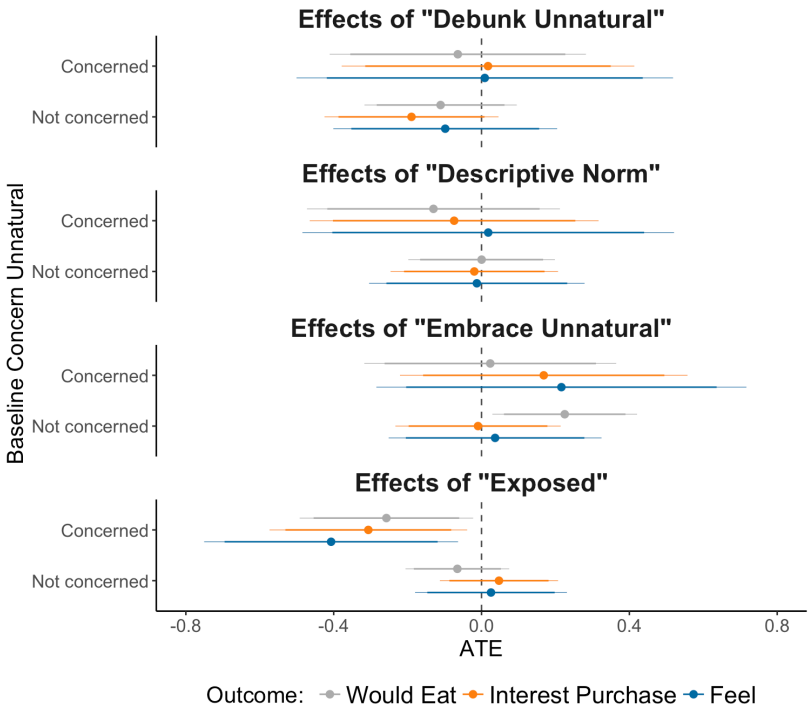

Figure 8. Heterogeneity in appeal effects by baseline concern about clean meat naturalness. Displays ATEs of each treatment appeal and negative social information ("exposed") on interest in clean meat, conditional on whether respondents were concerned about the naturalness of clean meat at baseline (y-axis). Dependent variables are: *would eat* ("Would you eat this product?", 1-5 scale), *interest purchase* ("how interested are you in purchasing the clean meat product you just read about?", 1-5 scale), and *feel* ("How do you feel about clean meat products?", 1-7 scale). All dependent variables are standardized to have mean equal to zero and variance equal to one, and are measured as the change between waves 1 and 3. Panel 1 (top) displays treatment effects of the *debunk unnatural* appeal, estimated separately for respondents who were concerned versus not concerned about the naturalness of clean meat at baseline; Panel 2 displays treatment effects of the *descriptive norm* appeal; Panel 3 displays treatment effects of the *embrace unnatural* appeal; Panel 4 (bottom) displays treatment effects of exposure to negative social information. Points represent ATEs, surrounded by represent 90% and 95% confidence intervals.

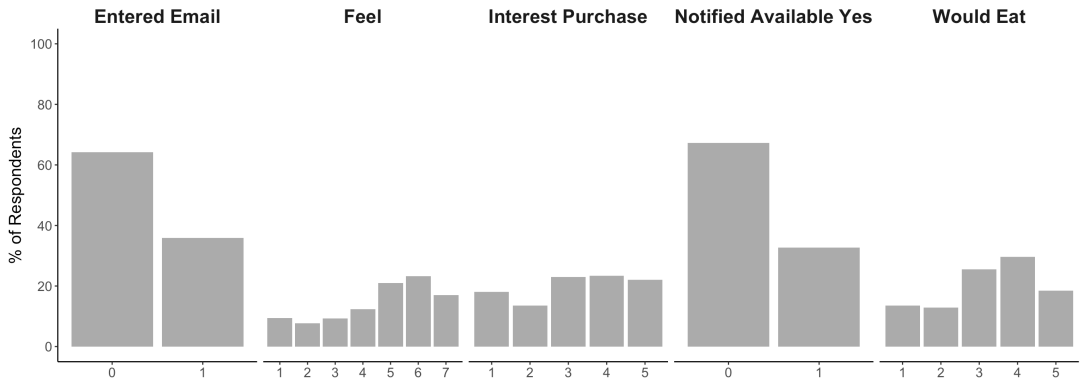

Figure 9. Descriptive statistics: Interest in clean meat products. Displays distributions of measures of interest in clean meat, as measured at baseline. Interest variables include: *entered email* (whether or not respondent entered email after "yes" response to "Would you like to be notified when clean meat products are available in your area?"), *feel* ("How do you feel about clean meat products?", 1-7 scale), *interest purchase* ("how interested are you in purchasing the clean meat product you just read about?", 1-5 scale), *notified available (yes)* ("Would you like to be notified when clean meat products are available in your area?"), *would eat* ("Would you eat this product?", 1-5 scale).

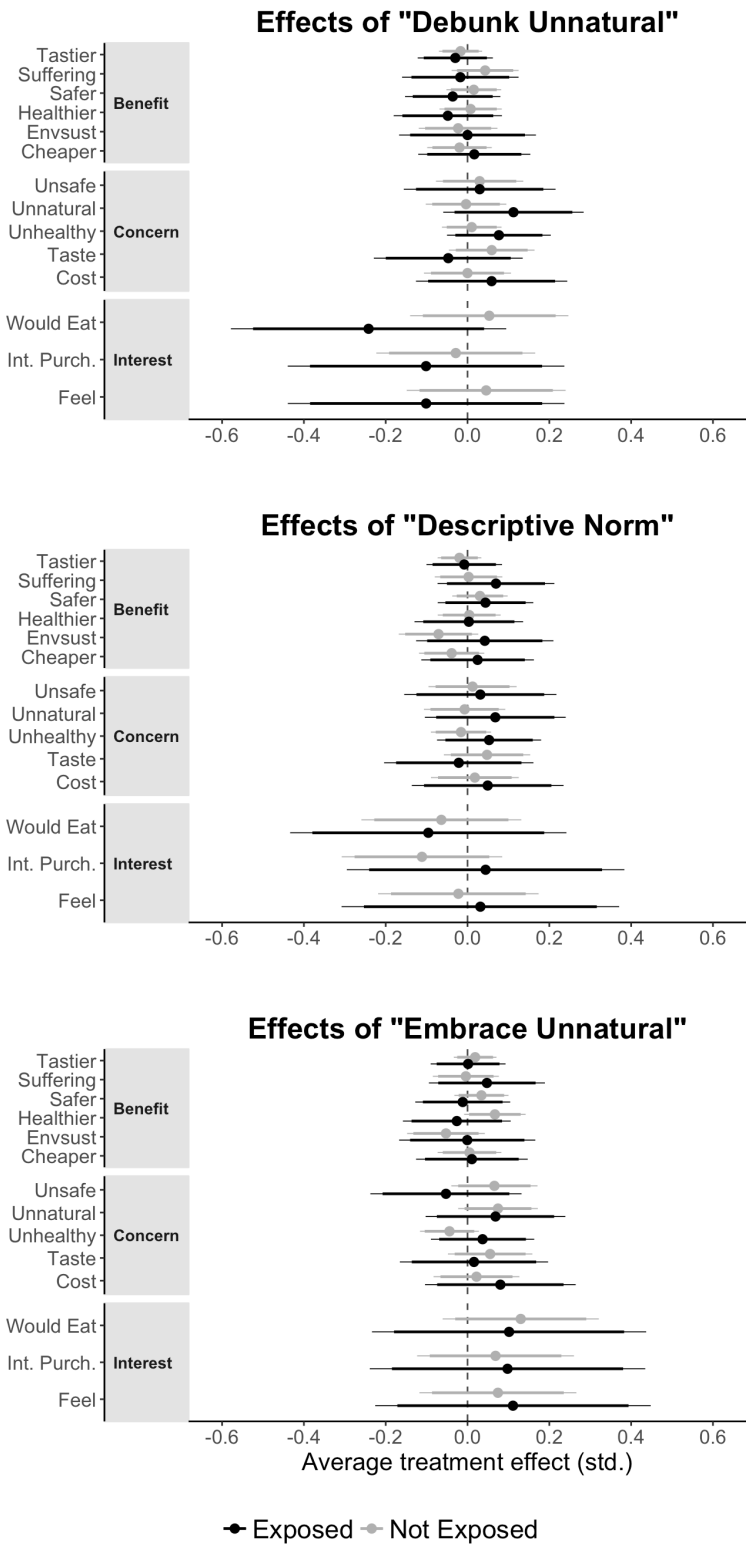

Figure 10. Heterogeneity in appeal effects by exposure to anti-acceptance social information. Displays the effects of each treatment appeal, estimated separately for respondents exposed to anti-acceptance social information versus respon-

dents that were not exposed. Panel 1 (top) displays treatment effects of the *debunk unnatural* appeal; Panel 2 displays treatment effects of the *descriptive norm* appeal; Panel 3 (bottom) displays treatment effects of the *embrace unnatural* appeal. The "concerns" and "benefits" variables are dichotomous, representing whether a respondent raised the concern/benefit (*y=1*) or not (*y=0*). Interest variables include: *would eat* ("Would you eat this product?", 1-5 scale), *interest purchase* ("how interested are you in purchasing the clean meat product you just read about?", 1-5 scale), and *feel* ("How do you feel about clean meat products?", 1-7 scale). The three interest variables are standardized to have mean equal to zero and variance equal to one. All dependent variables are measured as the change between waves 1 and 3. Points represent ATEs, surrounded by represent 90% and 95% confidence intervals.

References

Addady, Michal (2016, February 02). You Could Be Eating Lab-Grown Meat in Just Five Years. *Fortune*. Retrieved from: fortune.com.

Camerer, Colin F (2004). Prospect Theory In The Wild: Evidence From The Field. In Colin F Camerer, Loewenstein, George, Rabin, Matthew (eds.), *Advances In Behavioral Economics*.

Costa-Font, Montserrat, José M. Gil, and W. Bruce Traill (2008). Consumer Acceptance, Valuation Of And Attitudes Towards Genetically Modified Food: Review And Implications For Food Policy. *Food Policy*, 33(2), 99 - 111.

Graham N Dixon, Brooke Weberling Mckeever, Avery E Holton, Christopher Clarke, and Gina Eosco (2015). The Power Of A Picture: Overcoming Scientific Misinformation By Communicating Weight-Of-Evidence Information With Visual Exemplars. *Journal Of Communication*, 65(4), 639-659.

Ecker, Ullrich K H, Stephan Lewandowsky, and J Apai (2011). Terrorists Brought Down The Plane!--No, Actually It Was A Technical Fault: Processing Corrections Of Emotive Information. *Quarterly Journal Of Experimental Psychology,* 64(2), 283-310.

Ferdman, Roberto A. (2015, May 20). This is the future of meat. *Washington Post*. Retrieved from: www.washington-post.com.

Frewer, L. J., C. Howard, and R. Shepherd (1996). The Influence Of Realistic Product Exposure On Attitudes Towards Genetic Engineering Of Food. *Food Quality And Preference*, 7(1), 61 - 67.

L. J. Frewer, K. Bergmann, M. Brennan, R. Lion, R. Meertens, G. Rowe, M. Siegrist, and C. Vereijken (2011). Consumer Response To Novel Agri-Food Technologies: Implications For Predicting Consumer Acceptance Of Emerging Food Technologies. *Trends In Food Science & Technology*, 22(8), 442 - 456.

Garfield, Leanna (2017, June 27). Hampton Creek says it's making lab-grown meat that will be in supermarkets by 2018. *Business Insider*. Retrieved from: www.businessinsider.com.

Gerber, Alan S, Donald P Green, and Christopher W Larimer (2008). Social Pressure And Voter Turnout: Evidence From A Large-Scale Field Experiment. *American Political Science Review*, 102(1), 33-48

Goldstein, Noah J, Robert B Cialdini, and Vladas Griskevicius (2008). A Room With A Viewpoint: Using Social Norms To Motivate Environmental Conservation In Hotels. *Journal Of Consumer Research*, 35(3), 472-482

Hart Research Associates. (2017). Perceptions of Cellular Agriculture: Key Findings from Qualitative Research. Washington, DC: Hart Research Associates. Retrieved from: www.new-harvest.org/focus_groups

Hocquette, Aurélie, Carla Lambert, Clémentine Sinquin, Laure Peterolff, Zoé Wagner, Sarah P F Bonny, André Lebert, and Jean-François Hocquette (2015). Educated Consumers Don'T Believe Artificial Meat Is The Solution To The Problems With The Meat Industry. *Journal Of Integrative Agriculture*, 14(2), 273 - 284.

Johnson, H M and C M Seifert (1999). Modifying Mental Representations: Comprehending Corrections. In H M Johnson and C M Seifert (eds.), *The Construction Of Mental Representations During Reading* (303-318). Mahwah, Nj: Erlbaum.

Laestadius, L and M Caldwell (2015). Is The Future Of Meat Palatable? Perceptions Of In Vitro Meat As Evidenced By Online News Comments. *Public Health Nutrition*, 18(3), 2457-2467.

Lewandowsky, Stephan, Ullrich K H Ecker, Colleen M Seifert, Norbert Schwarz, and John Cook (2012). Misinformation And Its Correction: Continued Influence And Successful Debiasing. *Psychological Science In The Public Interest*, 13(3), 106-131.

Lusk, Jayson L., John M. Crespi, J. Bradley C. Cherry, Brandon R. Mcfadden, Laura E. Martin, and Amanda S. Bruce (2015). An FMRI Investigation Of Consumer Choice Regarding Controversial Food Technologies. *Food Quality And Preference, 40()*, 209 - 220.

Markowitz, E. and A. Shariff (2012). Climate change and moral judgement. *Nature Climate Change* 2, 243–247.

Miton, H. and H. Mercier (2015). Cognitive obstacles to pro-vaccination beliefs. *Trends In Cognitive Sciences* 19, 633–636.

Carl H Nelson (2001). Risk Perception, Behavior, And Consumer Response To Genetically Modified Organisms. *American Behavioral Scientist*, 44(8).

New York State Department of Health (2012). Common Vaccine Misperceptions and Concerns Explained. Retrieved from: www.health.ny.gov.

Nyhan, B. and J. Reifler (2015). Does correcting myths about the flu vaccine work? An experimental evaluation of the effects of corrective information. *Vaccine* 33, 459–464.

Nyhan, B., J. Reifler, S. Richey, and G. L. Freed (2014). Effective messages in vaccine promotion: A randomized trial. *Pediatrics*.

O'Keefe, Laura, Carly Mclachlan, Clair Gough, Sarah Mander, and Alice Bows-Larkin (2016). Consumer Responses To A Future Uk Food System. *British Food Journal*, 118(2), 412-428.

Rollin, Fanny, Jean Kennedy, and Josephine Wills (2011). Consumers And New Food Technologies. *Trends In Food Science & Technology*, 22(2), 99 - 111.

Roman, Sergio, Luis Manuel Sanchez-Siles, and Michael Siegrist (2017). The Importance Of Food Naturalness For Consumers: Results Of A Systematic Review. *Trends In Food Science & Technology 67*, 44-57.

Runge, Kristin K, Dominique Brossard, Dietram A Scheufele, Kathleen M Rose, and Brita J Larson (2017). Attitudes About Food And Food-Related Biotechnology. *Public Opinion Quarterly*, 81(2), 577-596.

Saher, Marieke, Marjaana Lindeman, and Ulla-Kaisa Koivisto Hursti (2006). Attitudes Towards Genetically Modified And Organic Foods. *Appetite*, 46(3), 324 - 331.

Siegrist, Michael (2008). Factors Influencing Public Acceptance Of Innovative Food Technologies And Products. *Trends In Food Science & Technology*, 19(11), 603 - 608.

Siegrist, Michael, Marie-Eve Cousin, Hans Kastenholz, and Arnim Wiek (2007). Public Acceptance Of Nanotechnology Foods And Food Packaging: The Influence Of Affect And Trust. *Appetite*, 49(2), 459 - 466.

Siegrist, Michael, Hans Kastenholz, and Nathalie Stampfli (2009). Acceptance Of Nanotechnology Foods: A Conjoint Study Examining Consumers' Willingness To Buy. *British Food Journal*, 111(7), 660-668.

Siegrist, Michael and Bernadette Sutterlin (2017). Importance Of Perceived Naturalness For Acceptance Of Food Additives And Cultured Meat. *Appetite*, 113, 320 - 326.

Linda Steg and Charles Vlek (2009). Encouraging Pro-Environmental Behaviour: An Integrative Review And Research Agenda. *Journal Of Environmental Psychology*, 29(3), 309-317.

Stone, Maddie (2016, May 27). The Future Will Be Full of Lab Grown Meat. *Gizmodo*. Retrieved from: gizmodo.com.

Tenbult, Petra, Nanne K. De Vries, Ellen Dreezens, and Carolien Martijn (2005). Perceived Naturalness And Acceptance Of Genetically Modified Food. *Appetite, 45(1)*, 47 - 50.

Tversky, Amos and Daniel Kahneman (1992). Advances In Prospect Theory: Cumulative Representation Of Uncertainty. *Journal Of Risk And Uncertainty*, 5(4), 297-323.

Wade-Benzoni, K. and L. Tost (2009). The egoism and altruism of intergenerational behavior. *Personality And Social Psychology Review* 13, 165–193.

Wilks, M. and C. J. C. Phillips (2017). Attitudes to in vitro meat: a survey of potential consumers in the united states. *Plos One* 12.

World Health Organization (2017). Six common misconceptions about immunization. Retrieved from: www.who.int.

Yaqub, O., S. Castle-Clarke, N. Sevdalis, and J. Chataway (2014). Attitudes to vaccination: A critical review. *Social Science and Medicine* 112, 1–11.