The effectiveness of anti-naturalistic fallacy strategies on acceptance of "clean" meat

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1. INTRODUCTION

Motivation. "Clean meat" – i.e. meat products made from cultured animal tissues – has the potential to significantly reduce animal suffering and environmental damage while improving human health. Although clean meat products have been the source of a great deal of excitement in the media over the past few years,[1] these products are likely to face substantial public resistance since they conflict with prevailing cultural intuitions and cognitions. Since clean meat products are viewed by many potential consumers as "artificial" or "lab-grown" meat, these products conflict with the widespread heuristic that "what is natural is good". Moreover, the expected benefits of clean meat are either temporally distant (e.g. long-term health benefits, avoiding catastrohpic climate change) or spatially removed (e.g. animal suffering in factory farms), making it difficult for consumers to incorporate these benefits in their decisionmaking calculus.[2]

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[1]See, e.g. https://www.washingtonpost.com/news/wonk/wp/2015/05/20/meet-the-future-of-meat-a-10-lab-grown-hamburger-that-tastes-as-good-as-the-real-thing/; http://fortune.com/2016/02/02/lab-grown-memphis-meats/; http://gizmodo.com/the-future-will-be-full-of-lab-grown-meat-1720874704.

[2]For a review of recent research on individual decisions with temporally or spatially distant consequences, see Wade-Benzoni and Tost (2009); Markowitz and Shariff (2012).

The "naturalistic heuristic" – where consumer attitudes are biased towards products that are more congruent with their notion of what is "natural" for humans to consume and what kinds of organisms/chemicals/processes occur in the natural environment – is not unique to clean meat. Genetically modified (GM) foods, vaccines, nuclear power, and stem cell research face similar barriers to acceptance in the general public. In short, although a naturalistic heuristic may in general help consumers choose healthier food products with less added sugars, fats, and preservatives, at the same time this heuristic poses a significant barrier to public acceptance of technologies that could have far-reaching benefits for scientific advancement, public health, environmental sustainability, and animal welfare.

There is a rapidly growing body of research on public perceptions of vaccines, GM foods, and nuclear power (see, e.g., Yaqub et al., 2014). which has recently expanded to the study of public attitudes towards clean meat products (e.g. Wilks and Phillips, 2017). Yet, few studies on vaccines, GM foods, or nuclear power have examined the effectiveness of competing messaging strategies at overcoming these naturalistic concerns and increasing consumer acceptance.[3] In particular, we are not aware of any experimental research that compares the efficacy of different messaging strategies for increasing consumer acceptance of clean meat products. Given that clean meat products are expected to become widely available to consumers in the next couple of years, this lack of research on effective strategies for overcoming consumers' naturalistic heuristic raises important concerns about the likely acceptance and uptake of clean meat products.

Research design. In this study, we set out to answer three main questions: (1) To what extent is consumer acceptance of clean meat products driven by concerns about health, safety, and "naturalness" – each of which is indicative of the naturalistic heuristic – rather than more conventional consumer concerns about cost and taste? (2) As a novel consumer product, how susceptible is consumer acceptance of clean meat products to *negative social information*, consisting of negative reactions towards clean meat products from peers? And (3) how effective is "direct debunking" of the naturalistic heuristic at increasing consumer acceptance of clean meat products compared to a simple "social norm" pro-clean meat message and a placebo message?

To address these questions, we conduct a three-wave 2x4 full factorial survey experiment that examines how messaging strategies and *negative social information* affect individual acceptance of clean meat products and susceptibility to the naturalistic fallacy. First, we randomly assign participants to receive negative social information or not, consisting of a sample of five negative reactions towards clean meat from previous survey respondents (e.g. "Artificial meat sounds disgusting"). Second, we randomly assign participants to read either a *placebo* article or one of three pro-clean meat articles: a *natural does not mean good* appeal, *most foods are unnatural* appeal, or *social norm* appeal.

The first two appeals are variations of a "direct debunking" strategy, similar to the "misperception correction" messaging strategy commonly used to combat anti-vaccination beliefs.[4] Both the *natural does not mean good* and *most foods are unnatural* appeals invokes

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the naturalistic heuristic in order to argue against its application in the case of clean meat products, although the two appeals differ in emphasis. Specifically, the *natural does not mean good* appeal focuses narrowly on debunking the naturalistic fallacy, 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). In contrast, the *most foods are unnatural* appeal emphasizes how clean meat products are similar to many other seemingly "unnatural" foods that have already been widely accepted by most consumers, thereby encouraging readers to add clean meat products to the set of products they deem as acceptable. This messaging strategy is meant to leverage consumers' "cultural intuitions" (Miton and Mercier, 2015) about what is acceptable by equating clean meat products with other products they have already accepted. Finally, the *social norm* appeal does not make any persuasive arguments invoking the naturalistic falalcy, instead conveying a *descriptive* 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 sets of results. <u>First</u>, before turning to the experimental results, we show that consumers' wariness about clean meat is driven far more by concerns about whether clean meat is natural, safe, and healthy – which are symptoms of the naturalistic fallacy – than how clean meat products taste or how much they cost. <u>Second</u>, we show that even small amounts of negative social information about clean meat can make consumers significantly more wary about clean meat products, and that these effects persist for a period of at least 10 weeks. These effects are strongest among individuals who already have low levels of interest in clean meat. <u>Third</u>, we show that, while pro-clean meat appeals based on debunking the naturalistic fallacy or conveying social norms can counteract nearly all of the negative effects of negative social information *in the short term*, the effects of the pro-clean meat appeals we evaluate in this study are indistinguishable from zero after 10 weeks. There is *some* evidence that the *most foods are unnatural* appeal – which combines debunking with familiarity to common foods – led to persistent increases in interest in clean meat products among individuals who had low levels of interest in clean meat at baseline. Overall, however, we fail to find any systematic evidence of persistent effects from the debunking and social norm appeals used in this study.

Contributions. The purpose of this study is to shed light on the ways in which individuals respond to the naturalisic fallacy and whether information treatments can help to counter it. More broadly, this research deepens our understanding of the ways in which individuals form opinions towards new technologies that may conflict with cultural intuitions. Given that online information and social media are an important source of misinformation that drives negative attitudes towards many technologies and products (e.g. GM foods, vaccines, nuclear power), these findings offer promise that simple online articles can effectively counteract negative attitudes.

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www.health.ny.gov/prevention/immunization/vaccine_safety/misperceptions.

2. EXPERIMENTAL DESIGN

Research questions. In this study, we set out to answer three main questions. First, to what extent is consumer acceptance of clean meat products driven by concerns about health, safety, and "naturalness" – each of which is indicative of the naturalistic fallacy – rather than more conventional consumer concerns about cost and taste? Second, as a novel consumer product, how susceptible is consumer acceptance of clean meat products to "negative social information"? Third, how effective is "direct debunking" of the naturalistic heuristic at increasing consumer acceptance of clean meat products compared to a simple "social norm" pro-clean meat message and a placebo message?

Data collection. Data was collected in three online survey waves.

Baseline survey (wave 1). First, participants were asked about demographics, current levels of meat consumption, attitudes, and potential moderators. All participants were also given basic information about clean meat and some purported environmental/health/ethical benefits of consuming clean meat products.

Treatment exposure (wave 2). Second, approximately one week after completing the baseline survey, the same participants were recontacted and asked to complete a second survey. Participants were randomly assigned to one of eight experimental cells (see below). Then participants assigned to the four "social information" cells were shown a page containing five short quotes from previous survey respondents that contain negative sentiment about clean meat (e.g. "This seems very unnatural. I don't feel comfortable about this."). All participants were then shown a placebo news article or one of three pro-clean meat appeals corresponding to their experimental cell. Immediately afterwards, all participants completed a short survey containing a discrete choice block (see below) and several open-ended questions regarding their reactions to the news article. Participants were also asked for their attitudes towards clean meat, willingness-to-pay, and interest in further information about clean meat products and vegetarian products.

Endline survey (wave 3). Finally, approximately 10 weeks after completing the treatment exposure survey, the same participants were recontacted and asked to complete a followup survey. Participants were asked to complete a short survey containing a discrete choice block, attitudes towards clean meat, willingness-to-pay, and interest in further information about clean meat products and vegetarian products.

Experimental conditions. This study is organized as a randomized 2x4 full factorial design, examining how social information and messaging appeals affect individual acceptance of clean meat products and susceptibility to the naturalistic fallacy. First, we randomly assign participants to receive *negative social information* or not, consisting of a sample of five negative reactions from previous survey respondents towards clean meat (e.g. "Artificial meat sounds disgusting").

Second, we randomly assign participants to read one of four articles: a *placebo* message, *natural does not mean good* appeal (appeal #1), *most foods are unnatural* appeal (appeal #2), or *social norm* appeal (appeal #3). All messages are approximately 150-200 words in length, with three images that help to convey the main message. The *placebo* message urges participants to walk more, and makes no mention of clean meat products or meat

consumption.

Appeals 1 and 2 are variations of a "direct debunking" strategy, similar to the "misperception correction" messaging strategy commonly used to combat anti-vaccination beliefs. While this messaging strategy is in widespread use, there is very little evidence that such correction-oriented appeals are effective at countering negative attitudes/beliefs (Nyhan and Reifler, 2015; Nyhan et al., 2014). While both the *natural does not mean good* and *most foods are unnatural* appeals invoke the naturalistic heuristic in order to argue against its application in the case of clean meat products, the two appeals differ in emphasis. The *natural does not mean good* appeal (appeal #1) provides several examples of objects/phenomena that are clearly good but unnatural (e.g. antibiotics) and objects/phenomena that are clearly bad but natural (e.g. appendicitis). In contrast, the *most foods are unnatural* appeal (appeal #2) 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 occuring 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 desirable product despite the naturalistic heuristic.[5] Specifically, by emphasizing how clean meat is similar to many other kinds of foods that have been widely accepted by most consumers, readers are encouraged to add clean meat products to the set of products that are deemed acceptable rather. Hence, if we were to find that the *most foods are unnatural* appeal is more effective than the *natural does not mean good*, this would suggest that appealing to consumers' cultural intutions is an important component of new product acceptance.

Finally, the *social norm* appeal (appeal #3) conveys a *descriptive* 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 attempt to debunk the naturalistic heuristic or to emphasize the benefits of clean meat. Instead, it merely signals to readers that many other consumers seem to be excited about clean meat products, rather than concerned about potential health and safety implications.

Subject recruitment and sample size. We recruited participants 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 400 subjects per experimental cell, for a total of 3200 subjects.

Primary outcome measures. All variables described in this section were measured in the baseline, treatment, and endline survey waves, unless otherwise stated. For all analyses reported in Section 3, non-binary dependent variables are standardized to have mean equal to zero and variance equal to one.

Interest in clean meat. We collect several attitudinal measures on attitudes towards clean meat, such as "how interested are you in purchasing the clean meat product you just read

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[5]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).

about?" (1-7 scale) and "Would you like to be notified when clean meat products are available in your area?" (yes/maybe/no and provision of e-mail address in a follow-up question asked to those answering "yes" or "maybe"). Respondents were only asked in waves 1 and 2 if they would like to be notified when clean meat products become available in their area.

Concerns about clean meat. We asked participants to select the two most important concerns they have about clean meat products. 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 asked participants to select the benefits they think clean meat products will have. We also provided participants with an open-ended text box to state what they perceive will be the most important benefits of clean meat products.

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 × 4 prices). We asked respondents to answer one of two alternative blocks of 6 questions (randomly assigned).

Secondary outcome measures. All variables described in this section were measured in the baseline, treatment, and endline survey waves, unless otherwise stated.

Attitudes towards factory farming. We collected four attitudinal measures on meat consumption and factory farming. Participants were asked to rate whether and how much factory farming contributes to animal suffering and whether this is an issue they care about; whether and how much factory farming contributes to environmental degradation, and whether this is an issue they care about; and whether they think it is morally preferable to avoid eating factory farmed meat. Participants were also asked whether they would be interested in receiving tips on how to reduce their meat consumption.

Perceptions of social norms. On a seven point scale, participants were asked whether they agree or disagree with the statement that more and more people in the US are reducing their meat consumption (1=strongly disagree, 7=strongly agree).

Perceptions of vegetarians. Participants were asked to give their feelings towards vegetarians (1=extremely positive, 7=extremely negative).

Perceptions of intelligence and sentience. Participants were asked to rate seven species of animals on a 1-7 scale in terms of perceived intelligence (1=very unintelligent, 7=very intelligent). Similarly, participants were asked to rate how capable these seven species of animals were of experiencing pain and suffering on a 1-7 scale (1=completely incapable, 7=highly capable). We use "humans" as a comparison group in the analyses.

Ease of reducing meat consumption. On a seven point scale ranging from very difficult (1) to very easy (7), participants were asked to rate how easy it would be to completely eliminate conventional meat products from their diet over the next year and how easy it would be to reduce their consumption of conventional meat products by 25% over the next year.

3. RESULTS

Overall, how interested are consumers in clean meat products? Based on the results of our survey, there is a sizable minority of consumers who are interested in trying clean meat products. At the end of the treatment survey wave (wave 2), 36.4% of respondents in the control group ($n = 308$) entered their email address in order to be notified when clean meat products become available in their area. In addition, 51.3% of respondents answered "probably yes" or "definitely yes" to whether they would eat a clean meat product, while 28.6% of respondents said that they were "very interested" or "extremely interested" in purchasing clean meat products. See Figure 4 in the Appendix for further information on these descriptives.

In the analyses that follow, we examine consumer attitudes towards clean meat products in several stages. <u>First</u>, before turning to the experimental results, we show that consumers' wariness about clean meat is driven far more by concerns about whether clean meat is natural, safe, and healthy – which are symptoms of the naturalistic fallacy – than how clean meat products taste or how much they cost. <u>Second</u>, we show that even small amounts of negative social information about clean meat can make consumers significantly more wary about clean meat products, and that these effects persist for a period of at least 10 weeks. These effects are strongest among individuals who already have low levels of interest in clean meat. <u>Third</u>, we show that, while pro-clean meat appeals based on deunking the naturalistic fallacy or conveying social norms can counteract nearly all of the negative effects of negative social information *in the short term*, the effects of the pro-clean meat appeals we evaluate in this study are indistinguishable from zero after 10 weeks. There is *some* evidence that the *most foods are unnatural* appeal – which combines debunking with familiarity to common foods – led to persistent increases in interest in clean meat products among individuals who had low levels of interest in clean meat at baseline. Overall, however, we fail to find any systematic evidence of persistent effects from the debunking and social norm appeals used in this study,

3.1. Naturalistic reasoning undermines interest in clean meat

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 i's interest in clean meat between waves 1 and 3 (measured by *feel*, *interest purchase*, and *would eat*) on the change in whether respondent i expressed a particular concern about clean meat. We examine five core concerns here: taste, cost, safety, unhealthy, 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. [6] Specifically, becoming concerned about whether clean

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[6]Or, conversely, respondents who went from being concerned to unconcerned about clean meat's "natural-

meat is natural is associated with a 0.35 standard deviation decrease in *would eat* ($p < 0.01$) and a 0.23 standard deviation decrease in *would purchase* ($p < 0.01$). These patterns are similar for concerns about the safety and health effects of clean meat products. In contrast, changes in concerns about taste and cost of clean meat products are only weakly associated with interest in clean meat. [7]

Furthermore, among respondents who did *not* raise the "unnatural" concern about clean meat in the baseline survey wave, 44.7% provided an email address at the end of the treatment wave to be notified when clean meat becomes available in their area. In contrast, only 28.9% of respondents who listed "unnatural" as a concern provided an email address.[8] By comparison, 41.2% of respondents who did *not* raise "taste" as a concern entered an email address in contrast to 32.4% among respondents raising the "taste" concern.

Given the novelty of clean meat products, these concerns about whether clean meat is natural and safe might merely be the result of an initial "shock factor", such that consumers' concerns would shift more towards price and taste as they become more comfortable over time with the normalcy of clean meat products. Our results offer some support for this perspective. Looking just at respondents in the control group who completed all three survey waves ($n = 174$), the percentage of respondents raising "unnatural" as a concern dropped from 55.2% to 48.3% between the baseline and endline waves (diff: 6.9%; $p = 0.09$). Similarly, the percentage of respondents raising "unsafe" as a concern dropped from 51.1% to 43.7% (diff: 7.5%; $p = 0.08$). However, there was only a slight drop in respondents raising "unhealthy" as a concern, from 11.5% to 10.3% (diff: 1.2%; $p = 0.66$). Conversely, the proportion of respondents citing "cost" as a concern increased moderately from 60.3% of respondents to 66.1% (diff: 5.8%; $p = 0.15$), while the proportion of respondents raising "taste" as a concern decreased from 57.5% to 51.1% (diff: 6.5%; $p = 0.12$). Hence, while we find some evidence that consumer concerns about clean meat shift away from "unnatural" and "unsafe" and move towards price through repeated exposure (without any further information about the benefits/costs of clean meat), concerns clean meat's health effects appear more sticky.

## 3.2. Effects of Negative social information

How contagious are anti-clean meat attitudes? As we've shown above, a sizable minority of consumers have a positive orientation towards clean meat products, yet at the same time

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ness" between waves 1 and 3 became substantially more interested in clean meat products over the same time period. The results in this figure 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.

[7] If anything, increases in concerns about cost and taste are *positively* associated with interest in clean meat products. This positive association likely flows from the fact that respondent concerns were measured in the form of a multichoice checkbox question. Respondents with strong anti-clean meat feelings focused on the safety, health effects, and naturalness of clean meat, crowding out attention to cost and taste. Respondents with pro-clean meat feelings tended to only check off taste and/or cost for a lack of alternative concerns, thereby inducing the positive relationship we observe.

[8] This strong association between the "unnatural" concern and interest in clean meat persists even after controlling for other concerns and demographics in a simple linear probability model framework.
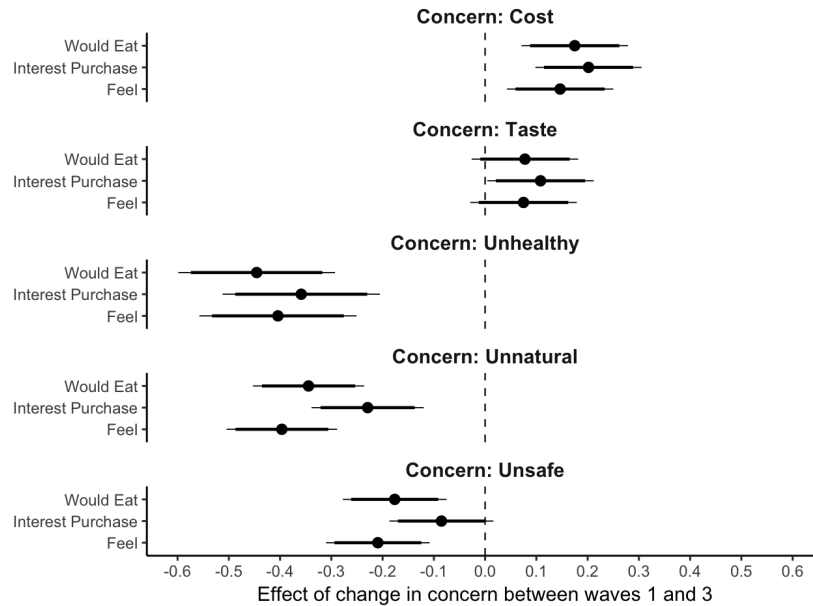
Figure 1: **Effect of concerns about clean meat on interest in clean meat**. Displays the estimated effect of a change in concerns about clean meat between waves 1 and 3 on corresponding change in interest in clean meat. Horizontal bars represent 90% and 95% confidence intervals. Non-binary dependent variables are standardized to have mean equal to zero and variance equal to one.

many consumers are wary about the safety, naturalness, and health consequences of these products. Given the novelty of clean meat products in the minds of consumers, however, the marginal effects of new information are likely to be particularly high. As a result, we should expect these attitudes to fluctuate widely as consumers become exposed to different clean meat products, marketing campaigns, and media narratives.

Here, we examine the extent to which the naturalistic fallacy is contagious. Specifically, we examine the extent to which a small amount of negative social information – in the form of negative sentiment towards clean meat expressed by respondents from a previous survey – undermines consumer interest in clean meat products. As described above, respondents in this study were randomly assigned to be exposed to negative 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").

The top panel of Figure 2 displays the effects of negative social information on attitudes towards clean meat, comparing all respondents who were exposed to the negative quotes against unexposed respondents. Points in black represent the difference in means between exposed and unexposed respondents on changes in interest in clean meat and concerns about clean meat between waves 1 and 3. Gray points represent the differences in means between waves 1 and 2. The results are discouraging, showing that small amounts of social information from complete strangers significantly decreases respondents' interest in clean

meat products, even when measured 10 weeks after treatment exposure. For instance, exposed respondents reported a significant decrease in willingness to try clean meat products (*would eat*: $d = -0.31$; $p < 0.01$) and interest in purchasing meat products (*interest purchase*: $d = -0.32$; $p < 0.01$) between waves 1 and 2 relative to unexposed respondents. In addition, negative social information led to increases in concerns about the health effects (*concern unhealthy*: $d = 0.07$; $p < 0.01$) and safety (*concern unsafe*: $d = 0.06$; $p < 0.01$) of clean meat products between waves 1 and 2.

Despite some attenuation, these effects persist when examining the corresponding changes between waves 1 and 3 (10 weeks after treatment). For instance, even after 10 weeks, exposed respondents reported a significant decrease in willingness to try clean meat products (*would eat*: $d = -0.17$; $p < 0.01$) and interest in purchasing meat products (*interest purchase*: $d = -0.13$; $p < 0.05$) between waves 1 and 2 relative to unexposed respondents. Exposed respondents also remained more likely to report concerns about the health effects of clean meat products (*concern unhealthy*: $d = 0.04$; $p < 0.09$). Exposed respondents were also somewhat more likely than unexposed respondents to report concerns about whether clean meat is natural (*concern unnatural*; $d = 0.04$; $p = 0.2$), although this difference does not reach conventional levels of statistical significance.

These results are disconcerting, showing that even very weak forms of negative social information – as in the form of five short quotes from completely anonymous individuals – can lead to persistent anti-clean meat attitudinal shifts. Even worse, these attitudinal shifts persist despite the fact that most respondents were asked to read a pro-clean meat appeal immediately after exposure to negative social information. [9] In the next subsection, we examine the effectiveness of these pro-clean meat appeals at countering negative social information.

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[9]Except for those exposed to the control appeal, representing approximately 25% of respondents.
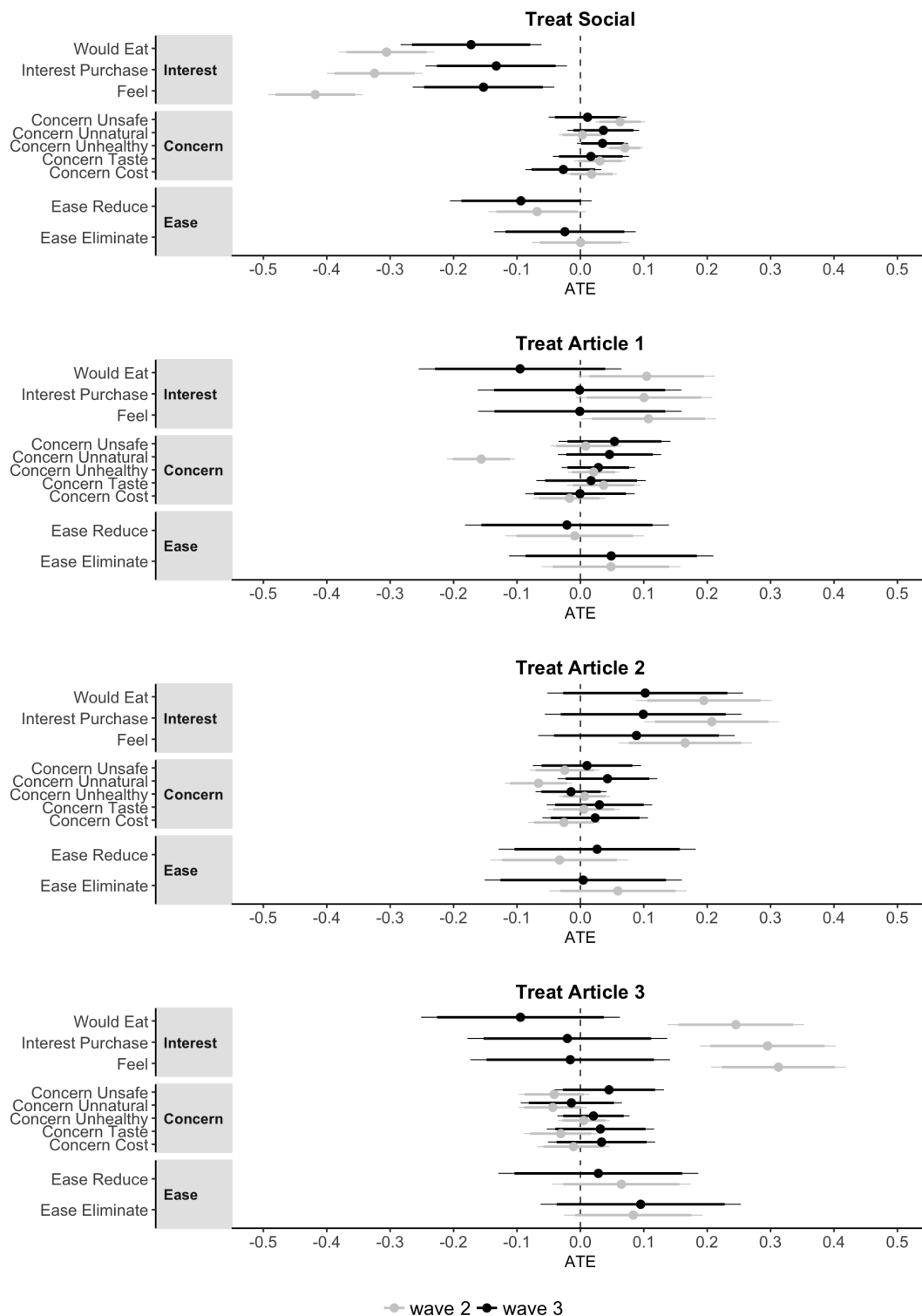
Figure 2: Effects of negative social information and pro-clean meat appeals, wave 2 vs. wave 3. Points in black represent the difference in means between exposed and unexposed respondents on changes in interest in clean meat and concerns about clean meat between waves 1 and 3. Gray points represent the differences in means between waves 1 and 2. Horizontal bars represent 90% and 95% confidence intervals. Non-binary dependent variables are standardized to have mean equal to zero and variance equal to one. Treat article #1: *natural does not mean good* appeal; Treat article #2: *most foods are unnatural* appeal; Treat article #3: *social norm* appeal.

3.3. Appeal effects

Can simple pro-clean meat appeals aimed at debunking the naturalistic fallacy or conveying descriptive social norms effectively overcome the pernicious effects of negative social infomation shown above? Here, we show that, while pro-clean meat appeals based on debunking or conveying social norms can counteract nearly all of the negative effects of negative social information *in the short term*, these counteracting effects decay over time and are indistinguishable from zero after 10 weeks.

Figure 2 displays the effects of the *natural does not mean good* appeal (Appeal #1), *most foods are unnatural* appeal (Appeal #2), and *social norm* appeal (Appeal #3) on interest in clean meat and concerns about clean meat relative to placebo. Points in black represent the difference in means between exposed and unexposed respondents on changes in interest in clean meat and concerns about clean meat between waves 1 and 3. Gray points represent the differences in means between waves 1 and 2.

As shown in Panels 2-4 in Figure 2, all three pro-clean meat appeals led to improvements in consumer attitudes towards clean meat products – as measured by *would eat*, *interest purchase*, and *feel* – between waves 1 and 2 relative to placebo. Both of the debunking appeals (*natural does not mean good* and *most foods are unnatural*) also led to decreases in concerns about whether clean meat products are unnatural. For instance, the proportion of respondents in the *natural does not mean good* arm raising "unnatural" as a concern decreased by roughly 15 percentage points more between waves 1 and 2 than among respondents reading the placebo article. 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. [10]

Overall, however, these effects did not persist over time. For instance, while, the *social norms* appeal consistently had somewhat larger effects than the other two appeals on consumer interest in clean meat when measured at wave 2, these effects had completaly shrunk to zero by wave 3 (10 weeks after treatment exposure). The same pattern appears for the *natural does not mean good* appeal, where the positive effects on interest in clean meat at wave 2 disappear when considering wave 3 measures of interest in clean meat. The *most foods are unnatural* appeal provides some optimism, since respondents exposed to this appeal were still more likely to report increases in interest in clean meat after 10 weeks relative to the placebo group, yet these effects do not reach conventional levels of statistical significance. Finally, the anti-naturalistic fallacy effects of the two debunking appeals in wave 2 do not persist to wave 3.

In short, despite encouraging short-term effects of the pro-clean meat appeals, we fail to find evidence of persistence in these effects over a 10 week period. This lack of persistence is especially concerning given that the pernicious effects of negative social information continued to suppress interest in clean meat after 10 weeks.

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[10]The *most foods are unnatural* and *social norms* 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.

3.4. Did appeals influence the least interested respondents?

Did the pro-clean meat appeals have more persistent effects on individuals who were already more/less interested in consuming clean meat products at baseline? Similarly, were the pernicious effects of negative social information concentrated among individuals who were already more/less interested in consuming clean meat products at baseline? We examine both of these questions in Figure 5 (Appendix), displaying the estimated treatment effects of negative social information and the three pro-clean meat appeals 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 (wave 1), measured based on responses to *feel* (left column) and *interest purchase* (right column). Looking at the bottom row of the figure, negative social information has little persistent effect on individuals who were already very interested in clean meat at baseline. Instead, negative 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 may be more resilient to negative coverage of clean meat products. On the other hand, high levels of susceptibility to negative social information among consumers with low to moderate interest in clean meat adds to the difficulties of converting skeptical consumers into regular buyers of clean meat products.

Turning to the three pro-clean meat appeals (rows 1-3), there is some evidence that the *most foods are unnatural* (Appeal #2) led to persistent improvements in interest in clean meat after 10 weeks among respondents who reported being *least* interested in clean meat at baseline. This result is encouraging, suggesting that a combination of debunking and analogies to common foods can be an effective strategy for overcoming skepticism from the least interested consumers. The other two appeals, however, fail to display any persistent effects regardless of respondents' baseline levels of interest in clean meat.

3.5. Did appeals influence the biggest meat-eaters?

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 "reducetarians" who only eat a few servings of meat products each week. In Figure 3, we estimate the effects of negative social information and the three pro-clean meat appeals 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. Curiously, negative social information has weaker effects on interest in clean meat after 10 weeks among the top third of meat eaters (more than 17 servings), yet these differences are not consistent for all measures of interest in clean meat. Conversely, each of the three pro-clean meat appeals is marginally more effective at improving interest in clean meat among the bottom third of meat eaters (0-10 servings), although the differences in effectiveness are imprecisely estimated.
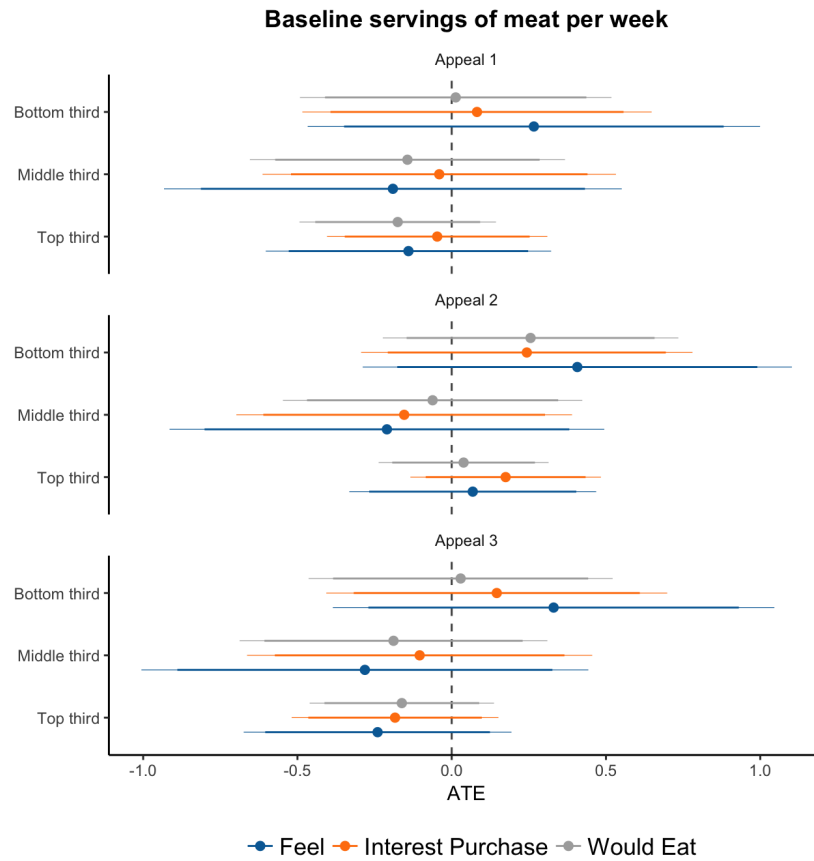
Figure 3: **Heterogeneity in appeal effects by number of servings of meat consumed per week at base-line.** Horizontal bars represent 90% and 95% confidence intervals. Non-binary dependent variables are stan-dardized to have mean equal to zero and variance equal to one. Treat article #1: *natural does not mean good* appeal; Treat article #2: *most foods are unnatural* appeal; Treat article #3: *social norm* appeal.

3.6. Combating negative social information

As shown in Figure 2, the pro-clean meat appeals counteract much of the pernicious ef-fects of negative social information in the short-term, but not over longer periods. However, these patterns do not shed light on whether any of the appeals *interact* with the negative social information – that is, whether any of the three appeals become significantly more or less effective when preceded by negative social information. We examine this possibility in Figure 6 (Appendix), displaying the effects of each appeal on interest in clean meat prod-ucts after 10 weeks, broken down by whether respondents were exposed to negative social information or not. Points in black represent the estimated appeal effects among respondents exposed to negative social information, while gray points represent estimated appeal effects among respondents not exposed.

There is some evidence that the *natural does not mean good* appeal (Appeal #1) is less effective at increasing interest in clean meat relative to placebo when preceded by negative

social information. Overall, however, the black and gray points track each other closely, suggesting that in the aggregate none of the three appeals are particularly ill- or well-suited for combatting negative social information.

4. CONCLUDING REMARKS

Overall, we show that simple "debunking" appeals aimed at combating the naturalistic heuristic can be effective at improving public acceptance of cultured meat products. At the same time, however, these positive effects can easily be over-shadowed by small amounts of negative social information. More results to come soon.

5. APPENDIX
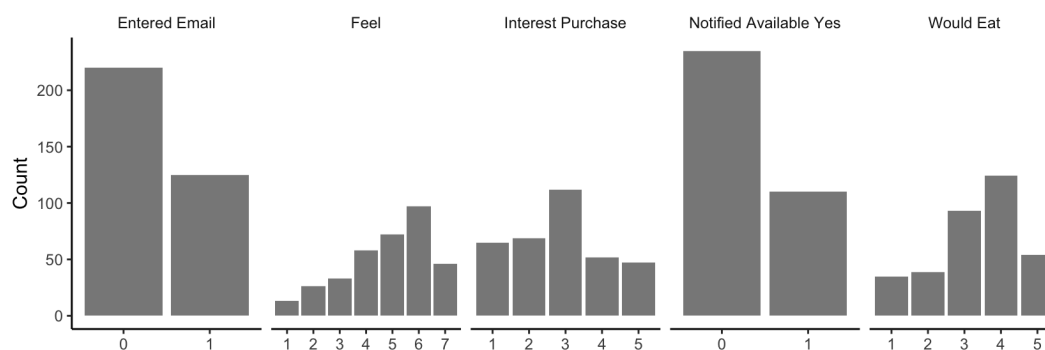
Figure 4: **Interest in clean meat products.**
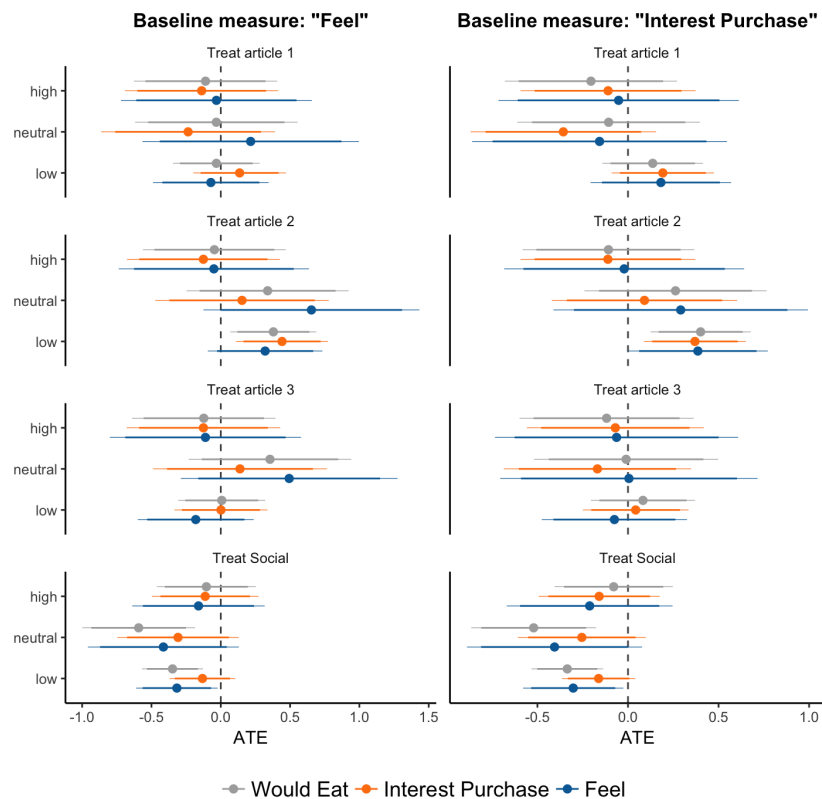
Figure 5: Heterogeneity in appeal effects by baseline interest in clean meat. Horizontal bars represent 90% and 95% confidence intervals. Non-binary dependent variables are standardized to have mean equal to zero and variance equal to one. Treat article #1: *natural does not mean good* appeal; Treat article #2: *most foods are unnatural* appeal; Treat article #3: *social norm* appeal.
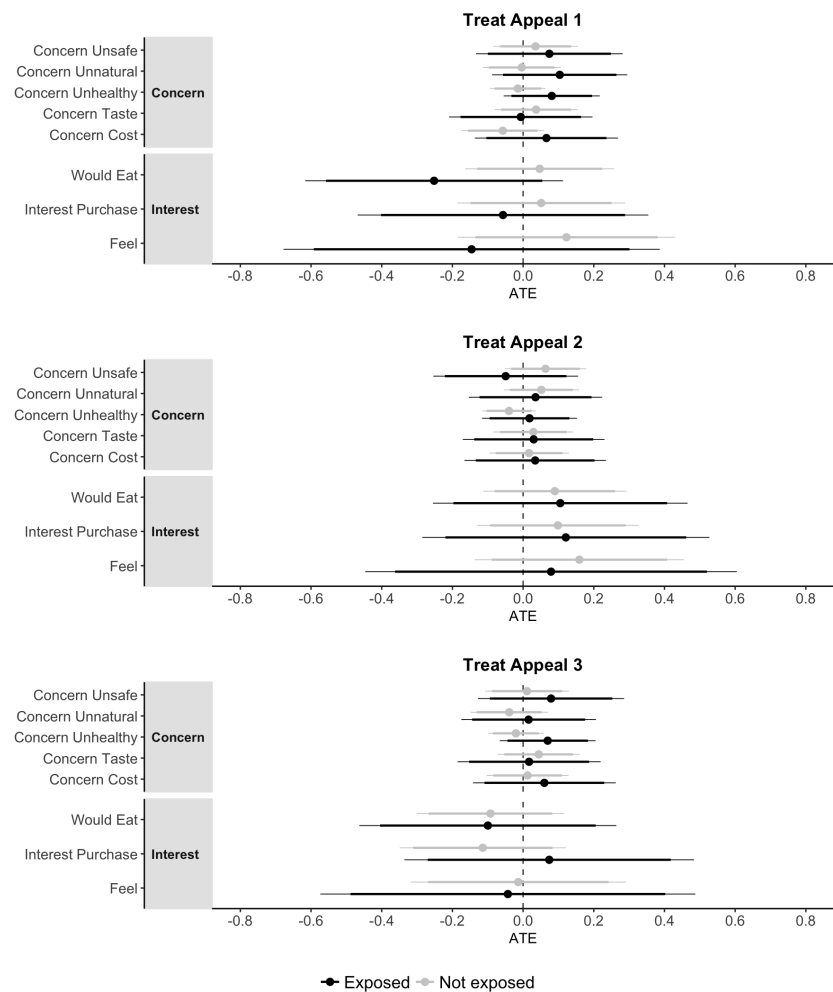
Figure 6: **Heterogeneity in appeal effects by whether respondents exposed to negative social information.** Horizontal bars represent 90% and 95% confidence intervals. Non-binary dependent variables are standardized to have mean equal to zero and variance equal to one. Treat article #1: *natural does not mean good* appeal; Treat article #2: *most foods are unnatural* appeal; Treat article #3: *social norm* appeal.

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