Effective strategies for overcoming the naturalistic heuristic

Experimental evidence on consumer acceptance of "clean" meat

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August 15, 2017

DRAFT (Version: 0.6)

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. While existing evidence suggests that pro-acceptance messaging appeals based on debunking this heuristic are ineffective at increasing consumer acceptance, there is little evidence on whether this ineffectiveness extends to new products for which consumers have not yet formed crystallized opinions. 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 "anti-clean meat social information" from anonymous consumers. We find persistent negative effects of anti-clean meat social information over 10 weeks. In contrast, improvements in consumer acceptance following the direct debunking and descriptive norms appeals were short-lived. The only appeal to successfully offset the undermining effects of anti-clean meat social information over 10 weeks was the embrace unnaturalness appeal, 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).

1. Introduction

Motivation. "Clean meat" — i.e. meat products made from cultured animal tissues, also known as "cultured" or "in vitro" meat — has the potential to significantly reduce animal suffering and environmental damage while also improving human health. Clean meat products have been the source of a great deal of media attention over the past few years as improvements in clean meat technologies have dramatically reduced production costs, with companies promising to have clean meat products available in stores by 2018.[2]

However, clean meat products are at risk of attracting a great deal of public resistance. First, many consumers attach labels such as "artificial" or "lab-grown" to these products, given that clean meat production processes conflict with the widespread heuristic that "what is natural is good".[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] In short, while the naturalistic heuristic may nudge consumers towards choosing food products with less added sugars, fats, and preservatives, at the same time this heuristic poses a major barrier to public acceptance of technologies that promise far-reaching benefits for public health, environmental sustainability, animal welfare, and scientific advancement. Second, the expected benefits of clean meat are temporally distant (e.g. avoiding catastrophic climate change) and spatially removed (e.g. animal suffering in factory farms, deforestation), making it difficult for consumers to incorporate these benefits into their decision-making calculus.[5]

While clean meat products are set to become widely available to consumers in the near future, few studies have examined consumer attitudes towards clean meat products, how these attitudes are shaped by short snippets of information exchanged in social networks, and what kinds of pro-clean meat messaging campaigns can be effective at

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2 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.

generating sustained improvements in consumer acceptance. This lack of research is an important oversight, given that public opinion could very easily crystallize against clean meat products, thereby undermining the far-reaching potential of clean meat products for combating environmental degradation and improving animal welfare.

In this study, we address two questions. First, to what extent does perceived "naturalness" undermine consumer interest in clean meat products? Existing work shows that many consumers are concerned about the naturalness and health effects of clean meat products (Wilks and Phillips 2017, Hocquette et al. 2015, Laestadius and Caldwell 2015, Hrat Research Associates 2017), and a great deal of research has shown that perceived food naturalness plays an important role in consumers' food choices (Roman et al. 2017, Lusk et al. 2015, Tenbult et al. 2005), yet there is little direct evidence that concerns about the naturalness of clean meat products are more important in undermining consumer acceptance relative to conventional consumer concerns such as cost and taste. [6]

Second, how effective are pro-clean meat appeals — either based on "debunking unnaturalness", "embracing unnaturalness", or conveying "descriptive social norms" — at creating sustained improvements in consumer acceptance of clean meat products compared to anti-clean meat information received from other potential consumers? Existing research has cast a pessimistic light on the potential for 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). It is not clear, however, whether this ineffectiveness of pro-acceptance messaging extends to novel technologies, for which consumers' opinions have not yet crystallized. Moreover, existing findings do not examine the flip side of the persuasion question: are *anti*-acceptance appeals just as ineffective at moving individual opinions as pro-adoption appeals? Given widespread risk aversion among consumers and greater attention paid to a decision's downsides (Nelson 2001, Tversky and Kahneman 1992, Camerer 2004), there is good reason to believe that consumer attitudes will be more sensitive to negative information about clean meat products. However, there is little available evidence on whether such an asymmetry in the effects of information appeals exists in the context of clean meat products, GM foods, vaccines, and related technologies.

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6 Siegrist and Sutterlin 2017 show that consumers are more accepting of risk (e.g. chance of getting colon cancer from eating meat) when meat is produced using conventional methods rather than in vitro. Yet the authors do not examine the role of perceived naturalness in consumers' overall interest in clean meat, nor do they compare the role of perceived naturalness to other potential consumer concerns.

Research design. In this study, we address these two questions through a 2x4 full factorial survey experiment that examines how three messaging strategies and anti-acceptance social information affect individual acceptance of clean meat products over a period of 10 weeks. We measure acceptance of clean meat products using a discrete choice experiment, along with a set of behavioral intention and attitudinal measures. To examine the effects of *anti-acceptance social information*, we randomly assign participants to receive social information or not, consisting of a sample of five negative reactions towards clean meat from other survey respondents (e.g. "Artificial meat sounds disgusting"). Next, to examine the efficacy of pro-clean meat appeals, we randomly assign participants to read either a *placebo* article or one of three pro-clean meat articles: a *debunking unnatural* appeal, *embrace unnatural* appeal, or *descriptive norm* appeal. Whereas the *debunking unnatural* appeal is aimed at weakening consumers' reliance on the naturalistic heuristic by illustrating some of its fallacies, the *embrace unnatural* appeal takes a softer approach by asking consumers to recognize that there are many exceptions to the naturalistic heuristic (without asking them to abolish the heuristic altogether). Finally, the *descriptive norm* appeal does not deliver any persuasive arguments that invoke the naturalistic fallacy, instead conveying 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.

Results. We produce three main results. First, we show that consumers' wariness about clean meat is driven far more by concerns about whether clean meat is natural and healthy — which are symptoms of the naturalistic fallacy — than how clean meat products taste or how much they cost. Second, we show that the *embrace unnatural* appeal led to sustained increases in consumers' willingness-to-pay and interest in clean meat over a 10 week period. In contrast, while the *debunking unnatural* and *descriptive norm* appeals led to encouraging short-term improvements in consumer acceptance of clean meat, these effects were short-lived. Third, in stark contrast to the null effects of these two appeals, we show that small snippets of negative social information about clean meat from complete strangers significantly undermines acceptance of clean meat, and that these effects persist for at least 10 weeks. These effects are strongest among individuals who were least interested in clean meat at baseline.

Contributions. This study makes four main contributions. First, we provide disconcerting evidence about the asymmetric effectiveness of pro- vs. anti-adoption appeals towards new food technologies, such that extremely small amounts of negative social information led to sustained reductions in consumer acceptance of clean meat, while two of the three pro-clean meat appeals had no discernible effects after 10 weeks. While the ineffectiveness of the *debunking unnatural* appeal is consistent with existing research on the challenges of correcting misinformation (see Nyhan et al. 2014, Lewandowsky et al. 2012), our results extend add to this literature in two ways. First, our results show that the

ineffectiveness of direct debunking strategies extends to novel technologies (such as clean meat) for which consumer attitudes have not yet crystallized. Second, we demonstrate asymmetric information effects, such that consumer attitudes are particularly susceptible to small amounts of anti-clean meat social information that activates the naturalistic heuristic.

Third, 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. An attractive feature of this strategy that may be responsible for its success is the leveraging of 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. Fourth, 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. Experimental design

2.1 Data collection

Data was collected in three online survey waves over an 11 week period with participants recruited through Amazon Mechanical Turk (MTurk). Each participant was paid US$0.50 for completing the baseline survey, US$0.50 for completing the treatment survey, and US$0.50 for completing the endline survey (for a total of US$1.50 for participation in the entire study). 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 9 (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.

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 information or not; and (b) read one of four half-page appeals. See Section 2.2 for more details on experimental conditions. 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 2.3.

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 2.3.

2.2 Experimental conditions

This study was organized as a randomized 2x4 full factorial design, examining how (1) anti-acceptance social information and (2) pro-clean meat messaging appeals affect individual acceptance of clean meat products and susceptibility to the naturalistic fallacy. In the treatment survey, study participants were randomly assigned to: (a) either receive anti-acceptance social information or not; and (b) read one of four half-page appeals, three of which were pro-clean meat appeals while the fourth was a placebo article about the health benefits of walking. 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.[7] 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).[8] 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 products 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.[9] 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. [10]

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

8 cf. Dixon et al. 2015.

9 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.

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

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. [11] In the case 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.

2.3 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:[12]

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"). In waves 1 and 2, but not in the endline survey, we also asked participants: "Would you like to be notified when clean meat products are available in your area?" ("yes/maybe/no" and dichotomous measure of whether respondent provided an e-mail address in follow-up question shown to those answering "yes" or "maybe").

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

12 Participants were also provided with several opportunities across the three survey waves to share their attitudes towards clean meat products in an open-ended format.

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. We also provided participants with an open-ended text box to state their most important concerns about clean meat products.

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. We also provided participants with an open-ended text box to state the most important benefits that clean meat products offered in their opinion.

3. Results

In the analyses that follow, we examine consumer attitudes towards clean meat products in five stages. First, before turning to the experimental results, we consider what factors drive consumer sentiment towards clean meat and show that consumers' wariness about clean meat is driven far more by concerns about whether clean meat is natural and healthy — which are symptoms of the naturalistic heuristic — than how clean meat products taste or how much they cost. Second, we examine the effects of the three pro-clean meat appeals on consumer willingness-to-pay, interest in, and concerns about clean meat products. Third, we illustrate the pernicious effects of small amounts of anti-acceptance social information. Fourth, we examine whether any of the pro-clean meat appeals were particularly effective or ineffective in the face of anti-acceptance social information. Fifth, we report subgroup heterogeneity in the results, illustrating whether the effects of the pro-clean meat appeals and anti-acceptance social information were concentrated among individuals who reported eating more meat at baseline and who were already wary of clean meat products at baseline.

3.1 Naturalistic reasoning undermines clean meat acceptance

How important are consumer concerns emanating from the naturalistic fallacy — such as perceptions that clean meat is "unnatural", "unsafe", or "unhealthy" — in undermining willingness to eat clean meat products relative to more conventional consumer concerns, such as price and taste? Here, we show that the former concerns are the main barriers to consumer interest in purchasing and eating clean meat products, while price and taste are only weakly related to consumer interest. Figure 1 illustrates this claim, displaying linear regression coefficients from regressing the change

in respondent interest in clean meat between waves 1 and 3 (measured by *feel*, *interest purchase*, and *would eat*) on the change in whether respondent expressed a particular concern about clean meat, while controlling for other concerns raised, baseline demographics, and baseline self-reported meat consumption.

Figure 1 display results across five core concerns: taste, cost, safety, unhealthy, and unnatural. As shown, respondents who went from unconcerned to concerned about clean meat's naturalness between waves 1 and 3 became substantially less interested in clean meat products over the same time period.[13] 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* ($p < 0.01$). These patterns are similar for concerns about the health and safety consequences of clean meat products, although the relationship is somewhat weaker regarding safety concerns. In contrast, changes in concerns about taste are not strongly related to interest in clean meat products. Moreover, individuals who reported becoming more concerned about cost between waves 1 and 3 became *more* interested in clean meat products. 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.

Among respondents who listed “unnatural” as a concern in the baseline survey wave, only 30.1% provided an email address at the end of the treatment wave to be notified when clean meat becomes available in their area. In contrast, 48.2% of respondents who did not list “unnatural” as a concern provided an email address. By comparison, 38.7% of respondents who selected “taste” as a concern in the baseline survey entered an email address in the treatment wave, compared to 38.5% among respondents not raising “taste” as a concern in the baseline wave.

These findings are mirrored in participants' open-ended descriptions of their attitudes towards clean meat products, in which a sizable number of responses were intently focused on the naturalness and health consequences of clean meat. For instance:

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13 Or, similarly, respondents who went from being concerned to unconcerned about clean meat's naturalness between waves 1 and 3 became substantially more interested in clean meat products over the same time period. The results in Figure 1 average across these two types of respondents — that is, those who went from concerned to unconcerned and unconcerned to concerned — as well as respondents who did not change their concern between waves 1 and 3.

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.”

Many other respondents had more moderate reactions, yet still hinted at concerns about the naturalness and health consequences of clean meat products:

Respondent D: “I need to see research on how it affects our bodies long term.”

Respondent E: “I know academically it's probably healthier, more humane, and won't taste any different [...] However there's a negative gut reaction to it I can't seem to push aside.”

Respondent F: “It seems strange to eat man made meat.”

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 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.[14] In the open-ended responses, these respondents focused overwhelmingly on the anticipated benefits of clean meat products for animal welfare and the environment, while not directly invoking concerns about the naturalness and health consequences of clean meat products. And when these interested consumers did qualify their enthusiasm, it was typically to add the caveat that they hoped clean meat products would taste as good as conventional meat products and would not be dramatically more expensive.

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14 Figure 10 in the Appendix contains further information on these descriptives.

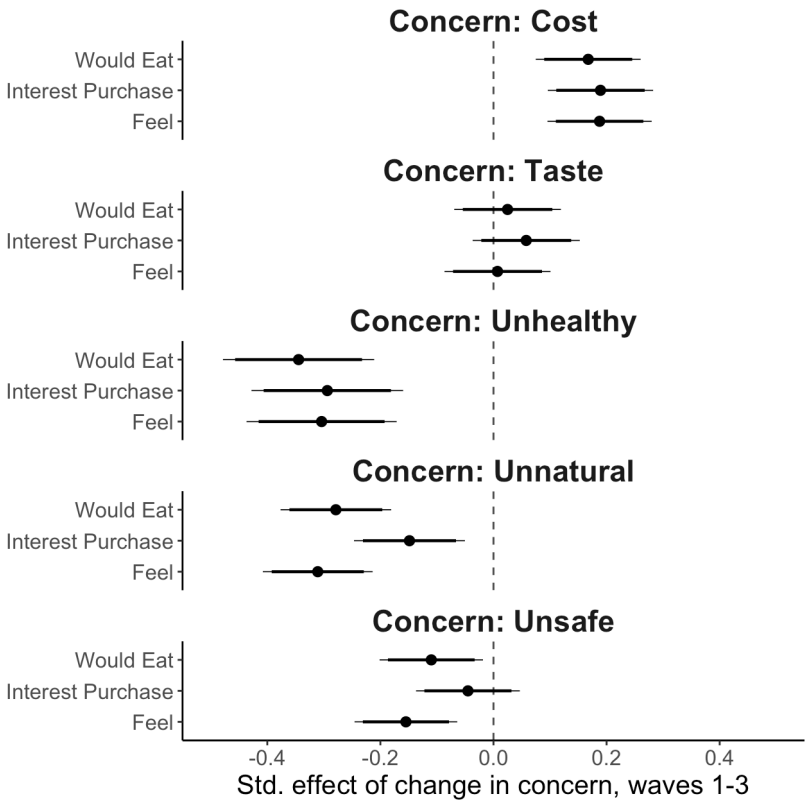

Figure 1. Link between concerns about clean meat and interest in clean meat. Displays estimated standardized effects of a change in concerns about clean meat between waves 1 and 3 on corresponding change in interest in clean meat. Estimates are produced from a simple linear regression of each measure 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.

An important caveat in the results reported in Figure 1 is that we did not experimentally manipulate respondents' perceptions of the unnaturalness of clean meat products (or the salience of this unnaturalness), leaving open the possibility that the observed relationships are driven by some unobserved third factor, or that the causal arrow instead points from interest in clean meat to concerns about its unnaturalness and health consequences. Nevertheless, by examining how *changes* in respondents' concerns correlate with *changes* in interest in clean meat over time, our results are robust to alternative explanations based on time-invariant factors. In terms of the direction of causation, our results do not settle the question of the extent to which consumer interest in clean meat is the product of concerns about unnaturalness and health consequences or whether these concerns about clean meat are merely by-products of motivated reasoning among consumers who dislike clean meat for other reasons. Nevertheless, our general finding that consumer

interest in clean meat is closely wedded to concerns about naturalness and health consequences, rather than price and taste, should be of particular interest to advocates of clean meat, as well as others studying the formation of consumer opinions towards new food technologies.

Finally, given the novelty of clean meat products in the minds of many consumers, could the link between consumer interest and concerns about the naturalness of clean meat products be explained by an initial "shock factor", in which we would expect consumer concerns to shift more towards price and taste as consumers become more comfortable with the normalcy of clean meat products? Our results offer some support for this perspective, although future work should examine this question more closely. Looking just at the respondents who were in the control group[15] and who completed all three survey waves (n=213), the percentage of respondents raising "unnatural" as a concern dropped from 55.4% to 46.5% between the baseline and endline waves (chg = 8.9%; $p < 0.05$). Similarly, the percentage of respondents raising "unsafe" as a concern dropped from 48.8% to 42.3% (chg = 6.6%; $p < 0.1$). However, there was virtually no change in the proportion of respondents raising "unhealthy" as a concern, staying roughly constant at 10.8%.[16] Hence, while we find some evidence that consumer concerns about clean meat shift *away* from "unnatural" and "unsafe" concerns and move *towards* concerns about price through repeated exposure (without any further information about the benefits/costs of clean meat), consumer concerns clean meat's health consequences appear more persistent.

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? In this subsection, 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.

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15 i.e. respondents who read the placebo appeal and who were not exposed to anti-acceptance social information.

16 In comparison, the proportion of respondents citing "cost" as a concern increased moderately from 61.0% of respondents to 66.2% (chg = 5.2%; $p > 0.1$), while the proportion of respondents raising "taste" as a concern decreased from 60.1% to 52.1% (chg = 8.0%; $p < 0.05$).

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 2.3) 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.[17]

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-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. See Figure 7 (Appendix) for results reported in odds ratios.

As anticipated, respondents exhibited a strong preference for conventional meatballs over clean or vegetarian meatballs, resulting in negative marginal willingness-to-pay across all experimental conditions. Respondents also expressed a preference for clean meatballs over vegetarian meatballs on average, as indicated by the rightward shift in the willingness-to-pay estimates for clean meatballs (top row) relative to vegetarian meatballs (bottom row).

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17 We estimate standard errors using the Delta method.

Turning to the effects of the three pro-clean meat appeals, 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.

In contrast, while the *social norms* appeal led to the largest *initial* gains in willingness-to-pay (as measured in wave 2), these effects largely disappeared 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. Finally, 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.

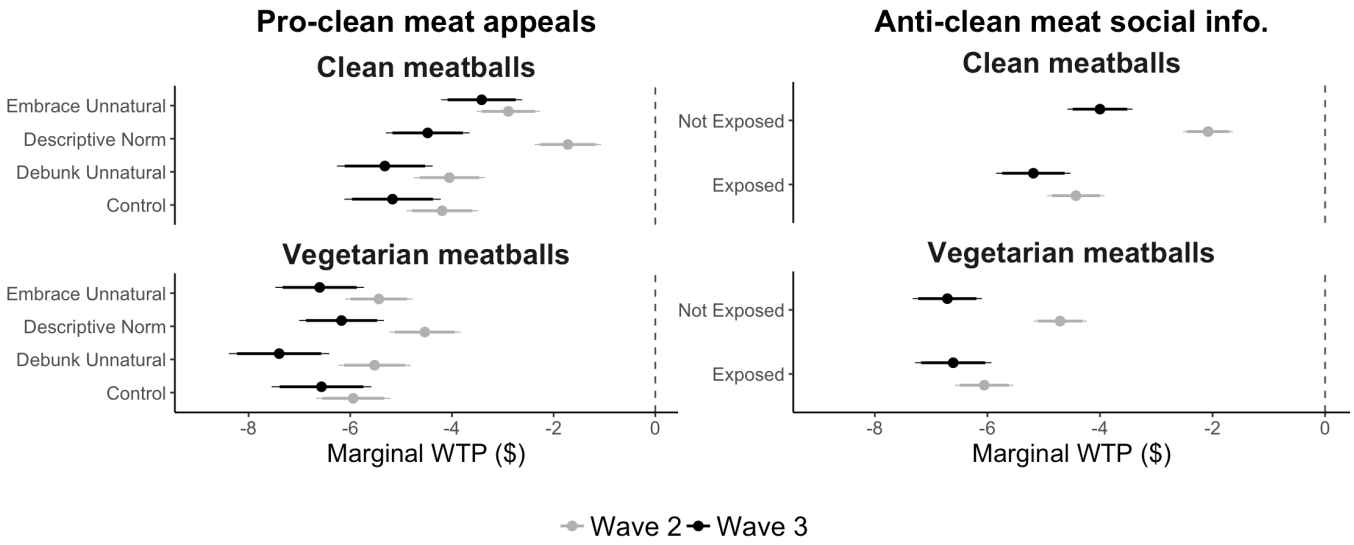

Figure 2. Treatment effects (willingness-to-pay). Displays the marginal willingness-to-pay relative to conventional meatballs for respondents in each experimental cell, with results shown separately for waves 2 and 3. A value of 0 on the x-axis indicates that respondents were indifferent between clean (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 treatment 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.[18] For instance, the proportion of respondents in the *debunk unnatural* arm raising "unnatural" as a concern decreased by roughly 15.6 percentage points more between waves 1 and 2 than among respondents who read the placebo article (SE=2.7; $p < 0.001$).

However, these encouraging initial findings for 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.

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18 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.

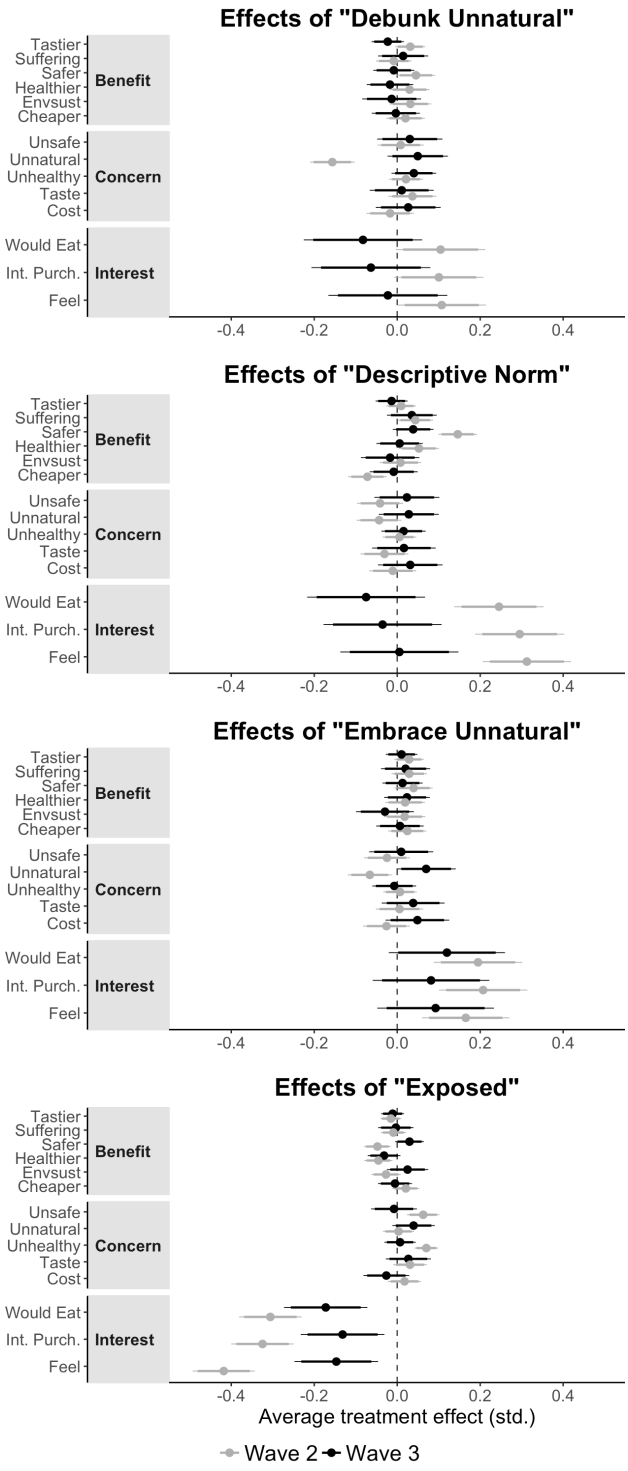

Figure 3. Treatment effects on interest, concerns, and perceived benefits. Displays average treatment effects (ATEs) for each treatment arm relative to control across three groups of outcomes: interest in clean meat, concerns about clean meat, and perceived benefits of clean meat. Panel 1 (top) displays 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*.[19] 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.

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

As we described in Section 3.1, a sizable minority of consumers have a positive orientation towards clean meat products, yet at the same time many consumers are wary about the naturalness and health consequences of these products. How contagious are the anti-clean meat attitudes of these wary consumers? In this section, we examine the extent to which snippets of anti-clean meat social information undermine consumer interest in clean meat products. As described in Section 2.2, 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").

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19 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.

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 had decayed somewhat by the 10 week followup survey yet remained large: 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 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 undermine consumer acceptance of new food technologies for at least 10 weeks post-treatment. 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.[20]

3.4 Combating negative social information

As we showed in Figure 3, the *debunk unnatural* and *descriptive norms* appeals counteracted much of the pernicious effects of anti-acceptance social information in the *short-term*, but not over longer periods. In contrast, we found reasonably strong evidence that the *embrace unnatural* leads to long-lasting improvements in consumer acceptance of clean meat, roughly on the same order of magnitude as the negative effects of anti-acceptance social information. However, these patterns do not shed light on whether the effectiveness of any of these appeals *interacts* with the presence the anti-acceptance social information — that is, whether any of the appeals become significantly more or less effective when preceded by anti-acceptance social information. For instance, while the *debunk unnatural* appeal had no positive effects on consumer acceptance in the aggregate, it may have been effective as an immediate

20 Except for those exposed to the placebo appeal.

counterpoint to negative social information. Conversely, while the *embrace unnatural* appeal had encouraging effects in the aggregate, negative social information could possibly shortcut these gains by priming individuals with the negative association between food naturalness and health/safety consequences.

We examine the possibility of these interactions in Figure 4, displaying the effects of each appeal on respondents' change in interest in clean meat products between waves 1 and 3, broken down by whether respondents were exposed to anti-acceptance social information in wave 2 or not. While the *embrace unnatural* and *descriptive norms* appeals are no more/less effective at improving consumer acceptance in the face of anti-acceptance social information, we find suggestive evidence that the *debunking unnatural* had a backfire effect on consumer interest and concerns when preceded by anti-acceptance social information. For instance, among respondents *not* exposed to anti-acceptance social information, the *debunking unnatural appeal* had virtually no effect on the proportion of respondents concerned about the naturalness of clean meat (ATE=0.4; $p > 0.1$). Among respondents exposed to the anti-acceptance social information, the *debunking unnatural* appeal led to an *increase* in the proportion of respondents between waves 1 and 3 (relative to placebo) who were concerned about clean meat's unnaturalness (ATE=11.2; $p = 0.2$). The evidence for this backfire effect should not be overstated, given imprecision in the estimated coefficients. Nevertheless, the consistency in this backfire effect across all three measures of clean meat, as well as concerns about unnaturalness and concerns about health consequences is noteworthy.

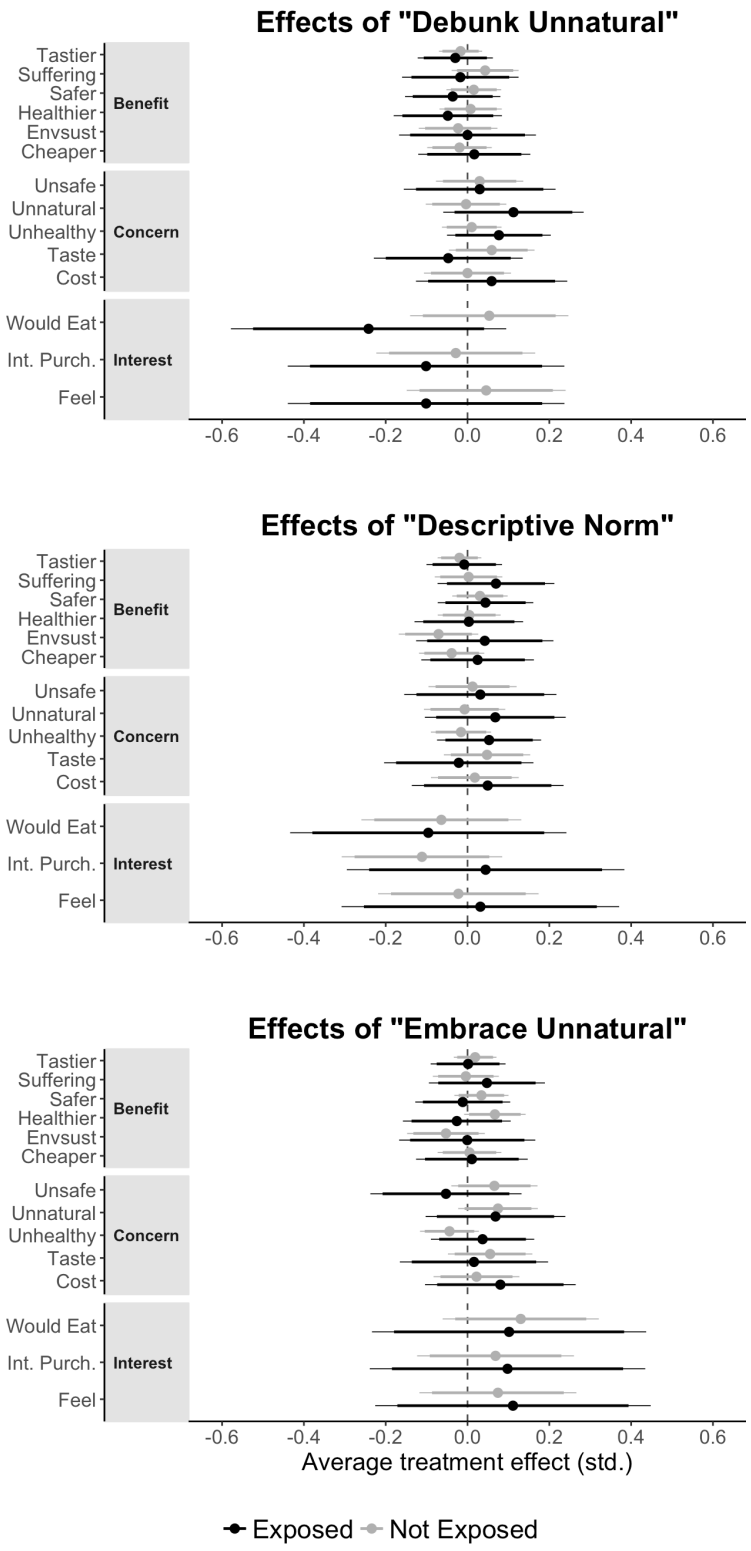

Figure 4. Heterogeneity in appeal effects by exposure to anti-acceptance social information. Displays the effects of each treatment appeal, estimated separately for respondents exposed to anti-acceptance social information versus respondents that were not exposed. Panel 1 (top) displays treatment effects 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.

3.5 Heterogeneous treatment effects

3.5.1 Effects on least interested consumers

Were the effects of the *embrace unnatural* concentrated among individuals who were already sympathetic towards clean meat products? Similarly, were the pernicious effects of anti-acceptance social information concentrated among individuals who were already less interested in consuming clean meat products at baseline? We examine both of these questions in Figure 5, displaying the estimated treatment effects of the three pro-clean meat appeals and anti-acceptance social information on interest in clean meat measured 10 weeks after treatment exposure. The treatment effects are estimated separately for individuals who reported "low", "neutral", and "high" levels of interest in clean meat in the baseline survey. Column 1 of Figure 5 displays the subgroup effects conditional on baseline *feel*, column 2 displays subgroup effects conditional on baseline *interest purchase*, and column 3 displays effects conditional on baseline *would eat*.

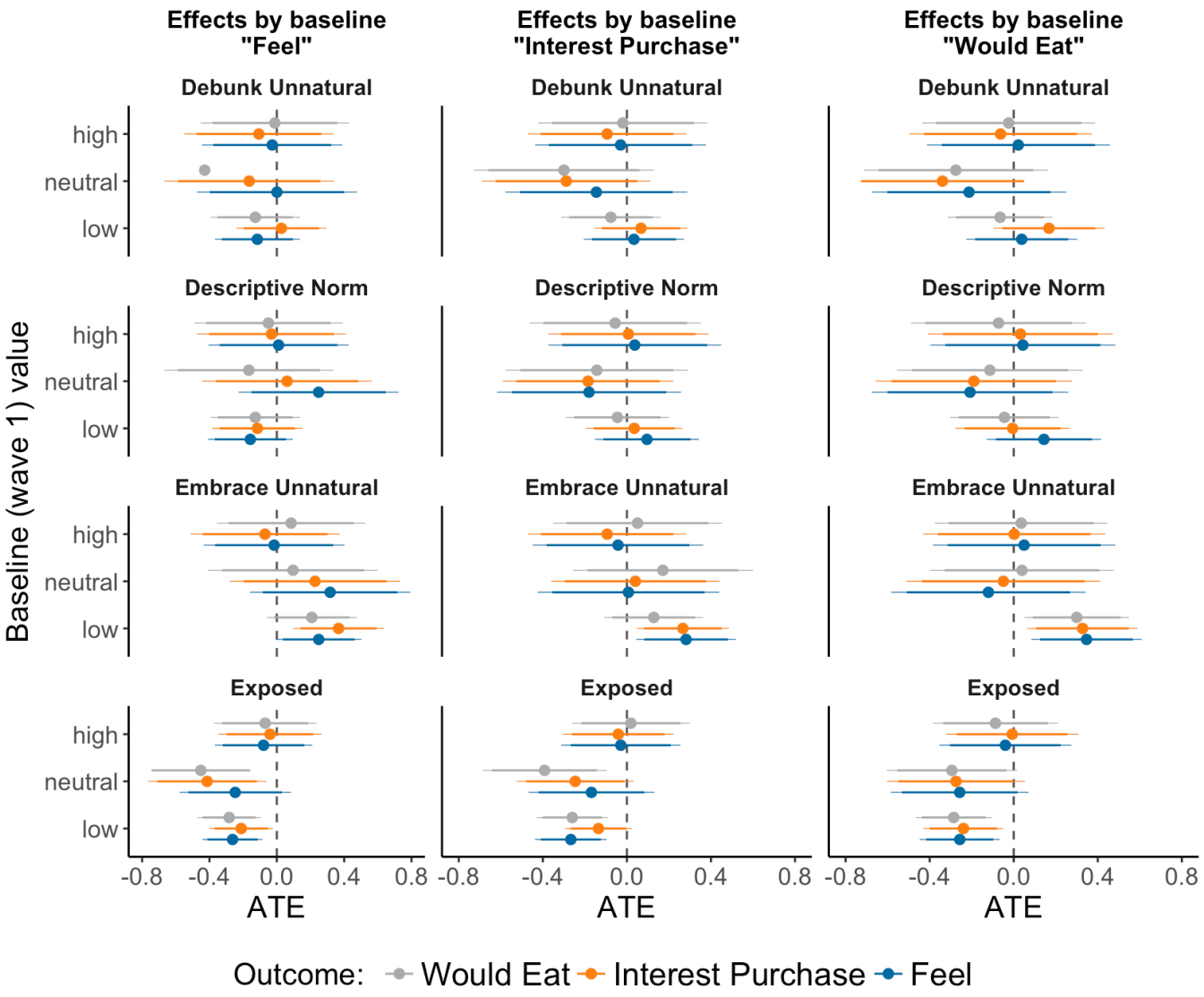

Figure 5. Heterogeneity in treatment effects by baseline interest in clean meat. Displays ATEs of each treatment appeal and negative social information ("exposed") on interest in clean meat. Results are estimated separately conditional on low vs. neutral vs. high levels of baseline interest in clean 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.

This Figure contains three main insights. First, anti-acceptance social information has little persistent effect on individuals who were already very interested in clean meat at baseline (bottom row of Figure 5). 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.

Second, the positive effects of *embrace unnatural* are concentrated among the respondents who were *least* interest in clean meat products at baseline. This result is encouraging, and is consistent with the results in Section 3.4 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.

Third, consistent with the main results reported in Figure 3, we find no evidence that the *debunking unnatural* and *descriptive norms* increased consumer acceptance of clean meat products, regardless of whether consumers were more or less interested in clean meat at baseline.

3.5.2 Effects on largest meat consumers

For clean meat products to achieve significant environmental, animal welfare, and health impacts, they will need to be adopted by typical meat-eaters rather than vegetarians and those who only eat a few servings of meat products each week. In Figure 8 (see Appendix), we estimate the effects of the pro-clean meat appeals and anti-acceptance social information separately for individuals who reported eating 0-10 servings of meat per week at baseline, 10.5-17 servings of meat per week at baseline, and more than 17 servings of meat per week at baseline.[21] While the coefficients in these plots are estimated too imprecisely to warrant any strong conclusions, two suggestive patterns are worth noting. First, anti-acceptance social information undermines interest in clean meat across low, moderate, and high frequency meat-eaters. Second, there is weak evidence suggesting that the *debunking unnatural* and *descriptive norms* appeals led to a backfire effect among moderate and high frequency meat-eaters, while the positive effects of the *embrace unnatural* appeal appear to be more concentrated among low frequency meat-eaters. These suggestive patterns should be scrutinized more closely in future work.

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21 These cutpoints correspond to the 33rd and 66th percentiles in self-reported baseline meat consumption.

4. Concluding remarks

While clean meat products may 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

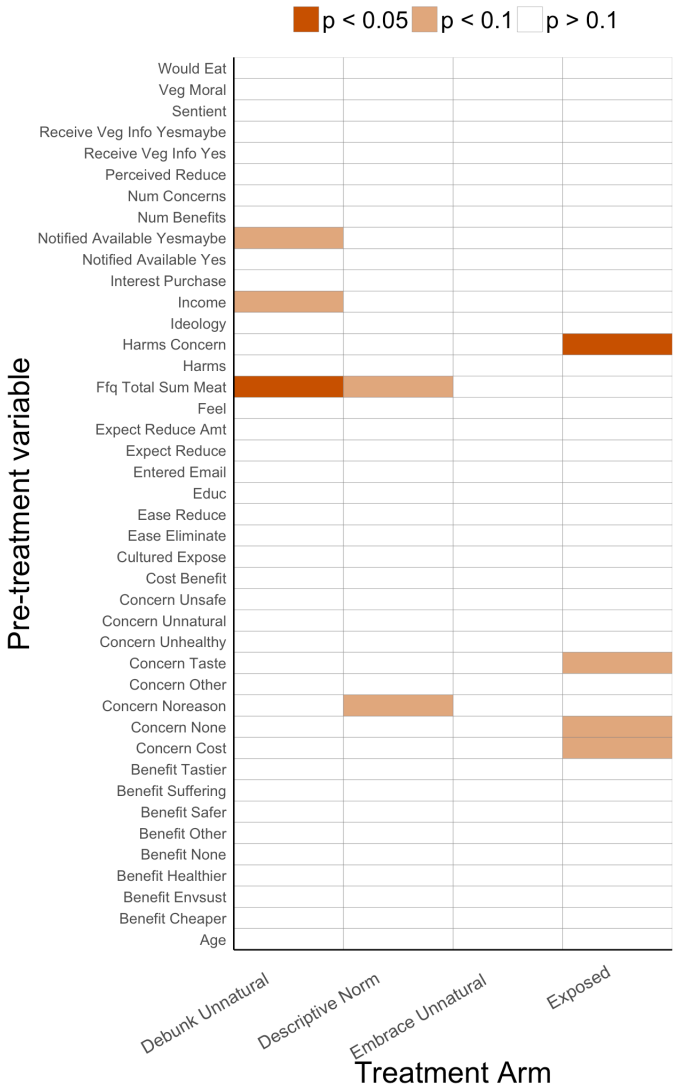

Figure 6. Experimental balance on pre-treatment variables. Displays pre-treatment balance on variables measured in wave 1 among respondents who completed all three survey waves (n=1515). Each cell represents the p-value for a t-test in the difference in means between the control group and the experimental 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 covariates. 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.

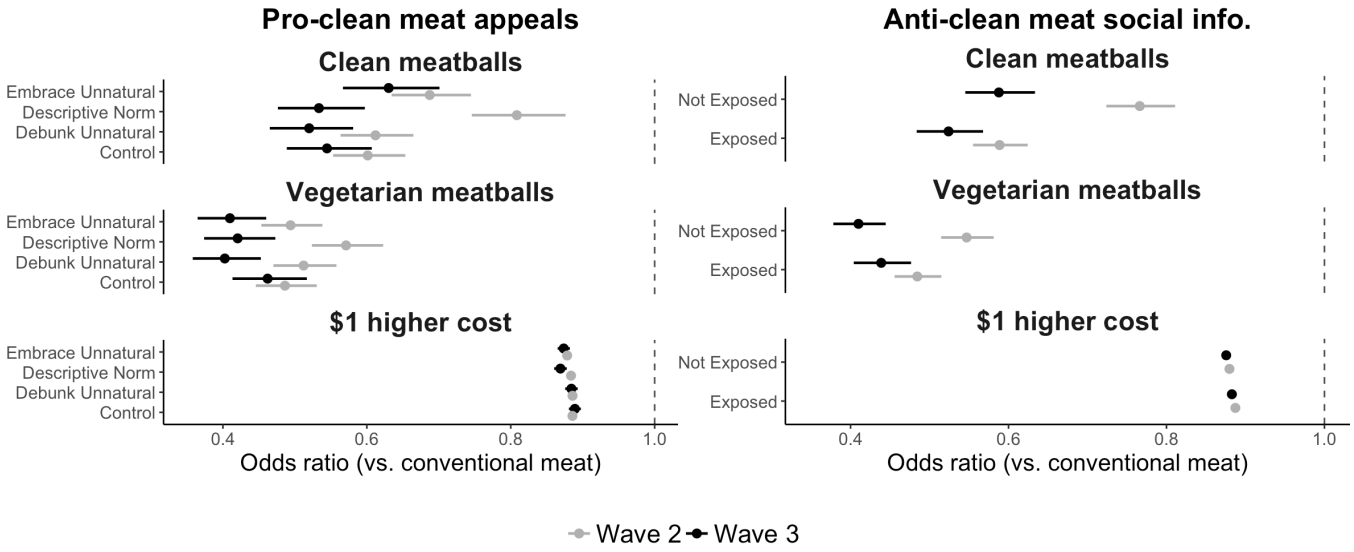

Figure 7. Treatment effects (discrete choice, odds ratio). Displays odds ratios of selecting clean (or vegetarian) meatballs relative to conventional meatballs among respondents in each experimental cell, with results shown separately for waves 2 and 3. A value of 1.0 on the x-axis indicates that respondents 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.

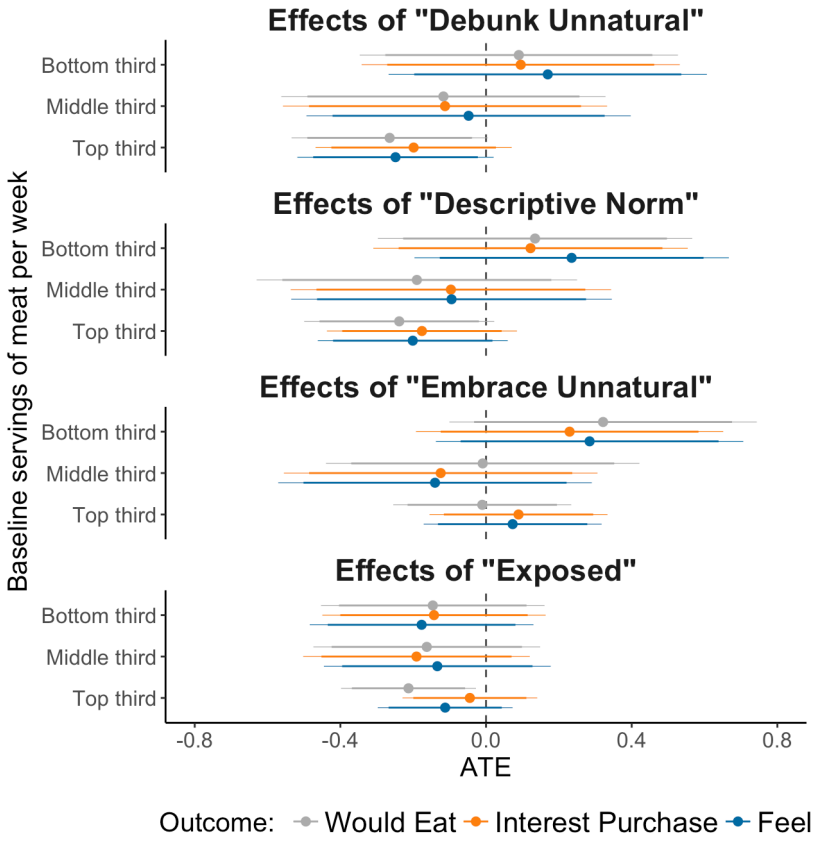

Figure 8. Heterogeneity in appeal effects by number of servings of meat consumed per week at baseline. Displays ATEs of each treatment appeal and negative social information ("exposed") on interest in clean meat. Results are estimated separately conditional on low vs. moderate vs. high levels of baseline 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.

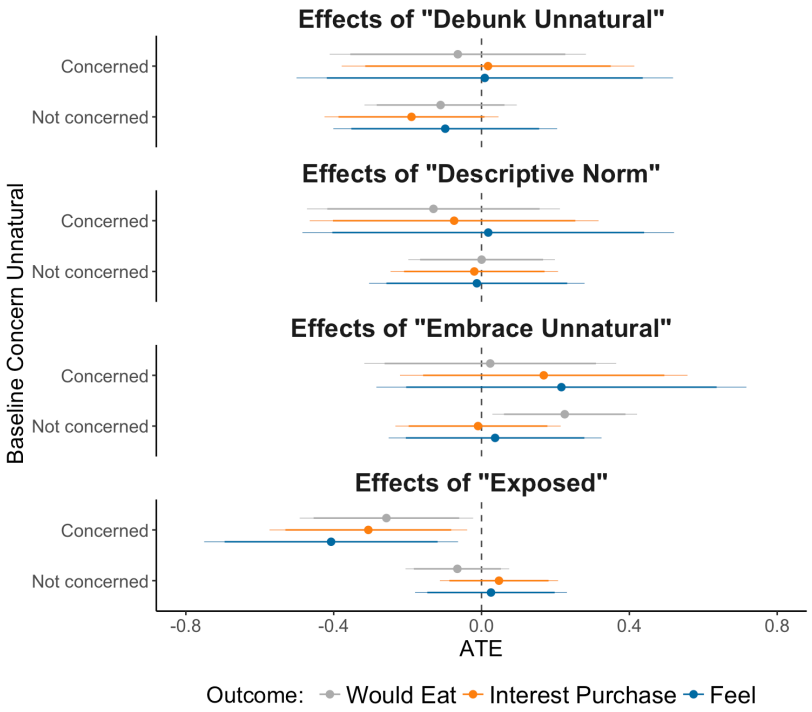

Figure 9. Heterogeneity in appeal effects by baseline concern about clean meat naturalness. Displays ATEs of each treatment appeal and negative social information ("exposed") on interest in clean meat, conditional on whether respondents were concerned about the naturalness of clean meat at baseline (y-axis). 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.

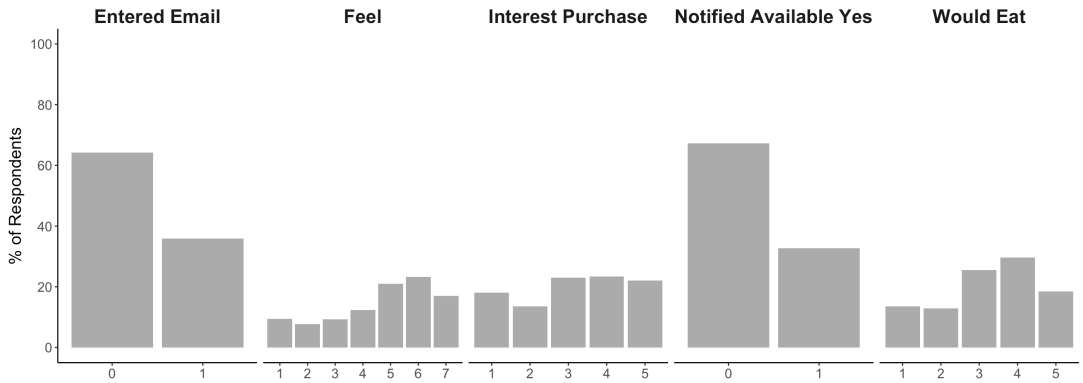

Figure 10. Descriptive statistics: Interest in clean meat products. Displays distributions of measures of interest in clean meat, as measured at baseline. Interest variables include: *entered email* (whether or not respondent entered email after "yes" response to "Would you like to

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).

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