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

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29 **Abstract**

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

43 **Keywords**

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

45

46 1. Introduction

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

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

62 However, it is unclear whether consumers will accept this novel food (Bryant & Barnett,
63 2018). While some studies show a high level of willingness to try clean meat (Wilks &
64 Phillips, 2017), others have found that less than half of consumers would eat clean meat, and
65 most would prefer conventional meat in practice (Slade, 2018; Surveygoo, 2018). Common
66 concerns about clean meat include its taste, price, and safety (Laestadius & Caldwell, 2015;
67 Tucker, 2014; Verbeke, Marcu, et al., 2015). One of consumers’ primary concerns about
68 clean meat is its alleged unnaturalness. This is a theme which has been observed in many
69 qualitative studies (Laestadius, 2015; Verbeke, Marcu, et al., 2015) and cited as one of the
70 most common reasons for rejecting clean meat in surveys (The Grocer, 2017). Indeed,
71 Siegrist and Sütterlin (2017) have demonstrated that the perceived unnaturalness of clean
72 meat explains a great deal of consumers’ safety concerns, whilst Siegrist, Sütterlin, and
73 Hartmann (2018) show that this perception evokes disgust and likely causes rejection of clean
74 meat in practice.

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

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

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

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

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

114

115

116 **2. Methods & materials**

117 *2.1 Participants*

118 *2.1.1 Power and sample*

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

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

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

138 ***2.2 Experimental procedure***

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

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

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

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

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

158 ***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.

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

166 **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!

167

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

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

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

182 *2.4 Terminology*

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

194 *2.5 Measures*

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

197 **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)?

198 The behavioural intentions measures shown in Table 2 were adapted from Wilks and Phillips
 199 (2017). Question 3 also included a response option for ‘Not applicable (I do not eat
 200 conventionally produced meat).’

201 **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?	

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

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

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

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

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

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

233 **Table 5: Persuasion checks**

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

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

236 **2.6 Statistical analysis**

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

241 Per the pre-registered analysis plan, multivariate outliers were detected and reeled in to avoid
 242 extreme values exerting undue influence on subsequent analyses using methods discussed by
 243 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

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

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

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

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

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

261 **3. Results**

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

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

278 **3.1 Perceptions of naturalness**

279 These analyses revealed that the experimental messages produced mixed results, as described
280 below. The 'conventional meat is unnatural' message was persuasive but the other two were
281 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.

282 **3.1.1 Perceived unnaturalness of clean meat**

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

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

296 **3.1.2 Perceived unnaturalness of conventional meat**

297 The ‘conventional meat is unnatural’ message highlighted unnatural practices in conventional
298 meat production, and framed clean meat as avoiding such practices. If these arguments
299 overcame concerns about unnaturalness, we would expect participants in this condition to be
300 more likely to say that conventional meat is unnatural than participants in the control
301 condition. As shown in Table 6, participants in this condition were significantly more likely
302 to perceive conventional meat as unnatural than participants in the control condition ($d =$
303 $.313$). This difference indicates that this argument for the unnaturalness of conventional meat
304 was persuasive.

305 **3.1.3 Perceived importance of meat naturalness**

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

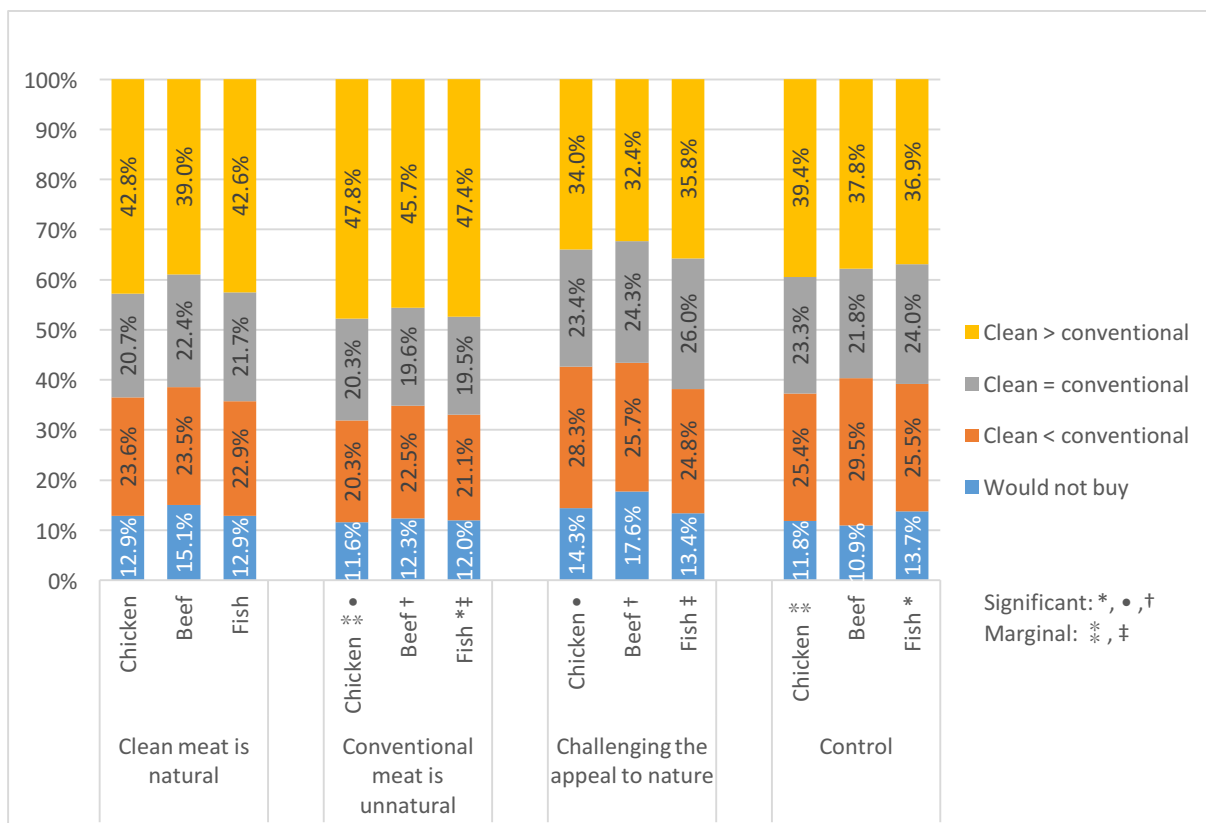
315 **3.2 Willingness to pay**

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

320 Of most relevance to hypotheses, relative to the control condition, the ‘conventional meat is
 321 unnatural’ condition produced significantly higher WTP for clean fish (est. = 0.34, Wald $\chi^2 =$
 322 4.51, $p = .03$; indicated with *) and marginally higher WTP for clean chicken (est. = 0.27,
 323 Wald $\chi^2 = 3.00$, $p = .08$; indicated with †). The findings for clean beef, while non-significant
 324 (est. = 0.23, Wald $\chi^2 = 2.26$, $p = .13$), were in the same direction.

325 Although less relevant, the ‘conventional meat is unnatural’ condition also produced
 326 significantly higher WTP than the ‘challenging the appeal’ condition for clean chicken (est. =
 327 0.49, Wald $\chi^2 = 9.72$, $p = .002$; indicated with •) and clean beef (est. = 0.47, Wald $\chi^2 = 9.26$, p
 328 = .002; indicated with †), and marginally higher WTP for clean fish (est. = 0.35, Wald $\chi^2 =$
 329 4.48, $p = .03^6$; indicated with ‡).

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



331
 332 To ensure that these results are not reliant on the particular analysis we chose, we also
 333 conducted non-parametric tests comparing the median WTP for each product in the
 334 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.

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

338 **3.3 Behavioural intentions**

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

342 After reading one of the promotional messages, overall levels of willingness for all of these
343 items were between 3 (I am unsure) and 4 (probably yes). Overall, 66.4% of participants were
344 probably or definitely willing to try clean meat, whilst just 12.1% were probably or definitely
345 not willing to try it. Similarly, 48.9% were probably or definitely willing to buy clean meat
346 regularly and 55.2% were probably or definitely willing to eat clean meat as a replacement
347 for conventional meat. Of people who currently eat plant-based meat substitutes ($n = 381$),
348 56.7% were somewhat or much more willing to eat clean meat. Of people who did not
349 currently eat plant-based meat substitutes ($n = 804$), 62.7% were somewhat or much more
350 willing to eat clean meat.

351 **3.4 Cognitive beliefs**

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

359 After reading one of the promotional messages, beliefs about clean meat were quite positive
360 overall: A majority of participants agreed or strongly agreed that clean meat would have
361 benefits for society (64.7%), be more environmentally friendly than conventional meat
362 (72.5%), be safe for human consumption (60.9%), be healthy (56.5%), and look, taste,
363 smell, and feel the same as conventional meat (56.3%).

364 **3.5 Attitude**

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

372 Overall, attitudes towards clean meat after reading one of these promotional messages can be
373 interpreted as fairly positive: the overall mean of 4.88 was on the positive side of the 7-point
374 composite scale, and the mean attitude in each condition was also above the midway point of
375 4.

376 **3.6 Affect**

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

380 One particular affect item—disgusted—is worth considering individually, given its
381 connection to the perceived unnaturalness of clean meat (Siegrist et al., 2018). Disgust was
382 low overall ($M = 1.78$) and did not differ significantly by condition (all post hoc-corrected ps
383 $> .22$). Notably, just 5.2% said they felt extremely disgusted about the idea of eating clean
384 meat, whilst 57.6% said they felt not at all disgusted after reading one of the promotional
385 messages.

386 **3.7 Overall clean meat acceptance**

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

392 Therefore, for these analyses, we created a composite variable representing overall clean
393 meat acceptance, which comprises all self-reported outcome variables in the study: the
394 attitude composite, the affect composite, the five cognitive beliefs items, and the four
395 behavioural intentions items. Compositing is supported by moderate-to-strong correlations
396 between predictors (Song, Lin, Ward, & Fine, 2013): The bivariate correlations ranged from r
397 $= .41$ to $r = .83$. Each of the 11 outcome variables was standardized prior to compositing,
398 and the continuous and ordinal predictor variables used in this section were also standardized.

399 **3.7.1 Overall clean meat acceptance by condition**

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

403 Pairwise difference tests were corrected with Tukey's HSD. Only one pairwise difference
404 emerged as significant: Participants in the 'conventional meat is unnatural' condition were
405 significantly more accepting of clean meat than those in the 'challenging the appeal'
406 condition ($p = .008$, $d = 0.21$). All other pairwise comparisons were non-significant ($ps >$
407 $.12$).

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

413 **3.7.2 The importance of naturalness**

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

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

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

430 **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.

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

438 **4. Discussion**

439 The goal of this study was to investigate the effectiveness of several possible messaging
 440 strategies intended to overcome concerns about the perceived unnaturalness of clean meat—
 441 concerns observed in several previous studies (Siegrist et al., 2018; Verbeke, Marcu, et al.,
 442 2015). Although the experimental messages were developed with several rounds of
 443 consultation from researchers and industry insiders and were pretested for how well they
 444 conveyed the intended meaning, our checks on the perceptions of naturalness suggested that
 445 readers only accepted one of the three messages: that conventional meat is unnatural.
 446 Arguments that naturalness is unimportant and that clean meat is natural failed to convince
 447 participants..

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

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

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

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

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

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

491 **4.1 Limitations**

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

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

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

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

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

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

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

528 **4.2 Future Directions**

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

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

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

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

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

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565 **Competing Interests Statement**

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

567 Christopher Bryant and Kristopher Gasteratos are affiliated with the Cellular Agriculture
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569 Green are affiliated with Faunalytics, which conducts research in order to help make animal
570 advocacy more effective. Kathryn Asher is affiliated with Animal Charity Evaluators, which
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577 [trial-evaluating-the-impact-on-self-reported-purchasing-preferences/](https://animalcharityevaluators.org/blog/clean-meat-or-cultured-meat-a-randomized-trial-evaluating-the-impact-on-self-reported-purchasing-preferences/)
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