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Perceived naturalness, disgust, trust and food neophobia as predictors of cultured meat acceptance in ten countries

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ABSTRACT

Cultured meat is a novel food technology that promises to produce meat in a more environmentally friendly and animal-friendly way. We conducted an internet survey in ten countries (Australia, China, England, France, Germany, Mexico, South Africa, Spain, Sweden and the US) with a total sample of 6128 participants. Results suggest that there are large cultural differences regarding the acceptance of cultured meat. French consumers were significantly less accepting of the idea than consumers in all other countries. Perceived naturalness of and disgust evoked by cultured meat were important factors in the acceptance of this novel food technology in all countries. Trust in the food industry, food neophobia and food disgust sensitivity indirectly and directly influenced the acceptance of cultured meat in almost all countries. In order to increase the acceptance of cultured meat, the similarity of cultured meat to traditional meat needs to be emphasized rather than the rather technical production process, which may evoke associations of unnaturalness and disgust.

1. Introduction

Meat production has a significant impact on the environment (Westhoek et al., 2014). Even the production of animal products with the lowest impact is typically associated with more harm to the environment than the production of plant proteins (Poore & Nemecek, 2018). Meat production imposes burdens on animals as well as on the environment (Grandin, 2014). If consumers reduced their consumption of animal proteins, the environmental impact of people's food consumption would decrease (Westhoek et al., 2014). There are also moral reasons for reducing the consumption of animal proteins (Hartmann & Siegrist, 2020; Pluhar, 2010). Mass production systems cannot guarantee animal well-being and animals need to be killed in order to produce meat. Most of the conventional animal production systems were not perceived as morally justifiable by German consumers, for example (Hartmann & Siegrist, 2020). Despite these negatives associated with animal proteins and the availability of alternative plant-based proteins, only a minority of consumers seem willing to substantially reduce their meat consumption by substituting plant-based proteins for animal proteins (Hartmann & Siegrist, 2017). This may be changing as plant-based meat alternatives improve in quality. Nevertheless, one proposed response is the production of cultured meat, for which production is transferred from the farm to the laboratory, where only muscle cells are grown instead of full animals (Post, 2012, 2014). Its proponents hope that cultured meat may offer both a more ethically justifiable and environmentally friendly way of producing meat. There is no consensus, however, whether cultured meat will be more environmental friendly compared with traditional meat (Chriki & Hocquette, 2020). Crucially though, the success of cultured meat depends on consumer acceptance. Therefore, a strong understanding of the factors that influence the acceptance of alternative proteins needs to be developed at an early stage of technology and product development.

The present research integrates various factors that have already been shown to influence acceptance of cultured meat in isolation. Stated willingness to buy cultured meat seems to differ across countries (Chriki & Hocquette, 2020; Gomez-Luciano, de Aguiar, Vriesekoop, & Urbano, 2019; Grasso, Hung, Olthof, Verbeke, & Brouwer, 2019), so we tested our proposed model in ten different countries.

It has been shown that cultured beef from muscle stem cells can be produced in the laboratory (Post, 2012, 2014), and it has been predicted that small-scale production of cultured meat of edible quality will be possible in the near future (Stephens et al., 2018). Further research is required, however, to make the production of cultured meat more efficient and sustainable and to produce thick cuts of meat such as steaks

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(Post, 2014). The industry is still a long time away from producing cultured meat at an industrial scale and a competitive price (Bhat, Kumar, & Bhat, 2017; Stephens et al., 2018). Technological feasibility is not the only challenge to efficient large-scale production of cultured meat, however. A number of consumer studies have examined consumer acceptance of the concept of cultured meat and found that many consumers are reluctant to embrace the concept (Bryant & Barnett, 2018). In one of the first studies of consumer acceptance of cultured meat, only 25% of participants would have been willing to try it, if some basic information was provided (Verbeke, Sans, & Van Loo, 2015). Higher values have been observed in some recent studies (Bryant, Szejda, Parekh, Desphande, & Tse, 2019; Wilks, Phillips, Fielding, & Hornsey, 2019); an Italian study reported that 54% of the participants would be willing to try cultured meat (Mancini & Antonioli, 2019).

A number of factors that influence people's stated willingness to eat cultured meat have been identified (Bryant & Barnett, 2018). Based on research into perceptions of cultured meat, we first discuss factors that may be important to consumer perception of cultured meat and then propose and test a model that shows how these variables may be related.

1.1. Perceived naturalness of cultured meat

Perceptions of naturalness are crucial to the acceptance of food technologies (Roman, Sanchez-Siles, & Siegrist, 2017). The results of one qualitative study suggested that cultured meat evoked feelings of tampering with nature (Marcu et al., 2015). Consumers differ in their perceptions of how natural cultured meat is, however. In a US sample, about one third of participants perceived cultured meat labeled as "clean meat" as unnatural, another third perceived it as natural and one third perceived it as neither natural nor unnatural (Bryant, Anderson, Asher, Green, & Gasteratos, 2019). Perceived naturalness of "clean meat" was positively associated with its acceptance (Bryant et al., 2019). Compared with conventional meat, cultured meat was perceived as unnatural and this perception contributed to low acceptance of this novel food (Siegrist & Sütterlin, 2017; Siegrist, Sutterlin, & Hartmann, 2018). The label that is used for cultured meat and how it is described to participants may have an impact on how natural or unnatural the product is perceived as being (Bryant & Barnett, 2018; Bryant & Dillard, 2019; Siegrist et al., 2018). Regardless, the available studies clearly suggest that perceived naturalness is an important factor to acceptance of cultured meat. One study claimed that naturalness was not important for the acceptance of cultured meat (Wilks et al., 2019). However, this study did not measure perceived naturalness of cultured meat but used an ad hoc scale that measured people's preference for naturalness and their skepticism toward human interventions. Therefore, this study's results do not provide any insights regarding the importance of perceived naturalness of cultured meat in terms of its acceptance.

1.2. Disgust evoked by cultured meat

Another important barrier to the acceptance of food is disgust. Disgust is a food rejection emotion, and there is evidence that disgust evolved to protect organisms from diseases and is part of the behavioral immune system (Terrizzi, Shook, & McDaniel, 2013). Disgust reactions have an important function in preventing humans from incorporating potentially harmful substances, but they can also be a barrier to the acceptance of new food sources and technologies (Chapman & Anderson, 2012; Hartmann & Siegrist, 2018; Ruby, Rozin, & Chan, 2015). Focus group discussions conducted in Belgium, Portugal and the UK revealed that consumers reacted to being informed about cultured meat with feelings of perceived unnaturalness and disgust toward the novel meat product (Verbeke, Marcu, et al., 2015). Compared to participants to whom cultured meat was not disgusting, participants to whom cultured meat was disgusting stated a lower willingness to try the product and perceived fewer benefits and more risks associated with cultured meat (Egolf, Hartmann, & Siegrist, 2019). Disgust related to a food may also be associated with perceptions of how natural it is. The perceived unnaturalness of cultured meat compared with conventional meat evoked feelings of disgust in respondents that negatively influenced their stated willingness to eat cultured meat (Siegrist et al., 2018).

1.3. Food disgust sensitivity

People tend to differ in their food disgust sensitivity (Hartmann & Siegrist, 2018) and this personality trait has been shown to influence people's eating behavior (Ammann, Hartmann, & Siegrist, 2018). Participants' food disgust sensitivity is associated with perceptions about how disgusting cultured meat is (Egolf, Hartmann, & Siegrist, 2019). The impact of disgust sensitivity on the acceptance of novel foods seems to depend on how disgust sensitivity is measured, however. Wilks et al. (2019) used eight items related to hygiene and food from the disgust scale by Olatunji et al. (2007) and did not find them significantly associated with stated willingness to eat cultured meat when controlling for food neophobia.

1.4. Food neophobia

Food neophobia is another personality trait that may be related to protecting humans from consuming unknown foods that may be potentially toxic. The food neophobia scale measures people's willingness to try out new and unfamiliar foods (Pliner & Hobden, 1992). Research suggests that persons with high values on this scale are hesitant to try or buy novel foods (Tuorila, Lähteenmäki, Pohjalainen, & Lotti, 2001). It has been shown that food neophobia is negatively associated with study participants' stated willingness to eat cultured meat (Bryant et al., 2019; Wilks et al., 2019).

1.5. Trust

When people lack the knowledge to evaluate a food technology, they may rely instead on the assessments of others; trust may determine whom they rely on (Siegrist & Cvetkovich, 2000). Various studies have shown that trust influences the perception of and acceptance of novel technologies (Siegrist, in press). Consumers who trust the food industry are, for example, more likely to accept nanotechnology foods and food packaging (Siegrist, Cousin, Kastenholz, & Wiek, 2007). We are only aware of one study examining the impact of trust on acceptance of cultured meat. This study did not find, however, that general distrust in science was a significant predictor of the acceptance of cultured meat (Wilks et al., 2019). Past research suggests that how trust is measured has a significant impact on its power to predict acceptance of and perceptions of the risks of novel technologies (Earle, 2010). It follows that trust in the food industry or food scientists specifically may be more relevant to perceptions of cultured meat than general trust in science.

1.6. Hypothesized model

Based on past research about the acceptance of cultured meat and other novel food technologies, we identified factors that are hypothesized to have a direct or indirect effect on the acceptance of cultured meat. Fig. 1 presents the model we tested in the present study. In line with a past study (Siegrist et al., 2018), we hypothesized that perceived naturalness of cultured meat affects acceptance both directly and indirectly, via disgust evoked. We also included personality related factors in our model. We hypothesized that trust in the food industry, food neophobia and disgust sensitivity indirectly influence the acceptance of cultured meat. More specifically, we predicted that participants having a high level of food disgust sensitivity are more disgusted by the idea of cultured meat than participants having a low level of disgust sensitivity (Egolf, Hartmann, & Siegrist, 2019). We further hypothesized a similar effect of food neophobia. Finally, we hypothesized that people who have trust in the food industry perceive cultured meat as more natural than

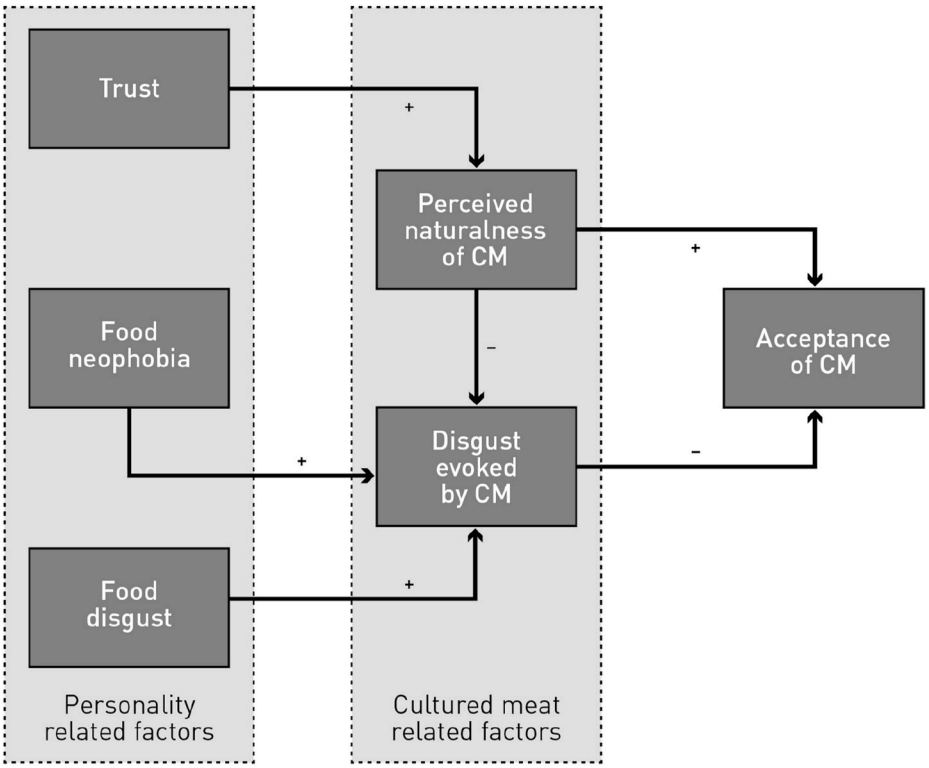

Fig. 1. The proposed model explaining acceptance of cultured meat (CM) that includes the three personality related factors trust, food neophobia and food disgust and the two mediators perceived naturalness of CM and disgust evoked by CM.

people who do not have much trust in the food industry. In other words, we assumed that a positive perception of the food industry results in a more positive perception of the products created by this industry. A further aim of the present study was to compare the acceptance of cultured meat across countries.

2. Method

2.1. Participants

An online survey was conducted in ten countries. In Australia, England, South Africa and the US the survey used an English questionnaire; a Spanish questionnaire was used in Mexico and Spain. Chinese, French, German and Swedish questionnaires were used in China, France, Germany and Sweden, respectively. The survey participants were recruited by commercial providers of sampling services. Quota samples were used in all countries, using the variables age (five age groups, with participants aged 20–69 years) and gender (50% females and 50% males for each age group). Participants who did not complete the survey or whose total survey duration was less than half of the median duration were excluded. The final sample consisted of 6128 participants. The percentage of men (lowest with 49% in Australia and highest with 52% in China) and the mean for age (lowest with 44 years in Mexico and highest with 46 years in Sweden) were also after exclusion of participants with short response times still very similar across the ten countries. Level of education was measured by asking participants how many years of education they had completed. To exclude unreasonable responses and outliers, responses higher than 25 years were treated as missing values. This resulted in the following mean values: South Africa 9 years, Sweden 10 years, France, Germany and the US 12 years, Australia and Spain 13 years, England and China 14 years and Mexico 15 years. The present study was approved by the Ethics Committee of ETH Zurich (EK 2018-N-104). More detailed information about the cross-cultural study can be found elsewhere (Egolf, Siegrist, et al., 2019).

2.2. Questionnaire

Food disgust sensitivity (FDS) was measured using the 8-item short version of the scale, known as the FDS-short (Hartmann & Siegrist, 2018). The FDS-short measures how disgusting people perceive eight food related situations (e.g., "Food donated from a neighbor whom I barely know"). Participants responded to these questions on a 6-point rating scale ranging from 1 (not disgusting at all) to 6 (extremely disgusting). The FDS-short has been shown to be a reliable and valid measure in the countries included in this study. Cronbach's alpha ranged between 0.69 and 0.76 (Egolf, Siegrist, et al., 2019). For the analyses presented, the mean value of the eight items was used.

Food neophobia was measured using the scale proposed by Pliner and Hobden (1992). The scale contains ten items (e.g., "If I don't know what is in a food, I won't try it."). Participants could respond to these items on a scale ranging from −3 (strongly disagree) to 3 (strongly agree). The average score was calculated with the items recoded from 1 to 7, with higher values indicating more food neophobia. Cronbach's alpha ranged between 0.70 and 0.88 (Egolf, Siegrist, et al., 2019).

Before participants responded to questions about cultured meat, they received the following information: "Red meat such as beef can be produced through tissue cultivation. To do so, a few cells are obtained from the muscle tissue of cows. These cells are artificially grown and develop into muscle cells. This production method is more environmentally friendly compared to conventional meat production and associated with less animal suffering. The taste of meat produced by tissue cultivation is comparable to conventionally-produced meat." This description was adapted from a previous study (Egolf, Hartmann, & Siegrist, 2019).

Participants first answered the question "Are you willing to eat cultured meat?" by moving a slider with possible responses ranging from "certainly not" to "absolutely". Then, they responded to the question "How artificial/natural do you assess cultured meat to be?" by moving a slider with possible responses ranging from "artificial" to "natural". The

disgust reaction was measured using the question "Do you perceive cultured meat as disgusting?" by moving a slider with possible responses ranging from "not disgusting at all" to "extremely disgusting". The responses were converted to numbers ranging from 0 to 100. However, when moving the slider, the participants did not see any numbers.

Trust in the stakeholders in the food sector was measured using the following four items: "I trust the food industry", "You can rely on governmental controls in the food sector", "I trust food retailers", and "I trust food scientists". Participants responded to these items on a 6-point rating scale ranging from 1 (strongly disagree) to 6 (strongly agree). The four items were highly correlated in each country and an average trust score was calculated. Cronbach's alpha ranged between 0.82 and 0.89.

3. Results

3.1. Differences in acceptance, perceived naturalness and evoked disgust across countries

Results of a one-way analysis of variance (ANOVA) suggest that there are significant differences across countries regarding the acceptance of cultured meat, $F(9, 6118) = 14.45$, $p < .001$). Means, standard deviations and the results of the Tukey B post-hoc tests are shown in Table 1. The lowest level of acceptance was observed in France ($M = 37.9$), this value was significantly lower than the values in all other countries. In Germany ($M = 44.9$) and the US ($M = 45.8$) the acceptance of cultured meat was also relatively low. Relatively high levels of acceptance were observed in Mexico ($M = 56.3$), South Africa ($M = 52.6$), England ($M = 52.0$) and Spain ($M = 50.1$). [1]

Perceived naturalness of cultured meat also differed significantly across the ten countries $F(9, 6118) = 22.53$, $p < .001$). Means, standard deviations and the results of the Tukey B post-hoc tests are shown in Table 1. Participants in South Africa ($M = 44.0$) and in Mexico ($M = 39.6$) perceived cultured meat as most natural, whereas participants in France ($M = 27.0$), Sweden ($M = 28.8$), Germany ($M = 29.7$), China ($M = 30.1$) and Spain ($M = 32.2$) perceived cultured meat as most artificial.

The idea of cultured meat evokes different levels of disgust across countries, $F(9, 6118) = 21.59$, $p < .001$). Means, standard deviations and the results of the Tukey B post-hoc tests are shown in Table 1. The highest levels of disgust were reported by participants in France ($M = 58.4$) and China ($M = 53.7$), while the lowest levels of disgust were experienced by participants in Mexico ($M = 38.3$) and England ($M = 42.2$).

Table 1
Means and Standard Deviations for evoked disgust, perceived naturalness and acceptance of cultured meat for the ten countries.

Country	Evoked Disgust	Perceived Naturalness	Acceptance
	M (SD)	M (SD)	M (SD)
Australia ($n = 600$)	48.2 (30.4)^{b,c,d}	35.6 (28.2)^{c,d,e}	47.1 (32.7)^{b,c,d}
China ($n = 572$)	53.7 (28.3)^{d,e}	30.1 (28.1)^{a,b}	47.5 (29.0)^{b,c,d}
England ($n = 612$)	42.2 (31.5)^{a,b}	33.0 (26.6)^{b,c,d}	52.0 (33.8)^{c,d,e}
France ($n = 618$)	58.4 (31.7)^{e}	27.0 (27.1)^{a}	37.9 (32.9)^{a}
Germany ($n = 617$)	46.2 (31.2)^{b,c}	29.7 (26.2)^{a,b}	44.9 (33.3)^{b}
Mexico ($n = 629$)	38.3 (30.6)^{a}	39.6 (31.1)^{e,f}	56.3 (34.2)^{e}
South Africa ($n = 620$)	45.5 (31.3)^{b,c}	44.0 (32.1)^{f}	52.6 (34.1)^{d,e}
Spain ($n = 611$)	45.9 (29.3)^{b,c}	32.2 (26.9)^{a,b,c}	50.1 (31.4)^{b,c,d,e}
Sweden ($n = 619$)	51.1 (34.0)^{c,d}	28.8 (27.9)^{a,b}	47.8 (35.2)^{b,c,d}
US ($n = 630$)	51.0 (30.8)^{c,d}	37.8 (28.6)^{d,e}	45.8 (32.8)^{b,c}

Note. Different letters within each column indicate significant ($p < .01$) differences based on the Tukey B post-hoc test.

[1] We did not find any regional differences for the acceptance of cultured meat. In all ten countries, participants from urban areas did not show significantly different levels of acceptance compared with participants from rural areas.

3.2. Explaining acceptance of cultured meat for combined sample

The theoretical model shown in Fig. 1 was tested using the procedure proposed by Hayes (2013). Model 6, which includes 2 mediators (perceived naturalness of cultured meat and disgust evoked by cultured meat) was used, and multiple X variables (trust, food neophobia and food disgust) were included (Hayes, 2013, p. 193). There are no paths between trust, food neophobia and food disgust in Figs. 1 and 2, but these variables were allowed to be correlated. Furthermore, all paths from the X variables on both mediator variables and acceptance of cultured meat were included in the model, in order to test whether there are additional effects beyond the ones predicted in the model shown in Fig. 1.

We first analyzed the sample with all participants from the ten countries (N = 6128). Only the significant coefficients are shown in Fig. 2. Results of the mediation models suggest that trust, food neophobia and food disgust sensitivity had, as predicted, significant indirect effects on the acceptance of cultured meat. All three bias-corrected bootstrap confidence intervals for the total indirect effects, based on 10,000 bootstrap samples, were different from zero. However, for all three variables, significant main effects ($p < .01$) were observed as well. Furthermore, perceived naturalness had both a direct and an indirect effect, via evoked disgust, on the acceptance of cultured meat. The model explained 53% of the variance in the acceptance of cultured meat.

3.3. Explaining acceptance of cultured meat for each country

The mediation model was also separately tested for each of the ten countries. The estimates for the variables explaining perceived naturalness of cultured meat are shown in Table 2, those for evoked disgust in Table 3 and those for acceptance in Table 4. In addition to the non-standardized coefficients and the standard errors, the 99%-CIs are shown.

In all ten countries, trust had a significant impact on perceived naturalness of cultured meat (see Table 2). Participants who had higher levels of trust in the stakeholders in the food domain perceived cultured meat as more natural than participants who had low levels of trust. Unexpectedly, in the Chinese sample food neophobia had a positive effect on perceived naturalness, and in South Africa food disgust sensitivity had a negative impact on perceived naturalness. Although not predicted, the latter effect seems reasonable. Food disgust may both directly and indirectly, via perceived naturalness, influence the disgust evoked by cultured meat. The fact that in the Chinese sample, food neophobia had a positive effect on perceived naturalness is more difficult to explain and could well be a chance finding.

The impact of the various factors on evoked disgust is shown in Table 3. Except for China, perceived naturalness was significantly negatively related to evoked disgust in all countries. In other words, participants who perceived cultured meat as more artificial were more disgusted by it than participants who perceived it as more natural. In all countries except France and the US, participants with high food disgust sensitivity were significantly more disgusted by cultured meat than those with low food disgust sensitivity. Food neophobia was positively related to disgust evoked by cultured meat in all countries except France, Germany and Mexico. Participants with higher levels of food neophobia were more disgusted by cultured meat than those with lower levels of food neophobia. Finally, in Australia, China and the US, trust was a significant predictor of disgust evoked by cultured meat. Participants with higher levels of trust were less disgusted by this novel food than participants with lower levels of trust.

The results in Table 4 suggest that in all countries perceived

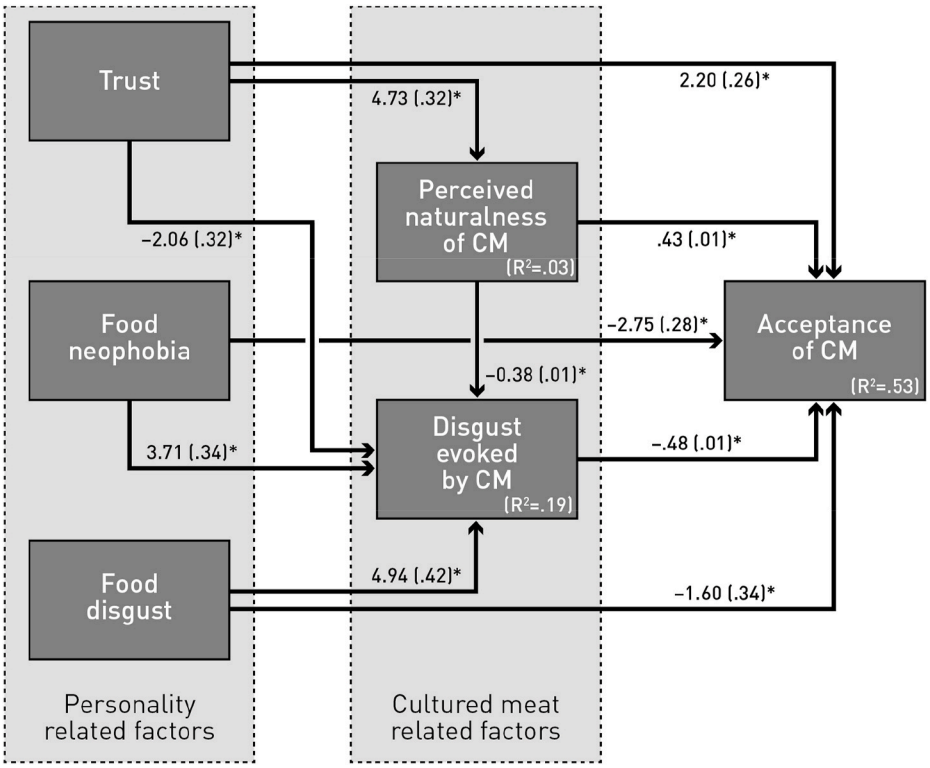

Fig. 2. Estimated unstandardized coefficients and standard errors for the combined sample (N = 6128) of all ten countries (*p < .01).

Table 2
Predictors explaining perceived naturalness of cultured meat in ten countries. Unstandardized coefficients, standard errors and 99% confidence intervals are shown.

Country	Trust	Food Neophobia	Food Disgust	R^2
	B (SE) [99%-CI]	B (SE) [99%-CI]	B (SE) [99%-CI]	
Australia	5.17 (1.00)** [2.60,7.75]	−0.36 (1.06) [-3.10,2.39]	−0.13 (1.29) [-3.47, 3.20]	.05
China	4.67 (1.06)** [1.92, 7.42]	4.58 (1.51)* [0.68, 8.48]	−0.10 (1.34) [-3.57, 3.36]	.04
England	4.70 (0.95)** [2.24, 7.15]	0.58 (0.90) [-1.75, 2.91]	−3.18 (1.25) [-6.42, 0.06]	.05
France	4.14 (0.93)** [1.74, 6.54]	0.49 (0.99) [-2.07, 3.04]	2.54 (1.26) [-0.70, 5.79]	.04
Germany	4.28 (0.95)** [1.84, 6.73]	1.06 (1.07) [-1.69, 3.81]	−0.51 (1.22) [-3.65, 2.63]	.03
Mexico	2.90 (1.08)* [0.11, 5.70]	0.40 (1.25) [-2.82, 3.62]	−3.08 (1.38) [-6.66, 0.50]	.02
South Africa	7.73 (1.08)** [4.93, 10.54]	0.00 (1.13) [-2.92, 2.93]	−5.19 (1.41)** [-8.83, −1.56]	.10
Spain	6.96 (1.07)** [4.19, 9.72]	1.45 (0.96) [-1.03, 3.94]	−0.54 (1.26) [-3.78, 2.71]	.07
Sweden	3.24 (1.02)* [0.60, 5.88]	−2.14 (1.18) [-5.19, 0.91]	−0.96 (1.23) [-4.14, 2.23]	.03
US	5.28 (1.02)** [2.65, 7.90]	−2.11 (0.95) [-4.56, 0.33]	2.00 (1.43) [-1.69, 5.69]	.05

Note. * < 0.01, ** < 0.001.

naturalness and evoked disgust had significant direct effects on the acceptance of cultured meat. In other words, participants who perceived cultured meat as more natural and for whom it evoked low levels of disgust showed greater acceptance of cultured meat than participants who perceived cultured meat as more artificial and for whom cultured meat evoked high levels of disgust. In some countries, food disgust sensitivity, food neophobia and trust had not just indirect but also significant direct effects on the acceptance of cultured meat. These results further support the idea that these personality factors have some impact on acceptance of cultured meat. The variables included in our model explained between 34% (China) and 61% (England and Sweden) of the variance in acceptance of cultured meat.

4. Discussion

The huge amount of meat produced to meet consumer demand is associated with large environmental impacts (Westhoek et al., 2014) and with production systems that many consumers perceive as ethically unjustifiable (Hartmann & Siegrist, 2020). Cultured meat has been proposed as an alternative protein source that provides the hedonic experience and the nutrition value of meat without the negative externalities associated with current methods of meat production (Post, 2012, 2014). Consumer acceptance is crucial, however, and a number of studies have suggested that many consumers are hesitant to accept the idea of cultured meat (Marcu et al., 2015; Verbeke, Marcu, et al., 2015). The present study examined acceptance of cultured meat and the factors that influence how acceptable consumers perceive this novel food to be in ten countries.

Substantial differences in acceptance of cultured meat were observed across countries. Consumers in France showed significantly lower levels of acceptance compared with those in the other nine countries. French consumers also perceived cultured meat as more unnatural and more disgusting than consumers in the other countries did. France is well known for its culinary heritage and tradition. The importance of food traditions to French consumers could be one reason for the very negative reactions evoked by a novel food such as cultured meat. Relatively high levels of acceptance of cultured meat were observed in Mexico, South Africa and England. The cuisines of Mexico and South Africa have been influenced by those from different countries and continents. Therefore, people in these countries may be more open to novel foods; consequently, higher levels of acceptance of cultured meat may have been observed. In England, ethnic foods from former colonies are highly prevalent. Familiarity with exotic foods may positively influence the acceptance of novel foods. The large differences observed across

Table 3
Predictors explaining disgust evoked by cultured meat in ten countries. Unstandardized coefficients, standard errors and 99% confidence intervals are shown.

Country	Perceived Naturalness	Trust	Food Neophobia	Food Disgust	R^2
	B (SE) [99%-CI]	B (SE) [99%-CI]	B (SE) [99%-CI]	B (SE) [99%-CI]	
Australia	−0.37 (0.04)** [-0.47, −0.27]	−3.09 (0.96)* [-5.57, −0.61]	4.67 (1.00)** [2.08, 7.26]	6.69 (1.22) ** [3.55, 9.83]	.27
China	−0.06 (0.04) [-0.17, 0.04]	−4.40 (1.04)** [-7.09, −1.71]	6.72 (1.46)** [2.94, 10.50]	5.76 (1.29) ** [2.43, 9.09]	.13
England	−0.38 (0.04)** [-0.49, −0.27]	−2.14 (1.03) [-4.81, 0.53]	3.81 (0.96)** [1.32, 6.30]	7.68 (1.34) ** [4.21, 11.15]	.24
France	−0.55 (0.04)** [-0.66, −0.45]	−1.13 (0.98) [-3.67, 1.41]	2.42 (1.03) [-0.24, 5.07]	2.70 (1.31) [-0.68, 6.09]	.24
Germany	−0.56 (0.04)** [-0.66, −0.45]	−0.05 (0.98) [-2.58, 2.48]	2.29 (1.09) [-0.51, 5.10]	7.87 (1.24) ** [4.67, 11.07]	.29
Mexico	−0.26 (0.04)** [-0.35, −0.16]	−1.63 (1.02) [-4.27, 1.02]	2.16 (1.17) [-0.87, 5.19]	3.87 (1.31) * [0.49, 7.24]	.11
South Africa	−0.40 (0.03)** [-0.49, −0.31]	−1.90 (0.97) [-4.42, 0.62]	3.91 (0.98)** [1.38, 6.44]	5.94 (1.23) ** [2.76, 9.12]	.29
Spain	−0.27 (0.04)** [-0.38, −0.16]	0.69 (1.17) [-2.34, 3.72]	4.08 (1.02)** [1.45, 6.72]	5.69 (1.33) ** [2.25, 9.12]	.12
Sweden	−0.57 (0.04)** [-0.68, −0.46]	−1.70 (1.07) [-4.46, 1.07]	3.43 (1.23)* [0.25, 6.60]	5.73 (1.28) ** [2.42, 9.04]	.30
US	−0.31 (0.04)** [-0.41, −0.20]	−2.79 (1.06)* [-5.52, −0.07]	4.52 (0.97)** [2.02, 7.02]	1.93 (1.46) [-1.84, 5.69]	.16

Note. * < 0.01, ** < 0.001.

Table 4
Predictors explaining acceptance of cultured meat in ten countries. Unstandardized coefficients, standard errors and 99% confidence intervals are shown.

Country	Perceived Naturalness	Evoked Disgust	Trust	Food Neophobia	Food Disgust	R^2
	B (SE) [99%-CI]	B (SE) [99%-CI]	B (SE) [99%-CI]	B (SE) [99%-CI]	B (SE) [99%-CI]	
Australia	0.44 (0.03) ** [0.35, 0.53]	−0.48 (0.03)** [-0.56, −0.39]	0.50 (0.80) [-1.56, 2.57]	−4.23 (0.84)** [-6.40, −2.06]	−2.05 (1.03) [-4.70, 0.60]	.57
China	0.38 (0.04) ** [0.29, 0.48]	−0.36 (0.04)** [-0.45, −0.26]	1.79 (0.94) [-0.64, 4.22]	−5.95 (1.33)** [-9.38, −2.52]	0.15 (1.17) [-2.87, 3.17]	.34
England	0.32 (0.04) ** [0.23, 0.42]	−0.65 (0.03)** [-0.73, −0.57]	2.11 (0.80)* [0.04, 4.18]	−0.68 (0.75) [-2.63, 1.26]	−2.15 (1.06) [-4.90, 0.59]	.61
France	0.51 (0.04) ** [0.41, 0.61]	−0.45 (0.03)** [-0.54, −0.37]	0.49 (0.79) [-1.56, 2.53]	−1.27 (0.83) [-3.41, 0.88]	0.61 (1.06) [-2.13, 3.34]	.55
Germany	0.57 (0.04) ** [0.46, 0.67]	−0.40 (0.04)** [-0.50, −0.31]	1.70 (0.85) [-0.50, 3.91]	−2.44 (0.95) [-4.89, 0.01]	−0.52 (1.11) [-3.39, 2.36]	.53
Mexico	0.43 (0.03) ** [0.34, 0.51]	−0.40 (0.04)** [-0.49, −0.31]	3.05 (0.91) ** [0.71, 5.39]	−3.93 (1.04)** [-6.61, −1.25]	−3.07 (1.16)* [-6.08, −0.07]	.44
South Africa	0.38 (0.03) ** [0.30, 0.46]	−0.52 (0.03)** [-0.60, −0.43]	0.63 (0.80) [-1.43, 2.69]	−3.36 (0.81)** [-5.45, −1.28]	−2.38 (1.02) [-5.02, 0.26]	.60
Spain	0.49 (0.04) ** [0.40, 0.58]	−0.42 (0.03)** [-0.50, −0.34]	4.14 (0.93) ** [1.74, 6.54]	−3.79 (0.82)** [-5.91, −1.68]	−2.15 (1.07) [-4.92, 0.61]	.52
Sweden	0.39 (0.04) ** [0.29, 0.48]	−0.56 (0.03)** [-0.65, −0.48]	1.53 (0.83) [-0.62, 3.68]	−1.75 (0.96) [-4.23, 0.73]	−1.30 (1.01) [-3.91, 1.31]	.61
US	0.43 (0.03) ** [0.35, 0.52]	−0.47 (0.03)** [-0.55, −0.39]	2.79 (0.82) ** [0.67, 4.91]	−2.84 (0.76)** [-4.81, −0.87]	−3.69 (1.13)* [-6.60, −0.77]	.55

Note. * < 0.01, ** < 0.001.

different cultures suggest that it may be problematic to generalize findings related to this technology from one country to other countries, and that cross-cultural research may be especially important when it comes to the acceptance of novel food technologies. Our results are in line with findings from recent research that showed large differences in stated willingness to purchase cultured meat, such as Gomez-Luciano et al., 's 2019 finding that Spanish consumers are more willing to buy such products than consumers in the UK, Brazil and the Dominican Republic. However, our finding that US and Chinese consumers did not differ in their level of acceptance of cultured meat is at odds with a recent study's (C. Bryant et al., 2019) finding that Chinese consumers showed higher levels of acceptance of cleaned meat compared with US consumers. One possible explanation for the different findings could be the different labels used—*clean meat* in the study of Bryant et al. (2019) versus *cultured meat* in our study. Future studies should consider testing whether people in different cultures differ in how much they value their food culture and whether this may be related to their acceptance of novel foods.

Various predictors have been proposed to explain the acceptance of cultured meat (Wilks et al., 2019). These predictors can be grouped into two broad categories: variables that are related to perceptions of cultured meat (i.e., perceived naturalness of cultured meat, disgust evoked by cultured meat) and factors that are related to the personality characteristics of the consumer (i.e., food neophobia, food disgust sensitivity, trust in the food industry). The latter variables are not related to cultured meat, and therefore would be expected to have lower predictive power than the former group of variables. Results of the aggregated data set, which can be viewed as a meta-analysis of the results from the ten countries, suggest that perceived naturalness has a direct positive effect on the acceptance of cultured meat as well as an indirect effect, via disgust evoked. In other words, one reason cultured meat evokes disgust in some participants is its perceived artificiality. For all ten countries, perceived naturalness of cultured meat and disgust evoked by cultured meat were significant predictors of the acceptance of cultured meat. It should be noted, however, that no significant mediation could be observed for China, only direct effects of perceived naturalness and evoked disgust on acceptance of cultured meat. Furthermore, the observed effects of perceived naturalness and evoked disgust differed across countries. The direct effect of perceived naturalness on acceptance was significantly lower for England than for Germany, as the CIs shown in Table 4 suggest. In England, the effect of evoked disgust on acceptance was significantly larger than in China, Germany, Mexico and Sweden. Overall, the results are in line with those

of previous studies that emphasized the importance of perceived naturalness (Bryant et al., 2019) and evoked disgust (Verbeke, Marcu, et al., 2015) to the acceptance of cultured meat. Furthermore, we were able to replicate the finding that perceived naturalness not only has a direct effect on the acceptance of cultured meat, but also an indirect effect via disgust evoked by cultured meat (Siegrist et al., 2018). A recent study questioned the importance of naturalness for the acceptance of cultured meat (Wilks et al., 2019). However, this study did not measure perceived naturalness of cultured meat but the participants' general preference for naturalness (e.g., "More often than not, human intervention causes damage to nature.", p. 140).

As predicted, the personality factors food neophobia and food disgust sensitivity had, in the aggregated sample, a positive influence on the level of disgust evoked by the idea of cultured meat. Participants who had high levels of trust in the food industry not only perceived cultured meat as more natural but also as more disgusting than participants with low levels of trust in the food industry. Trust in the food industry, food neophobia and food disgust sensitivity not only had the predicted indirect effects, all three also had direct effects on stated acceptance of cultured meat. Our results suggest, therefore, that one reason trust and disgust sensitivity did not have an influence on the acceptance of cultured meat in the study conducted by Wilks et al. (2019) may be related to the measurement of the constructs. Furthermore, we were able to successfully replicate the earlier finding that food neophobia influences the acceptance of cultured meat (Wilks et al., 2019).

How strongly the three consumer related factors influenced the acceptance of cultured meat differed somewhat across countries. In all ten countries, participants with high levels of trust in the food industry perceived cultured meat as more natural than participants with low levels of trust in the food industry. Food disgust sensitivity influenced disgust evoked by cultured meat in all countries, with the exception of France and the US. In the US sample, food disgust sensitivity had a significant direct effect on stated acceptance of cultured meat, but it did not in the French sample. The hypothesized effect of food neophobia was observed in all countries except for France, Germany and Mexico. France was, therefore, the only country in which neither food disgust sensitivity nor food neophobia had a significant direct or indirect effect on stated willingness to accept cultured meat. Participants in France reported the lowest acceptance of cultured meat and the most negative perception of cultured meat, so a ceiling effect may help explain this finding. The low acceptance of cultured meat in France is also supported by a study in which the majority of participants were from France (Hocquette et al., 2015).

Some limitations of the present study need to be addressed. Sex and age were used as quota variables. It is very likely, however, that the samples were biased toward better educated people. This may have been especially the case for Mexico and China, where the number of years participants spent in school was higher than in the other countries. Furthermore, we included countries from Europe, North America, Africa, Asia and Oceania in our study, but South Africa differs in a number of aspects from other African countries and China differs in many ways from other Asian countries. For example, the cuisine of South Africa is more strongly influenced by European cuisine compared with those of other African countries. Another limitation is that meat consumption or more specifically, beef consumption, was not measured in the present study. Therefore, we could not control whether the frequency of meat consumption influenced the acceptance of cultured meat. Overall, our model seems to provide a better explanation of the acceptance of cultured meat in Western countries compared with African or Asian countries. Future studies should examine whether perceived naturalness of foods is different in non-Western countries.

As in all other studies examining consumer acceptance of the idea of cultured meat, we had to provide some information about this novel food technology. In the present study, we used the same description that has been used in a previous study examining the impact of disgust on various food technologies in Switzerland (Egolf, Hartmann, & Siegrist, 2019). Based on past studies, we know that the labels used for and descriptions of cultured meat provided influence its acceptance (C. J. Bryant & Barnett, 2019; Siegrist et al., 2018). Given that the associations observed between perceived naturalness and evoked disgust and willingness to eat cultured meat were similar for both a technical and a non-technical description of cultured meat (Siegrist et al., 2018), the description used in the present study may have had only a limited effect on the results observed.

In line with the results of other studies (Bekker, Tobi, & Fischer, 2017; Gomez-Luciano et al., 2019), the results of the present research suggest that cultural factors play an important role in the acceptance of cultured meat. It is, therefore, important to first introduce cultured meat in cultures that are more open to this idea. France, for example, would certainly not be a good market to start with. Furthermore, the perceived naturalness of cultured meat was a very important factor for acceptance in all countries. If consumers have the impression that cultured meat is not a natural product, it is less likely to be accepted. These findings imply that for successful marketing, product labels and related storytelling should focus mainly on the meat-like properties of the novel food and not on the production process, which is unlikely to be perceived as natural. Given the importance of trust, it will be important that cultured meat is brought to market by retailers and producers consumers trust relatively well. Finally, given the importance of food neophobia and food disgust to acceptance, cultured meat should imitate conventional meat as closely as possible in order to reduce the negative impact of these consumer personality factors.

Ethics

The present study was approved by the Ethics Committee of ETH Zurich (EK 2018-N-104).

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