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Strategies for overcoming aversion to unnaturalness: the case of clean meat

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Abstract

Clean meat (grown from animal cells rather than rearing animals) has the potential to address many concerns associated with meat production. However, research suggests that the perceived unnaturalness of clean meat could be a barrier to consumer acceptance. This study investigated the efficacy of different messages designed to address consumers' concerns about clean meat naturalness. In an experimental design, participants read one of four messages: clean meat is natural, conventional meat is unnatural, naturalness is not important, or highlighting benefits of clean meat without addressing naturalness. The results indicated that arguing that conventional meat is unnatural resulted in a significant increase in some measures of acceptance compared to other messages. Arguing that clean meat is natural and challenging the appeal to nature were less persuasive, and challenging the appeal to nature resulted in some measures of acceptance being lower than not addressing naturalness. We discuss these results in the context of existing naturalness research and give recommendations for further research.

Keywords

Clean meat; cultured meat; meat; naturalness; consumer behavior; attitudes

1. Introduction

Modern animal agriculture contributes substantially to a plethora of global problems including climate change, antibiotic resistance, and animal suffering (Garnett, 2009; Norwood & Lusk, 2011; Oliver, Murinda, & Jayarao, 2011). Despite this, consumers are generally unwilling to reduce their meat consumption (Tobler, Visschers, & Siegrist, 2011) and economic growth in developing countries means that global meat consumption is likely to continue to rise (Delgado, 2003), exacerbating many of the problems associated with animal agriculture in its current form. Though diverse forms of conventional meat production vary in their impacts, all types contribute to significant global problems.

As Hartmann and Siegrist (2017) have argued, these trends necessitate exploring various meat alternatives, including clean meat (also called ‘cultured meat’ or ‘in vitro meat’). Clean meat can be produced using cell cultures without the need to slaughter animals, thus circumventing many of the environmental and ethical problems associated with conventional meat production (Post, 2012; Tuomisto & de Mattos, 2011). Although clean meat is not yet commercially available, several companies are poised to bring a product to market within five years (Shapiro, 2018).

However, it is unclear whether consumers will accept this novel food (Bryant & Barnett, 2018). While some studies show a high level of willingness to try clean meat (Wilks & Phillips, 2017), others have found that less than half of consumers would eat clean meat, and most would prefer conventional meat in practice (Slade, 2018; Surveygoo, 2018). Common concerns about clean meat include its taste, price, and safety (Laestadius & Caldwell, 2015; Tucker, 2014; Verbeke, Marcu, et al., 2015). One of consumers’ primary concerns about clean meat is its alleged unnaturalness. This is a theme which has been observed in many qualitative studies (Laestadius, 2015; Verbeke, Marcu, et al., 2015) and cited as one of the most common reasons for rejecting clean meat in surveys (The Grocer, 2017). Indeed, Siegrist and Sütterlin (2017) have demonstrated that the perceived unnaturalness of clean meat explains a great deal of consumers’ safety concerns, whilst Siegrist, Sütterlin, and Hartmann (2018) show that this perception evokes disgust and likely causes rejection of clean meat in practice.

This response is an example of the appeal to nature, a well-documented fallacy whereby people assume that naturalness is analogous to goodness (Moore, 1903). Demonstrably, this is not the case: there are many unnatural things which are good (e.g. modern medicine) as well as natural things which are bad (e.g. earthquakes). In other contexts, it is clear that naturalness in and of itself has no bearing on goodness; as Shapiro (2018) points out, ‘unnatural’ ice from freezers is no worse than ‘natural’ ice from glaciers. However, Laestadius (2015) points out that prevailing ethics are not always good ones, but that failing to engage with such perceptions is likely to have practical consequences in terms of consumer behaviour. As Welin (2013, p. 29) argues, ‘Whether or not a good argument can be made for the unnaturalness of [clean] meat... one has to take such perceptions seriously.’ Indeed, similar consumer concerns likely contributed to policies restricting the cultivation of genetically modified (GM) foods in Western Europe (Schurman, 2004), and thus identifying effective strategies for addressing the appeal to nature may prove useful in other food technology contexts.

Mielby, Sandøe, and Lassen (2013) found that consumers used the term ‘unnatural’ to object to several aspects of GM crops. Whilst some objected to human interference, others were more concerned about crops’ abnormal features or their own personal unfamiliarity with the concept. Meanwhile, Deckers (2005, p. 451) has argued that consumers who object to unnatural agricultural products may have distinct worldviews in which ‘the instrumentalization of the nonhuman world is questioned to a larger extent’—that is, they may be more concerned than others about people manipulating the environment for their own use. It seems, therefore, that whilst some consumers use the term ‘unnatural’ imprecisely to object to unrelated features of products (such as unfamiliarity), others are committed to worldviews in which naturalness itself is valued.

This is in line with Laestadius (2015), who has argued that, in the context of clean meat, objections about naturalness generally fall into two categories. On one hand, some people infer that, because clean meat is unnatural, it probably has negative consequences for human health and/or the environment in practice. Others assume that clean meat is inherently bad because of its unnaturalness. The author argues that, whilst the former type of objection may be able to be overcome by evidence to the contrary, the latter appears to be more deeply rooted in fundamental ideas about naturalness as an ideology (see Marcu et al., 2015) and may therefore be more resistant to reasoning.

The present study, therefore, sought to investigate the efficacy of several messaging strategies designed to address the appeal to nature in the context of consumer acceptance of clean meat. The study aims to answer the questions:

1. Can consumer acceptance of clean meat be increased by directly addressing concerns about naturalness?
2. What is the relative efficacy of arguments that clean meat is natural, that conventional meat is unnatural, and that naturalness is unimportant?

2. Methods & materials

2.1 Participants

2.1.1 Power and sample

The purpose of this study was to put the above questions to a fair test, allowing for the possibility that the answer to the first question is no. Therefore, it was crucial to be able to draw meaningful conclusions from null effects. To that end, a power analysis was conducted in order to determine the required sample size. This was initially based on estimated effect sizes from a review of the literature and subsequently updated based on the results of a pilot study of 110 participants.

We aimed to detect differences between conditions as well as an overall difference; therefore, the power analysis examined our ability to find significant pairwise differences in willingness to try clean meat (our primary outcome measure) using a two-tailed independent samples *t* test. Based on consultations with researchers and industry stakeholders, we chose a minimal meaningful effect size of $d = .24$ and an 80% power level. With the standard significance level of $\alpha = .05$, the power analysis indicated the study would require a sample size of 275 subjects in each of four experimental conditions (1,100 in total).

The final sample of 1,185 U.S. adults surpassed the number suggested by the power analysis.¹ This sample was census-balanced and recruited through the research firm Ipsos: 550 (46.4%) were male, 627 (52.9%) were female, and 8 (0.7%) had other gender identities. The mean age was 47.3 (SD = 16.8). Diet was extrapolated from a basic consumption item (“Which of the following do you eat at least occasionally?”),² according to which, 2.2% of participants were vegetarian or vegan, 2.5% were pescatarian, and 95.3% were omnivorous.

2.2 Experimental procedure

An experimental survey design was used to compare the efficacy of four different promotional messages addressing the naturalness concern: messages that were as close as possible to the type of message that would be used by clean meat manufacturers and advocates.

The experimental procedure for this study was pre-registered at the Open Science Framework (Faunalytics, 2018). The study also received full ethical approval from the Social Science Research Ethics Committee at the University of Bath.

First, participants read a description of the study and gave their informed consent to take part. Block randomization was used to evenly allocate participants to one of the four conditions based on gender and diet (two characteristics found to predict acceptance of clean meat in previous studies).³ All participants answered questions about their familiarity with clean meat and read an introductory passage describing it, to ensure that everyone had the same basic information before they received the promotional message.

At this stage, participants then read the message. The development and content of these messages are described in more detail in the next section.

Participants then answered questions about their behavioural intentions, attitudes, beliefs, affective reactions, and willingness to pay (WTP) for clean meat. These questions are summarized in Section 2.4. Finally, participants were debriefed, thanked for taking part, and compensated for their time in Ipsos credit (worth approximately \$2).

2.3 Promotional messages

¹ Overall, 463 (28%) of the original 1,648 survey respondents were automatically ejected from the study for failing one of two basic attention checks. Although this ensures that those who completed the study were paying attention, it may introduce a degree of selection bias.

² Participants were asked to select all that applied of the following options: beef or other red meat (e.g., lamb, goat, bison), pork (e.g., bacon, ham, ribs), poultry (e.g., chicken, turkey, duck), fish or shellfish (e.g., tuna, lobster, shrimp, oysters), dairy products (e.g., milk, yogurt, cheese, ice cream), and eggs. They could alternatively choose ‘I never eat any of the above.’ Participants were considered pescatarian if they reported consumption of fish but no other meats. They were considered vegetarian if they reported consumption of eggs and/or dairy, but no meats. They were considered vegan only if they indicated that they never eat any of the above.

³ Prior to the main analyses, ANOVA and chi square analyses indicated no significant differences between experimental groups on relevant demographic factors including age, gender, diet, race, state, education, income, and familiarity with clean meat. This demonstrates that random assignment was successful.

The manipulated variable in this study was the central argument of a promotional message. The introductory paragraph of the message was held constant to set the positive tone. It was followed by one of the four arguments about naturalness shown in Table 1: (1) clean meat is natural, (2) conventional meat is unnatural, (3) challenging the appeal to nature, and (4) a control message which outlined some benefits of clean meat but did not mention naturalness. The control message was designed to match as closely as possible the messaging used by manufacturers on their websites at that time (e.g., Memphis Meats, Just).

Table 1: Promotional messages given to participants in each experimental condition.

Condition	Message
Introductory passage (shown to all participants)	Clean meat is real meat, grown from animal cells without the need to raise and slaughter farm animals. It has significant benefits for the environment, animals, and human health. Products include chicken (as shown), beef, and more!
Clean meat is natural	Clean meat products are made using a natural process very similar to the way yogurt and beer are fermented. This is a method which has been used in food manufacturing for thousands of years. The development of clean meat resembles how muscles naturally grow within an animal very closely. In fact, this process of cell growth is present in all natural life. Clean meat has many benefits for human health, animals, and the environment. But best of all, it's all-natural!
Conventional meat is unnatural	Production of conventional meat today is far from natural. Animals are fed antibiotics and hormones so that they grow much faster and larger than they would in nature. Unsanitary farming conditions increase the risk of contamination from feces, as well as viruses and bacteria. The meat also contains additives, artificial coloring, and preservatives, and is often treated with radiation. Clean meat avoids all of those issues. It has many benefits for human health, animals, and the environment. But best of all, it's just meat!
Challenging the appeal to nature	You might think that clean meat is unnatural, but naturalness does not necessarily mean goodness. Indeed, most modern food (including rice, tomatoes, milk, and – yes – meat) has been manipulated by people to make it suit our needs, and it is tastier and more nutritious as a result. On the other hand, some plants (like many types of poisonous mushroom) are completely natural but can easily kill you. Clean meat has many benefits for human health, animals, and the environment. It's a perfect example of humans improving on nature!
Control	There are many reasons to eat clean meat: It requires much less water to produce and will cause far less climate change than conventionally-produced meat; it doesn't require animals to suffer or die; it can feed far more people from the same amount of land; and it has the same or better nutritional content as conventionally-produced meat.

In sum, clean meat has many benefits for human health, animals, and the environment. But best of all, it's delicious real meat!

These messages were developed in close consultation with industry professionals and clean meat advocates, to reflect the best arguments those key stakeholders could raise in response to unnaturalness concerns. They began as many pages of ideas, points, and references from many individuals and were pared down over multiple rounds of feedback to the arguments presented above. In short, this study's messages, whilst open to criticism, represent a strong test of marketers' ability to overcome unnaturalness concerns with rationale argument.

Specifically, the first argument in Table 1 takes a defensive tack, defending clean meat against the allegation of unnaturalness; the second argument can be considered offensive, highlighting concerns about the naturalness of conventional meat); and the third argument was developed to reject the premise that naturalness is an important factor in food altogether.

In order to hold constant other features of the messages, they were checked for length and readability using an online tool (Readable, 2018). They were also informally pretested on a small convenience sample to confirm that they were perceived as presenting the intended message (a manipulation check).

2.4 Terminology

Throughout the present study — both in the study materials and this article — we used the term 'clean meat,' though it is also sometimes called 'cultured meat' or 'in vitro meat.' We made this decision because, at the time of data collection, most clean meat companies and advocates were using the term after several studies showed this name was associated with the highest level of consumer acceptance (Animal Charity Evaluators, 2017; The Good Food Institute, 2017). Whilst many continue to use the term 'clean meat', others in the industry now use the term 'cell-based meat', and the preferred nomenclature may continue to change in the future. However, given the positive associations with 'clean meat' shown in previous research, this choice of terminology made for a conservative test of our hypotheses: insofar as the name 'clean meat' reduces concerns about the product, its effectiveness may overlap with the promotional messages, which had the same purpose.

2.5 Measures

The measures used to assess participants' acceptance of clean meat are shown in Tables 2 through 5.

Table 2: Behavioural intention measures.

Question	Response options
1. Would you be willing to try clean meat?	
2. Would you be willing to buy clean meat regularly?	Definitely no (1) to
3. Would you be willing to eat clean meat as a replacement for conventionally-produced meat?	Definitely yes (5)

4. How willing would you be to eat clean meat compared to plant-based substitutes (e.g. soy)?

The behavioural intentions measures shown in Table 2 were adapted from Wilks and Phillips (2017). Question 3 also included a response option for ‘Not applicable (I do not eat conventionally produced meat).’

Table 3: Cognitive belief measures.

Question	Response options
To what extent do you agree or disagree that...	
1. Eating clean meat is likely to be healthy?	
2. Clean meat is likely to be safe for human consumption?	
3. Clean meat is more environmentally friendly than conventionally-produced meat?	Strongly disagree (1) to Strongly agree (5)
4. Clean meat is likely to look, taste, smell, and feel the same as conventionally-produced meat?	
5. Clean meat will have benefits for society?	

The cognitive beliefs items shown in Table 3 were adapted from Bryant and Barnett (in prep), and based on measures used in various previous studies of food technology acceptance (Cardello, 2003; Frewer, Howard, Hedderley, & Shepherd, 1997; Magnusson & Hursti, 2002; Scholderer & Frewer, 2003; Tan, Verbaan, & Stieger, 2016; Tanaka, 2004; Tenbült, de Vries, Dreezens, & Martijn, 2005; Titchener & Sapp, 2002). The sequence of these questions was randomised to control for order effects.

Table 4: Items, response options, and reliability measures for composite variables.

Measure	Items	Response options	Reliability
Attitude	1. For me to eat clean meat would be...* 2. For me to eat clean meat would be...	1. Extremely good (1) to Extremely bad (7) 2. Extremely unpleasant (1) to Extremely pleasant (7)	$\alpha = .88$
Affect	Indicate the extent to which each of the following describes your feelings about eating clean meat: 1. Disgusted* 2. Excited 3. Anxious* 4. Comfortable 5. Ethical 6. Immoral*	Not at all (1) to Extremely (7)	$\alpha = .75$

* Denotes item was reverse scored. Within these measures, the sequence of items was randomised to control for order effects.

The attitude composite shown in Table 4 used Fishbein and Ajzen's (2010) recommended construction. The items of the affect composite were chosen based on reactions to clean meat commonly observed in previous research (Laestadius & Caldwell, 2015; Verbeke, Marcu et al., 2015). Three positively-framed and three negatively-framed items were chosen to prevent response sets.

As well as the measures listed above, participants also indicated their WTP for clean meat. This was done by showing participants pairs of conventional and clean meat products in each of three categories (chicken nuggets, beef burgers, and fish sticks). They were shown a price for the conventional meat version and asked to indicate the maximum they would be willing to pay for the clean meat version. For the purpose of analyses, a difference score was calculated between the participant's maximum price for clean meat and the given price for conventional meat, to indicate relative willingness. Participants could also indicate that they would not buy the clean meat version at any price. If they chose that option, they were subsequently asked whether they would buy the conventional meat version instead, to differentiate between people unwilling to buy clean meat and people unwilling to buy that product (chicken nuggets, beef burgers, or fish sticks) at all. People who would not buy either product were excluded from analyses, as their unwillingness to buy clean meat cannot be said to stem from the fact that it is cultured.

The distribution of values was extremely non-normal and unsuitable for standard parametric tests. Therefore, in order to analyze the data, responses were categorised as one of the following: would not buy the clean product at all, would pay less for it than the conventional product, would pay equal, or would pay more.

Table 5: Persuasion checks

Question	Response options
1. Clean meat is unnatural.	Strongly disagree (1) to Strongly agree (5)
2. Conventionally-produced meat is unnatural.	
3. It is important for meat to be natural.	

The measures of perceptions of naturalness shown in Table 5 were included to check the persuasive efficacy of the intervention messages on relevant beliefs.

2.6 Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics, Version 22. ANOVA and chi square analyses were used to check for differences between groups on relevant demographic factors. ANOVAs were then used to check for differences in measures of agreement with the persuasion checks.

Per the pre-registered analysis plan, multivariate outliers were detected and reeled in to avoid extreme values exerting undue influence on subsequent analyses using methods discussed by Judd, McClelland, and Ryan (2017).⁴ This was deemed necessary because clean meat can be

⁴ All output variables were examined for multivariate outliers as a function of experimental condition using Cook's D and leverage values. Values were considered outliers if they had a

divisive, creating a potential for a few very negative responses to exert undue influence on the analyses.

For the main analyses, ANOVAs were used to compare measures of behavioural intentions, cognitive beliefs, attitudes, affective responses, and perceptions of naturalness between experimental conditions.

For willingness to try clean meat, which was considered a primary analysis in the pre-registration, planned pairwise comparisons were conducted between the control condition and each experimental condition. The other three pairwise analyses for willingness to try clean meat were Bonferroni-corrected.

All pairwise comparisons for the other Likert-type measures, which were considered secondary analyses, were corrected for post hoc analysis using Tukey's HSD, which is designed for making all possible comparisons.

Finally, ordinal regression was used to compare WTP for clean meat between experimental conditions. This was also considered a primary analysis, so as with willingness to try clean meat, planned pairwise comparisons were conducted between the control condition and each experimental condition. The other three pairwise analyses for WTP were Bonferroni-corrected.

3. Results

The results of ANOVAs and pairwise comparisons for all Likert-type outcome variables are provided in Table 6. For all of these, outlier adjustments were performed using the method described above. This resulted in outlier values in outcome variables being adjusted to the nearest acceptable value for between 41 and 106 records per variable. The pattern of results did not differ substantially if outliers were left unadjusted.

In the table, statistically significant differences between pairs of means—as determined using the criteria laid out in the previous section—are denoted in the table using subscript letters. Means that significantly differ have different subscripts, whereas means that do not differ share a subscript. For example, in the 'perceived importance of naturalness' row, those in the 'clean meat is natural' condition showed significantly higher agreement than those in the 'challenging appeal to nature' condition (as indicated by subscripts *a* and *b*, which these two conditions do not share). However, those in the 'conventional meat is unnatural' condition and the control condition were not significantly different from the other conditions (as indicated by subscripts *a* and *b*, which are shared with all other conditions). As shown, most outcome variables did not differ significantly between conditions, though there were some significant differences in attitude and cognitive beliefs.

3.1 Perceptions of naturalness

These analyses revealed that the experimental messages produced mixed results, as described below. The 'conventional meat is unnatural' message was persuasive but the other two were not.

Cook's $D > 4/n$ (Bollen & Jackman, 1990) or a leverage $> 2(p + 1)/n$ (Hoaglin & Welsch, 1978), and were reeled in to the nearest acceptable value.

3.1.1 Perceived unnaturalness of clean meat

The ‘clean meat is natural’ message focused on similar processes used in current food production, and argued that clean meat production relies on natural processes. If these arguments were able to overcome concerns about unnaturalness, we would expect participants in this condition to be less likely to say that clean meat is unnatural than participants in the control condition. However, there was no significant difference, as shown in Table 6. This finding indicates that this argument for clean meat’s naturalness, was not persuasive.

Given that no significant condition differences emerged, we considered the overall, top-line results in order to examine the extent of naturalness concerns in the population. These results indicated that concerns about the naturalness of clean meat were held by only a minority of participants. Across all conditions, 34.1% agreed or strongly agreed with the statement that “clean meat is unnatural,” whilst 34.2% disagreed or strongly disagreed, and 31.6% neither agreed nor disagreed.

3.1.2 Perceived unnaturalness of conventional meat

The ‘conventional meat is unnatural’ message highlighted unnatural practices in conventional meat production, and framed clean meat as avoiding such practices. If these arguments overcame concerns about unnaturalness, we would expect participants in this condition to be more likely to say that conventional meat is unnatural than participants in the control condition. As shown in Table 6, participants in this condition were significantly more likely to perceive conventional meat as unnatural than participants in the control condition ($d = .313$). This difference indicates that this argument for the unnaturalness of conventional meat was persuasive.

3.1.3 Perceived importance of meat naturalness

The ‘challenging the appeal to nature’ message focused on explaining and debunking the naturalistic fallacy with some examples. If the messaging was persuasive, participants in the ‘challenging the appeal to nature’ condition would have been less likely to perceive naturalness as important than participants in the control condition. However, as shown in Table 6, the difference between these two means was not significant. The only significant pairwise difference was between the ‘clean meat is natural’ condition and the ‘challenging the appeal to nature’ condition, such that participants felt that naturalness was more important in the former ($d = .274$). These findings suggests that our attempt to convince participants that naturalness in meat is unimportant was not persuasive.

Table 6: Outcome variables in each experimental condition, and overall.

Measure	Overall mean	Condition means			ANOVA		
		Clean meat is natural	Conventional meat is unnatural	Challenging appeal to nature	Control	F	p
Persuasion checks (5-point scale)							
Perceived unnaturalness of clean meat	2.98	3.01 _a	2.91 _a	3.03 _a	2.99 _a	0.57	.64
Perceived unnaturalness of conventional meat	2.58	2.55 _a	2.82 _b	2.48 _a	2.48 _a	6.54	< .001
Perceived importance of naturalness	3.80	3.94 _a	3.82 _{ab}	3.69 _b	3.77 _{ab}	3.57	.01
Behavioural intentions (5-point scale)							
Willingness to try clean meat	3.88	3.81 _a	3.98 _a	3.81 _a	3.91 _a	1.92	.13
Willingness to buy clean meat regularly	3.47	3.45 _a	3.57 _a	3.38 _a	3.49 _a	2.02	.11
Willingness to eat clean meat as a replacement for conventional meat	3.54	3.48 _a	3.65 _a	3.45 _a	3.57 _a	2.51	.06
Willingness to eat clean meat compared to plant-based substitutes (for 381 participants who ate them)	3.67	3.66 _a	3.77 _a	3.48 _a	3.74 _a	1.54	.21
Willingness to eat clean meat compared to plant-based substitutes (for 804 participants who did not eat them)	3.81	3.76 _a	3.91 _a	3.77 _a	3.79 _a	1.11	.35
Cognitive beliefs (5-point scale)							
Perceived healthiness of clean meat	3.64	3.61 _{ab}	3.78 _a	3.53 _b	3.65 _{ab}	4.14	.01
Perceived safety of clean meat	3.71	3.68 _{ab}	3.83 _a	3.63 _b	3.73 _{ab}	2.73	.04
Perceived environmental friendliness of clean meat	4.03	4.04 _{ab}	4.09 _a	3.87 _b	4.10 _a	5.10	.002
Perceived similarity in taste of clean meat to conventional meat	3.57	3.58 _{ab}	3.65 _a	3.46 _b	3.60 _{ab}	2.46	.06 ⁵
Perceived benefits to society of clean meat	3.79	3.75 _a	3.82 _a	3.71 _a	3.87 _a	1.84	.14
Attitude & Affect							
(Positive) attitude (7-point scale)	4.88	4.78 _{ab}	5.07 _c	4.70 _a	4.98 _{bc}	5.31	.001
(Positive) affect (5-point scale)	3.47	3.41 _a	3.55 _a	3.42 _a	3.49 _a	1.95	.12

⁵ Pairwise comparisons can still be made without a significant omnibus *F* test if appropriate corrections are made for family-wise error (Hsu, 1996)

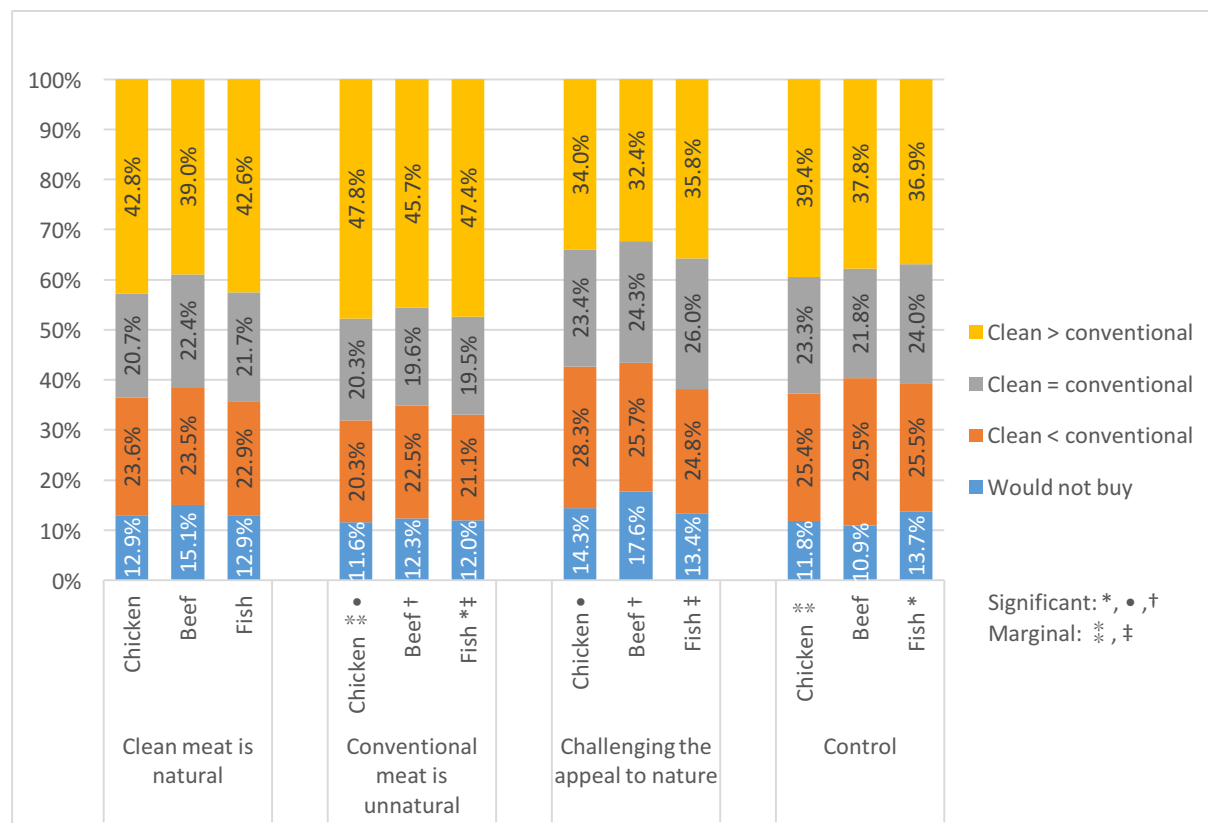
3.2 Willingness to pay

Figure 1 shows the distribution of WTP for all three products and all conditions. It is apparent from the graph that the three products behaved similarly. Although we analysed them separately, the overall pattern should be considered. Using the significance conventions laid out in Section 2.4 above, several findings emerged.

Of most relevance to hypotheses, relative to the control condition, the ‘conventional meat is unnatural’ condition produced significantly higher WTP for clean fish (est. = 0.34, Wald $\chi^2 = 4.51$, $p = .03$; indicated with *) and marginally higher WTP for clean chicken (est. = 0.27, Wald $\chi^2 = 3.00$, $p = .08$; indicated with †). The findings for clean beef, while non-significant (est. = 0.23, Wald $\chi^2 = 2.26$, $p = .13$), were in the same direction.

Although less relevant, the ‘conventional meat is unnatural’ condition also produced significantly higher WTP than the ‘challenging the appeal’ condition for clean chicken (est. = 0.49, Wald $\chi^2 = 9.72$, $p = .002$; indicated with •) and clean beef (est. = 0.47, Wald $\chi^2 = 9.26$, $p = .002$; indicated with †), and marginally higher WTP for clean fish (est. = 0.35, Wald $\chi^2 = 4.48$, $p = .03^6$; indicated with ‡).

Figure 1: Willingness to pay for clean meat relative to conventional meat.



To ensure that these results are not reliant on the particular analysis we chose, we also conducted non-parametric tests comparing the median WTP for each product in the experimental conditions against the control condition. The analyses comparing conventional

⁶ Note that because this was a post hoc analysis, this contrast is marginally significant when compared against a Bonferroni-corrected alpha of .0167.

meat is unnatural to control were marginally significant for chicken, beef, and fish ($ps < .06$), which supports the results of our main WTP analysis. Neither of the other two experimental conditions differed significantly or marginally from the control.

3.3 Behavioural intentions

As shown in Table 6, no significant differences emerged between conditions in willingness to: try clean meat, buy it regularly, eat it as a replacement for conventional meat, or eat it relative to plant-based substitutes.

After reading one of the promotional messages, overall levels of willingness for all of these items were between 3 (I am unsure) and 4 (probably yes). Overall, 66.4% of participants were probably or definitely willing to try clean meat, whilst just 12.1% were probably or definitely not willing to try it. Similarly, 48.9% were probably or definitely willing to buy clean meat regularly and 55.2% were probably or definitely willing to eat clean meat as a replacement for conventional meat. Of people who currently eat plant-based meat substitutes ($n = 381$), 56.7% were somewhat or much more willing to eat clean meat. Of people who did not currently eat plant-based meat substitutes ($n = 804$), 62.7% were somewhat or much more willing to eat clean meat.

3.4 Cognitive beliefs

As shown in Table 6, despite some significant differences in beliefs by experimental condition, none produced significantly more positive beliefs than the control message. Participants in the ‘conventional meat is unnatural’ condition believed clean meat to be significantly healthier ($d = .293$), safer ($d = .226$), tastier ($d = .218$), and more environmentally friendly ($d = .268$) than those in the ‘challenging the appeal to nature’ condition. Indeed, the latter condition *reduced* beliefs about environmental friendliness relative to the control ($d = .271$).

After reading one of the promotional messages, beliefs about clean meat were quite positive overall: A majority of participants agreed or strongly agreed that clean meat would have benefits for society (64.7%), be more environmentally friendly than conventional meat (72.5%), be safe for human consumption (60.9%), be healthy (56.5%), and look, taste, smell, and feel the same as conventional meat (56.3%).

3.5 Attitude

As shown in Table 6, there were significant differences between conditions on the composite attitude measure, although none of the experimental messages produced significantly more positive attitudes than the control message. Those in the ‘conventional meat is unnatural’ condition had significantly more positive attitudes towards clean meat compared to those in the ‘clean meat is natural’ ($d = .221$) and ‘challenging the appeal to nature’ ($d = .299$) conditions. Those in the ‘challenging the appeal to nature’ condition also had significantly less positive attitudes than those in the control ($d = .222$).

Overall, attitudes towards clean meat after reading one of these promotional messages can be interpreted as fairly positive: the overall mean of 4.88 was on the positive side of the 7-point composite scale, and the mean attitude in each condition was also above the midway point of 4.

3.6 Affect

No significant differences in the affect composite emerged between conditions (see Table 6). The overall level of affect ($M = 3.47$) falls between scale points 3 (moderately) and 4 (quite a bit).

One particular affect item—disgusted—is worth considering individually, given its connection to the perceived unnaturalness of clean meat (Siegrist et al., 2018). Disgust was low overall ($M = 1.78$) and did not differ significantly by condition (all post hoc-corrected $ps > .22$). Notably, just 5.2% said they felt extremely disgusted about the idea of eating clean meat, whilst 57.6% said they felt not at all disgusted after reading one of the promotional messages.

3.7 Overall clean meat acceptance

All of the above analyses were pre-registered. The following analyses, while not pre-registered, are included to clarify the patterns in the data, which can be hard to draw by eye from the many variables in the study. We could equally have run these analyses using each of the outcome variables, but the results would have been messier and far more susceptible to familywise error.

Therefore, for these analyses, we created a composite variable representing overall clean meat acceptance, which comprises all self-reported outcome variables in the study: the attitude composite, the affect composite, the five cognitive beliefs items, and the four behavioural intentions items. Compositing is supported by moderate-to-strong correlations between predictors (Song, Lin, Ward, & Fine, 2013): The bivariate correlations ranged from $r = .41$ to $r = .83$. Each of the 11 outcome variables was standardized prior to compositing, and the continuous and ordinal predictor variables used in this section were also standardized.

3.7.1 Overall clean meat acceptance by condition

ANOVA was used to examine overall clean meat acceptance (the composite variable) as a function of experimental condition—this provides a picture of the overall pattern of results observed in the study, with the exception of WTP and the persuasion checks.

Pairwise difference tests were corrected with Tukey's HSD. Only one pairwise difference emerged as significant: Participants in the 'conventional meat is unnatural' condition were significantly more accepting of clean meat than those in the 'challenging the appeal' condition ($p = .008$, $d = 0.21$). All other pairwise comparisons were non-significant ($ps > .12$).

The lack of significant differences between the control and any of the other message conditions suggests that promotional messages specifically targeting naturalness were no more successful in shifting unnaturalness concerns than the current, untargeted messaging. Although this represents a failure to persuade, it provides valuable information about the difficulty of shifting attitudes in this domain through rational argument.

3.7.2 The importance of naturalness

This study stemmed from previous work highlighting concerns about the perceived unnaturalness of clean meat (Siegrist & Sütterlin, 2017; Verbeke, Marcu, et al., 2015). Although attempts to overcome those concerns did not bear much fruit, we looked for evidence to support the initial assumption that concerns about unnaturalness reduce acceptance of clean meat.

To this end, overall clean meat acceptance was regressed on the items measuring perceived unnaturalness of clean meat, perceived unnaturalness of conventional meat, and the importance of meat naturalness. Condition was also included as a dummy-coded predictor.

Controlling for condition, all three naturalness variables significantly predicted overall clean meat acceptance, as shown in Table 7. That said, the size of the effects varied substantially: the perceived unnaturalness of clean meat was far and away the strongest predictor of positivity. The perceived unnaturalness of conventional meat also exerted a substantial—albeit much smaller—influence, and the perceived importance of meat naturalness had a small but significant effect. That is, to the extent that participants believed that clean meat is natural and/or that conventional meat is unnatural and/or that meat naturalness is unimportant, they were more accepting of clean meat.

Table 7: Regression for overall clean meat acceptance.

	B	SE	t	p
Intercept	0.05	.04	1.43	.15
Contrast: Clean meat is natural vs. Control	-0.07	.05	-1.42	.16
Contrast: Conventional meat is unnatural vs. Control	-0.002	.05	-0.05	.96
Contrast: Challenge vs. Control	-0.13	.05	-2.64	.01
Perceived unnaturalness of clean meat	-0.49	.02	-26.43	< .001
Perceived unnaturalness of conventional meat	0.12	.02	6.55	< .001
Perceived importance of naturalness	-0.04	.02	-2.06	.04

Note. All ordinal/continuous variables are standardized.

Directly supporting Siegrist et al.'s (2018) finding that perceived unnaturalness predicted disgust, a parallel regression analysis with the 'disgusted' affect item as the dependent variable showed that perceiving clean meat as unnatural was associated with substantially more disgust ($B = 0.48$, $SE = .03$, $t = 19.25$, $p < .001$). Perceiving meat naturalness as important was also associated with more disgust ($B = 0.15$, $SE = .03$, $t = 6.02$, $p < .001$). Perceiving conventional meat as unnatural showed a marginal negative association with disgust toward clean meat ($B = -0.04$, $SE = .03$, $t = -1.72$, $p = .09$).

4. Discussion

The goal of this study was to investigate the effectiveness of several possible messaging strategies intended to overcome concerns about the perceived unnaturalness of clean meat—concerns observed in several previous studies (Siegrist et al., 2018; Verbeke, Marcu, et al., 2015). Although the experimental messages were developed with several rounds of consultation from researchers and industry insiders and were pretested for how well they conveyed the intended meaning, our checks on the perceptions of naturalness suggested that readers only accepted one of the three messages: that conventional meat is unnatural. Arguments that naturalness is unimportant and that clean meat is natural failed to convince participants..

Given the care that was taken in developing these messages, we believe it is reasonable to interpret these results as an indication that arguing for clean meat's naturalness or the unimportance of naturalness are relatively intractable strategies. In contrast, the argument that conventional meat is unnatural gained some traction, albeit with limited impact. This argument may be worth considering as a strategy—it showed some promise in this study and has the potential for greater indirect impact if the message could be strengthened.

Most notably, in this study, the 'conventional meat is unnatural' message showed a tendency to out-perform the control message across the three pseudo-behavioral WTP measures: it produced significantly higher WTP for clean fish sticks, marginally higher WTP for clean chicken nuggets, and non-significantly higher WTP for clean beef burgers. Specifically, participants who read about the unnaturalness of conventional meat were more likely to pay more for clean meat than in the control condition.

On the self-report measures, the argument that conventional meat is unnatural did not significantly out-perform the control message, although the trend was such that it produced the most positive results of the four conditions on almost all outcomes (see Table 6). Because the self-report measures were focused on clean meat alone, this result suggests that most of the effect of the experimental message was to lower the appeal of conventional meat—which was not directly measured—relative to clean meat. This appears to explain why participants in this condition were willing to pay more for clean meat relative to conventional meat than in the control condition.

It is important to consider that only a third of participants said that clean meat is unnatural, and the average disgust reported was very low. Likely due to this study's use of promotional messaging and the positive term 'clean meat' (The Good Food Institute, 2017), participants in this study were less disgusted by and judgmental of clean meat as has been observed in previous studies.. As noted in Section 2.4, this made for a conservative test of differences between the messages: less of a naturalness objection to mitigate means less room for improvement in the experimental conditions relative to control.

Overall, the results favour the view that highlighting the unnatural elements of conventional meat may be the best way for clean meat advocates and producers to address consumer concerns about unnaturalness of clean meat. However, clean meat advocates should interpret this result with some caution, as this data indicates that such concerns may not be as prevalent as previous research has suggested if positive messaging and terminology are used. Moreover, it is important to consider the strategic implications of adopting offensive messaging which directly attacks conventional meat producers, given their potentially crucial role in bringing clean meat to market through investment (Forbes, 2018).

At the same time, it is worth noting that challenging the appeal to nature consistently produced the least favourable responses of any argument. This may reflect Deckers' (2005) observation that, for some consumers, naturalness is a deeply rooted worldview. The current study suggests that challenging this worldview is unlikely to be an effective strategy for persuading consumers. Conversely, pointing out that conventional meat is also unnatural produced slightly but consistently higher measures of acceptance. This appears to be in line with Laestadius (2015), who found that some consumers made this argument in defence of clean meat, though this often did not extend to the conclusion that naturalness was irrelevant.

4.1 Limitations

This study was subject to several limitations. First, because only U.S. adults were studied, the findings may not be completely generalizable to other cultures or countries.

In addition, the proportion of would-be participants who were removed for failing attention checks was higher than ideal. Although their removal ensures respondent attention, it may introduce some selection bias. More generally, it may be indicative of low panel quality that could have reduced our ability to find significant associations.

Participants in this study read one of four promotional messages about clean meat. Though the purpose of the study was to test the relative efficacy of these promotional messages, it is likely that in a broader societal context, people will be exposed to a range of pro- and anti-clean meat messages. This study does not, by design, address the interaction of conflicting messages from different sources. It is impossible to know how the tested messages would be perceived in the context of counter-messaging.

Furthermore, the use of the term ‘clean meat’ throughout this study may limit the applicability of findings if the industry adopts different terminology. At the time of data collection, most producers and advocates of clean meat were using this term, though many now use the term ‘cell-based meat’, and this may continue to change. That said, ‘clean meat’ was adopted originally on the basis of its positive associations, and it is reasonable to assume that continued testing and refinement of industry messaging will lead to—if not clean meat—the eventual adoption of a similarly positive term.

It is also worth noting several limitations of the WTP measure in particular. First, it is important to bear in mind that this measure directly followed positive messaging about clean meat, potentially producing higher values than would be observed in reality. In addition, because this measure is hypothetical, it is susceptible to the commonly-observed hypothetical bias, in which consumers tend to overestimate how much they are willing to pay for a product (e.g. Loomis, 2011). It is for this reason that we have provided only broad WTP categories above and focused on the comparison between conditions.

Participants’ self-report responses may also be subject to bias. First, forecasting error is probable: predicting one’s own future attitudes and behaviours towards a product which is not yet available is difficult (Bryant & Barnett, 2018). Unfortunately, there is little that can be done to avoid it, as clean meat is not yet available. Hypothetical and predictive questions are the only option, though we took care to frame them as realistically as possible.

Finally, participants may have been subject to social desirability bias—answering as they believe others would want them to—for questions about a product with such profound ethical and environmental implications (Grimm, 2010). That said, because even participants who read our control message were exposed to arguments about these implications, we believe that the potential impact of this bias is minimal.

4.2 Future Directions

We suggest that future research carefully consider whether trying to directly overcome perceptions of unnaturalness is the most effective option before pursuing it further—a few of this study’s effects suggest there may be potential for it to backfire. These results suggest that

a focus on the unnaturalness of conventional meat is more likely to be effective, but as noted above, this is not without risk of alienating potential allies.

In addition, the effectiveness of the ‘conventional meat is unnatural’ message in this study was limited, with mixed results across different outcome measures. We recommend that, if this is to be considered as a strategy for advancing clean meat, further testing of similar and stronger messages should be carried out.

The overall high rates of clean meat acceptance observed in this study suggest another potential strategy: that providing potential consumers with positive educational messaging about the benefits and characteristics of clean meat may be a good way to reduce the emphasis on naturalness before it becomes the focus of the conversation. Further research will be needed to determine which aspects of this messaging are effective, as this study did not directly compare them: for instance, information about the taste, texture, and nutritional profile, or the health, environmental, or animal welfare benefits. This type of research would be similar to studies conducted by Verbeke, Sans, and Van Loo (2015) and Bekker, Fischer, Tobi, and van Trijp (2017) in Belgium and the Netherlands, respectively. In those studies, reading positive information about clean meat made participants more willing to try it and improved their attitudes toward it.

In particular, one can expect that highlighting personal benefits (e.g. health, product safety) over societal benefits (e.g. animal welfare, environmentalism) might produce stronger intentions to engage with clean meat, though this is yet to be demonstrated empirically. Furthermore, the inclusion of societal benefits alongside personal benefits may ‘dilute’ the effectiveness of the more persuasive arguments (de Vries, Terwel, & Ellemers, 2014), another phenomenon which could be explored in the context of clean meat. Other work might explore cultural variation in the construction of naturalness as an important concern for consumers, including as an indicator of environmentalism and safety.

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566 The authors are employed by or affiliated with various animal advocacy organisations.

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