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First impressions and food technology neophobia: Examining the role of visual information for consumer evaluations of cultivated meat

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ABSTRACT

Discussions and images of cultivated meat are increasingly common in popular media, often stressing highly technical aspects. Despite growing research on cultivated meat, the importance of information provision in specific, little is known about the influence of images on consumer attitudes and evaluations. Using a representative sample of 727 potential consumers in Germany, the current research employed an experimental survey with a between-subjects design, where participants received information about cultivated meat and its prospective benefits together with (a) no images, (b) images presenting meat in a more familiar form, or (c) images with a laboratory focus. Logistic quantile regression is employed for the first time to assess how determinants of consumer evaluations vary depending on one's intention to try and consume cultivated meat. The results underscore the key role of food technology neophobia as a determinant of consumer evaluations. Moreover, our findings help to clarify why individuals are likely to accept (and not just reject) cultivated meat as well as suggest the potential for misleading inferences when relying on linear regression for analyzing issues of consumer acceptance, behavioral intentions, and the like.

1. Introduction

Now is the moment of first impressions with cultivated meat. Year after year, the number of companies promising to supply meat that is grown in laboratory conditions without needing to harm animals is growing, reflecting an increased flow of funding and investment flowing into this sector. In 2021 alone, more than 100 companies have entered this sector, with $1.38 billion invested in cultivated-meat firms. This represents more than two-thirds of the historic total of what has been invested (Good Food Institute 2022). The countries reported as likely to soon give regulatory approval, such as Israel and Japan, is also growing (Good Food Institute 2023), with final steps toward regulatory approval just met in the United States (Poinski 2023). Thus, mentions of how each year will at last "be the year of cultivated meat", when it becomes widely available, are not uncommon (Jack 2023; De Nood 2023). Given the negative environmental impacts of conventional meat production (e.g., Xu et al. 2021), many studies have assessed the prospective benefits of cultivated meat (Lynch and Pierrehumbert 2019; Tuomisto and Teixeira de Mattos 2011; Sinke et al. 2023). Informed by expected growth in global meat demand, along with the difficulties this would pose for land use and resource requirements, there is a sense in some circles that cultivated (or plant-based) meat substitutes could offer a solution. One recent consultancy estimate has predicted that 35% of all meat consumed by 2040 would be cultivated meat (AT Kearney 2019). While almost sure to be overly optimistic, such predictions illustrate the growing attention to cultivated meat in the academia literature and popular press.

However, unless one lives in Singapore (or soon two cities in the United States), it is currently not possible to eat cultivated meat. For any consumer seeking to satisfy their curiosity or gauge if the products taste like real meat, they will have to rely on how the depiction of the alternatives in and by media sources. One key consideration is therefore what such products are called, or for that matter allowed to be called. This is one reason why the name used for such products, like clean, cell-based, cultured, or slaughter-free meat, receives significant attention and is the source of much research and discussion with regard to how this impacts

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individual perceptions (Bryant and Dillard 2019; van Loo et al. 2020; Verbeke et al. 2021; Malerich and Bryant 2022). Many studies have also demonstrated the influence of information on consumer perceptions of cultivated meat, notably if positive or negative aspects are stressed (Bekker et al. 2017; Bryant and Dillard 2019; Van Loo et al. 2020; Baum et al. 2021; Zhang et al. 2022). Information stressing benefits is shown to improve attitudes and evaluations, with the opposite true if risks are accentuated (Bekker et al. 2017; Baum et al. 2021). Also, Baum et al. (2022) and Zhang et al. (2022) show evaluations may be improved by "counter-messaging", positioning cultivated meat as a potential solution to shortcomings of conventional production. Van Loo et al. (2020) also linked positive information to greater willingness to pay. Using mediation analysis, Baum et al. (2021) have revealed how the relationship between information provision and behavioral intentions is mediated by implicit and explicit attitudes, along with identifying a limited impact of complexity and length of information. Interestingly, other studies (Bryant and Dillard 2019; Bekker et al. 2021) have identified "naming" effects for cultivated meat, that is, how describing this product as "real" meat or meat substitute could impact perceptions. Such insights offer, *inter alia*, a useful point of overlap with research on the consumer associations of cultivated meat (Michel et al. 2021; Bryant and Barnett 2018, 2019; de Oliveira Padilha et al. 2022).

Despite growing research on cultivated meat, the role of information provision in specific, there remain several gaps. For one, given the tendency for media coverage to feature the underlying technological expertise, there is a surfeit of pictures and photographs that feature laboratories, cleanliness, and petri dishes (Bomkamp 2020). However, there is little research examining the relevance of visual information, particularly if emphasis on technical aspects affects consumer evaluations. This contrasts with the robust literature demonstrating the importance of images for information processing (Edell and Staelin 1983; Choi et al. 2019), in the context of political campaigns (Lee et al. 2020), health perceptions (Lee et al. 2022) and climate and environmental communication (Metag et al. 2016; Krause and Bucy 2018). Moreover, Keib et al. (2018) found pairing news stories with positively valenced images (versus one with negative or no images) attracted more attention and stronger intentions to click and share. Regarding green advertising, Lee and Cho (2022) revealed that, regardless of message focus on gains or losses, positive images had a positive influence on brand attitudes and purchasing intentions, with the reverse true of negative images. Given the lack of direct experience with cultivated meat, type of image utilized could play an especially large role. And yet, the only study which employs any kind of images for their information provision is Bryant and Dillard (2019), who included a laboratory image for their "high tech" frame and of ostensibly normal meat frying in a pan for the "same meat" frame. If the high-tech nature of cultivated meat is stressed (by text and image), attitudes were less positive and willingness to eat cultured meat over other alternatives was lower. From the perspective of proponents of cultivated meat, how cultivated meat tends to be presented has been a source of consternation and provided motivation, for example, for setting up an "image library" for journalists or start-ups consisting of "fewer bad stock photos and more images of real, delicious products" (Bomkamp 2020).

The current research examines whether and how image focus influences consumer evaluations. To do so, we use information treatments that combine information on prospective benefits with images either accentuating the technological sophistication of cultivated meat or signaling the similarity of such products to conventional meat. These treatments are contrasted with one that consists of just information. We further contribute to the growing literature on cultivated meat by exploring the role of information on consumer evaluations alongside that of food technology neophobia. While (un)naturalness and disgust have long attracted consideration (Verbeke et al., 2015a, 2021; Wilks et al. 2019, 2021; Siegrist et al. 2018; Bryant et al. 2019; Kamrath et al. 2019; Siegrist and Hartmann 2020a; Motoki et al. 2022), growing appreciation is given to how much people are averse to new kinds of food. At times, this has been conceived in terms of the reluctance to eat unfamiliar foods (food neophobia; Gómez-Luciano et al. 2019; Dupont and Fiebelkorn 2020; Siegrist and Hartmann 2020a; Baum et al. 2022; Hamlin et al. 2022), though the more specific hesitancy to consume foods made using novel technologies (food technology neophobia) is increasingly identified as a key predictor (Baum et al. 2021; Asioli et al. 2022; Heidmeier and Teuber 2022; Krings et al. 2022; Wendt and Weinrich 2023). After all, some of the concerns about cultivated meat, as one of the salient cases of a novel food technology, are better explained thusly. There is also evidence food neophobia struggles to explain perceptions of cultivated meat (Baum et al. 2022; Hamlin et al. 2022). However, no study has considered the relevance of food technology neophobia in a targeted manner, notably, how its significance varies across participants depending on their evaluations of cultivated meat or how this factor influences how individuals respond to information (with or without images). To this end, we make first use of a logistic quantile regression (Bottai et al. 2010; Lagerkvist and Okello 2016) to assess how determinants of behavioral intentions toward cultivated meat vary, depending on if individuals are rejecting or accepting of cultivated meat, or in between. By considering the influence of thinking styles (i.e., preferences for intuition and deliberation; Betsch 2004), we also explore the relevance of such tendencies for intentions and evaluations of cultivated meat. Such styles have been previously revealed to influence food purchasing decisions (Richetin et al. 2007; Songa and Russo 2018). Ultimately, we highlight the significance of food technology neophobia as a determinant central to perceptions of cultivated meat, even after controlling for thinking styles, implicit attitudes, and other factors. Results of the logistic quantile regression also identify the conditional significance of determinants of behavioral intentions, with their importance revealed to vary along the population distribution.

2. Method

2.1. Participants

The experiment was conducted online in 2021, with a sample provided by Qualtrics and based on nationally representative panels in Germany. Prior and informed consent was obtained from respondents before the collection of survey data; all data was delivered to researchers in a de-identified and anonymized form. The sample consisted of 727 individuals and was broadly representative with respect to age, geographic area, gender, income, and education (Table 1). With only 43% of participants female, the sample is rather under-representative of this group. It is over-representative of those with a university degree and under-representative of those at higher income levels. Otherwise, the sample is reflective of the German population in terms of age, with a mean close to 60 and age range from 18 to 83 (participants needed to be at least 18 years old); those in rural regions; belonging to families with children at home; and most income levels.

2.2. Design and procedure

Before soft launch, the questionnaire was pilot tested using a convenience sample (10% of total sample), with revisions made based on feedback, including for flow and comprehensibility of German translations. The experimental survey was conducted online through the inter-operationalized platforms of *Qualtrics* and *Inquisit 6.1.2* from Millisecond. The latter was used to program and conduct the Implicit

Table 1
Sociodemographic characteristics for the sample.

Characteristic		Sample	Population
Gender	Male	57.1%	49.3 %[1]
	Female	42.6%	50.7%
	Other	0.3%	
Average age (years)		49.87 *(15.19)*	44.7
Region	Rural area or village	26.0%	22.5%
	Small- or medium-sized city	36.0%	45.5%
	Large city	38.0%	32.0%
Educational attainment	Hauptschulabschluss or lower	11.7%	33.2%
	Mittlere Reife	38.4%	30.9%
	Abitur (High School)	20.5%	17.2%
	Hochschulabschluss (University)	29.4%	18.5%
Household income (monthly, net)	< 1,000€	10.6%	9.45%
	1,000€ – 2,000€	29.0%	25.65%
	2,000€ – 3,000€	27.5%	23.57%
	3,000€ – 4,000€	20.1%	16.23%
	> 4,000€	12.8%	25.11%
Political views[a]	Strongly left	8.8%	*ND*
	Slightly left	22.4%	
	Center	57.9%	
	Slightly right	9.2%	
	Strongly right	1.7%	
Children at home[b]	Yes	24.4%	28.4%
	No	75.6%	71.6%
Frequency of eating meat substitutes	Monthly or more	39.9%	*ND*
	Seldom or never	60.1%	
Prior awareness of cultivated meat	Yes	20.1%	*ND*
	No	79.9%	

Note: [a]Strongly left represents values of −5 to −4, slightly left −3 to −2, center −1 to 1, slightly right 2 to 3, strongly right 4 to 5; [b]one missing value. Population statistics from the World Bank for gender, Statista for age, educational attainment, rural population, and children at home, the Federal Agency for Civic Education (BpB) for educational attainment, and the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) for populations living in large cities. *ND* stands for "no data".

Table 2
Overview of Experimental Design.

Procedure	Related measures
Introductory text + Age check	
Assessment of meat and meat-substitute eating behaviors	*Meat-substitute familiarity* (1-item measure) *Meat-eating frequency* (4-item measure for beef, pork, lamb, poultry consumption)
Self-reported awareness of cultivated meat	*Prior awareness* (1-item measure based on Verbeke et al. 2015b)
Background information about cultivated meat (+Comprehension check)	
Randomized assignment to information treatment: Control (only background information); (2) Text (no pictures); (3) Familiar (text and images with familiar tone); (4) High-tech (text and laboratory-inflected images)	
Transfer to Inquisit + Instructions about IAT	
Assessment of implicit attitudes	Single-Target Picture IAT (from de Liver et al. 2007; Karpinski and Steinman 2006)
Return to Qualtrics + Items on Geographic Area and Gender	
Assessments of explicit attitudes	8-item semantic differential scale (based on Richetin et al. 2007)
Assessment of behavioral intentions (*dependent variable*)	4-item measure (based on Wilks and Phillips 2017)
Assessment of potential covariates	*Abbreviated food technology neophobia* – 9-item measure from Schnettler et al. (2017) *Preference for intuition and deliberation* – 18-item measure from Betsch (2004) *Cognitive reflection test* – 3-item measure using tasks from Frederick (2005)
Demographics	Education, Number of children at home, Income, Political views
End Question and Debrief	

Association Test (Appendix III). The experiment consisted of three parts (Table 2): (1) background information on cultivated meat (with a comprehension check) in *Qualtrics*, items on eating behaviors and prior awareness of cultivated meat, followed by randomized assignment to treatment groups; (2) Implicit Association Test (IAT) in *Inquisit*; and (3) in *Qualtrics*, items related to explicit attitudes, behavioral intentions, food technology neophobia, preference for intuition and deliberation, the cognitive reflection test, and socio-demographic items.[1] Two attention checks were mixed in the last section.

The final sample consists of those who (i) answered the comprehension check correctly in the two chances given; (ii) did not fail attention checks; (iii) filled in all three parts; and (iv) passed 'speeder' checks (i.e., minimum duration) set up for longer measures of preference for intuition and deliberation and food technology neophobia. Out of a total 775 responses, 17 represented duplicates (identified by respondent number); we retained the data from the first completion in such cases. A further 31 failed to complete the IAT and/or were identified as speeding through the survey and/or IAT (using the approach from Greenwald et al. 2003). This resulted in a final sample of 727 individuals which was employed for further analysis.

The information-provision experimental survey used a 3x1 + 1 between-subjects design, with participants randomly assigned information on cultivated meat and its prospective benefits but no images ("Text", N = 197), with images presenting meat in a more familiar form ("Familiar", N = 208), or images with laboratory focus ("High-tech", N = 185). There was also a "Control" group (N = 137) that received the short introductory information without details on prospective benefits (Table A.1 in Appendix I). Through this design, we can explore if the focus of images had an influence on behavioral intentions and how this interacts with the other covariates (e.g., food technology neophobia and preference for intuition and deliberation) – or, more generally, whether there was a differential impact from receiving more than a short description. To ensure images would have the desired effect, a preliminary assessment was conducted (in *Qualtrics*) of potential images for the information treatments. By subjecting 21 images, belonging to four clusters (laboratory focus, machinery and equipment, packaged products, prepared products), for consideration by a group of pilot testers (N = 14), we could rule out the images not perceived to be associated with cultivated meat or for which perceptions were broadly divergent. This resulted in the final version of the three treatments (Fig. A.1 for English translations).

2.3. Material

2.3.1. Behavioral intentions

The dependent variable for this analysis was behavioral intentions towards cultivated meat. To measure this construct, we employed four items entailing (pseudo)behaviors of cultivated meat: willingness to try, regularly purchase, eat rather than conventional meat, and pay more (based on Wilks and Phillips 2017; Bryant et al. 2019). All items were measured using a 7-point Likert scale (1 = *very unlikely*, 7 = *very likely*). For willingness to eat instead of conventional meat, we eschewed forcing vegetarians/vegans to make a false choice by providing the option of "No interest in both". For those individuals (8.0% of the sample) choosing this option, their measure for *behavioral intentions* was solely based on the other three items. As expected, means of the items decreased with rising level of commitment: with the highest related to willingness to try ($M = 5.16$), then willingness to purchase regularly (M

[1] Based on preliminary analysis (including correlation analysis), the measures for *prior awareness* and *cognitive reflection test* were identified as being uncorrelated with the dependent variable of *behavioral intentions*. We do not discuss these further but do provide details on the *cognitive reflection test* in Tables A.2 and A.5. We also note that, for *prior awareness*, 31.2% of participants stated that they had previously heard of cultivated meat.

= 4.61) and prefer over conventional meat ($M = 4.34$), and lowest for willingness to pay more ($M = 3.63$). Behavioral intentions are positive overall for the first three while generally negative for willingness to pay. We ultimately decided to construct a measure using the first three items, given their stronger conceptual and statistical correspondence and since willingness to pay is more likely to suffer from hypothetical bias. Principal components analysis with varimax rotation on the 3 items extracted one factor ($M = 4.77$), with factor loadings high and reliability more than adequate (Cronbach's $\alpha = 0.945$; McDonald's $\omega = 0.946$).

Before conducting logistic quantile regression (Section 2.4), this variable underwent a logistic transformation, which served as the dependent variable. The logit transformation of behavioral intentions has a range of −1.874 to −0.776, mean of −1.110, and standard deviation of 0.243.

2.3.2. Explicit attitudes

To measure *explicit attitudes* of cultivated meat, we used a 7-point semantic differential scale (based on Richetin et al. 2007), where individuals were asked to select the point between two poles of contradictory descriptive words (e.g. *unhealthy-healthy*, *bad-good*) that best expressed their views. Principal components analysis with varimax rotation on the 8 items extracted one factor ($M = 4.92$), with all factor loadings high and reliability more than adequate (Cronbach's $\alpha = 0.959$; McDonald's $\omega = 0.960$).

2.3.3. Implicit attitudes

To measure perceptual differences of cultivated meat, we used a version of the IAT, the single-target IAT (ST-IAT) (de Liver et al. 2007; Karpinski and Steinman 2006). The ST-IAT utilizes a series of task blocks wherein participants are asked to sort pictures of cultivated meat to assess differences in response time (see Appendix III for detailed description). ST-IAT thereby gives a measure of the strength of automatic (implicit) associations (i.e., D-score) calculated directly by *Inquisit*, via the scoring algorithm of Greenwald et al. (2003). In absolute terms, the stronger the association, the higher the D-score: positive scores reveal favorable (implicit) views, while negative scores reveal unfavorable ones. D-scores can range from −1 to 1; those in our sample range from −0.969 to 0.943 ($Me = 0.023$).

2.3.4. Food technology neophobia

To measure reluctance to eat food produced with novel food technologies, the abbreviated food technology neophobia scale (FTNS) was used (Schnettler et al. 2017). As a shorter, validated form of the original version by Cox and Evans (2008), this 9-item scale is both convenient and addresses validity issues of the original. All items were measured via a 6-point Likert scale (1 = *completely disagree*, 6 = *completely agree*); the higher the FTNS score, the more neophobic the participant. The set of German-translated items from Baum et al. (2021) is employed (full list in Table A.3). Principal components analysis with varimax rotation on the 9 items extracted a single factor ($M = 3.57$), with all factor loadings high and reliability more than adequate ($\alpha = 0.911$; $\omega = 0.916$).

2.3.5. Preference for intuition and deliberation

To measure one's tendency to employ deliberative and/or intuitive thinking styles, we used the preference for intuition and deliberation scale (PID) (Betsch 2004). The 18-item scale consists, theoretically, of two orthogonal sub-scales related to intuition (PID-I) and deliberation (PID-D) (Table A.4). Unlike other scales like the Rational Experiential Inventory (Pacini and Epstein 1999), PID is unrelated to the ability or enjoyment of logical thinking but rather corresponds to the mode of thinking individuals expect to be successful (Betsch 2004). All items asked how applicable a statement was for participants and their decision-making, on a 6-point Likert scale (1 = *completely unapplicable*, 6 = *completely applicable*); the higher the PID score, the stronger the tendency for intuitive or deliberative thinking. This scale has been applied to consumption of soft drinks (Richetin et al. 2007) and intentions to buy healthy food (Songa and Russo 2018), both with the IAT. As the PID scale is widely replicated, we conducted principal components analysis with varimax rotation on the 18 items, pre-specifying two factors should be extracted. One item (PID-5) performed poorly and was removed; all others loaded adequately (greater than0.45) and as expected on their respective sub-scale. We obtained separate 8-item PID-I ($M = 4.03$) and 9-item PID-D factors ($M = 4.41$), both with more than adequate reliability (PID-I: $\alpha = 0.842$; $\omega = 0.842$; PID-D: $\alpha = 0.846$; $\omega = 0.844$).

2.3.6. Meat-eating frequency and meat-substitute familiarity

Participant were asked how often they eat beef, pork, lamb, poultry, seafood, dairy and eggs, and/or meat substitutes (e.g., tofu, plant-based alternatives). A tabular overview is shown in Appendix I (Table A.6). Drawing on correlation analysis, we first created a single-item factor related to how often people consumed meat substitutes (*Meat-substitute familiarity*), since this item was loosely or negatively correlated with the others. With 60% of participants stating they seldom or never consumed such products, we created a dummy variable with this coded as "0″ and those eating such products at least monthly as "1". We also created a four-item factor which combined responses for beef, pork, lamb, poultry (*Meat-eating frequency*), excluding dairy and seafood. Principal components analysis with varimax rotation on the 4 items extracted one factor, with loadings high and reliability acceptable ($\alpha = 0.656$; $\omega = 0.668$).

2.4. Data analysis

Statistical analyses were conducted using SPSS v28.0, which included frequency distributions, correlation analysis, principal component analysis, and reliability analysis (Table A.2). Also, we assessed the normality of distributions using Shapiro-Wilk testing, determining that implicit attitudes, explicit attitudes, and behavioral intentions were non-normally distributed, with the same true for the covariates as well.

Given the non-normality of the *behavioral intentions* measure, specifically its bi-modal nature (Fig. A.2), we employ logistic quantile regression over linear regression (Bottai et al. 2010). Use of logistic quantile regression is crucial when outcomes are bounded from above and below and if values close to boundaries are more likely to occur. Following Bottai et al. (2010), we use the following transformation: $logit(Behavioral\ Intentions) = \log[(Behavioral\ Intentions + \varepsilon)/(60 - Behavioral\ Intentions + \varepsilon)]$, with $\varepsilon = 0.001$. By using a small quantity for ε, we ensure that the logistic transformation is defined for all values of the dependent variable – though any other reasonably small number could be used instead.

Quantile regressions have several advantages, including the fact that they are robust to type of population distribution and can be used to make inferences regarding conditional effects of the variables depending on the local region of the distribution (Buhai 2004; Bottai et al. 2010; Lagerkvist and Okello 2016). On the latter point, this facilitates the "deconstruction" of models focused on the mean of the population distribution, i.e., linear regression (Buhai 2004), and the drawing of inferences regarding local behavior near a specified quantile. By estimating a model with a grid of quantiles spaced throughout the population distribution, we can investigate how the importance of a predictor is "conditioned" on the specific quantile of the dependent variable (Davino et al. 2015). For each quantile, parameter estimates are calculated, which can then be interpreted in the same way as linear regression. In the context of quantile regression, though, these estimates signify the change in y per unit of a selected predictor for a specific conditional quantile, holding other predictors constant. Key findings of (logistic) quantile regressions can be gleaned by looking at which covariates are significant for a given quantile and the patterns that emerge across the quantiles (Table 3). Inference based on such patterns is also enabled by graphical representations (from *SPSS*) for each input variable (Fig. 1). It is crucial to stress that the quantile-regression approach does not conduct separate regressions for each quantile but

Table 3
Results for Logistic Quantile Regression of Behavioral Intentions (Logistic Transformation).

	θ = 0.10	θ = 0.30	θ = 0.50	θ = 0.70	θ = 0.90	Mean
Intercept	−0.598***	−0.600***	−0.743***	−0.789***	−0.858***	−0.648***
	(0.125)	(0.095)	(0.061)	(0.046)	(0.047)	(0.074)
Food technology neophobia	−0.196***	−0.160***	−0.114***	−0.076***	−0.048***	−0.149***
	(0.012)	(0.009)	(0.006)	(0.004)	(0.004)	(0.007)
Information treatments ("Text" as reference)						
Control treatment	0.038	0.013	0.016	0.008	−0.010	0.014
	(0.035)	(0.026)	(0.017)	(0.013)	(0.013)	(0.020)
Familiar treatment	0.028	0.000	0.009	−0.014	0.003	0.011
	(0.031)	(0.023)	(0.015)	(0.011)	(0.012)	(0.018)
High-tech treatment	−0.047	−0.008	0.005	−0.004	−0.001	−0.018
	(0.032)	(0.024)	(0.016)	(0.012)	(0.012)	(0.019)
Preference for intuition	0.032	0.029*	0.013	0.014*	0.010	0.028**
	(0.016)	(0.012)	(0.008)	(0.006)	(0.006)	(0.010)
Preference for deliberation	−0.041*	−0.025	0.000	0.001	0.007	−0.023*
	(0.018)	(0.013)	(0.009)	(0.006)	(0.007)	(0.010)
Implicit attitudes	0.057	0.007	0.025	0.038**	0.028*	0.050*
	(0.035)	(0.027)	(0.018)	(0.013)	(0.013)	(0.021)
Meat-Substitute Familiarity	0.023	0.043*	0.032*	0.027**	0.017	0.040**
	(0.026)	(0.020)	(0.013)	(0.009)	(0.010)	(0.015)
Meat-Eating Frequency	0.069***	0.038**	0.025**	0.019**	0.013	0.055***
	(0.019)	(0.014)	(0.009)	(0.007)	(0.007)	(0.011)
Political Views ("Conservative")	−0.018**	−0.011*	−0.006*	−0.003	0.000	−0.010**
	(0.006)	(0.005)	(0.003)	(0.002)	(0.002)	(0.004)
Educational attainment	−0.022	−0.043*	−0.010	−0.016	−0.013	−0.022
	(0.025)	(0.019)	(0.013)	(0.009)	(0.010)	(0.015)
Children at home (1 = Yes)	0.064*	−0.011	−0.016	−0.007	−0.009	−0.005
	(0.029)	(0.022)	(0.014)	(0.011)	(0.011)	(0.017)
Observations	727	727	727	727	727	727
Pseudo R-squared	0.427	0.305	0.232	0.195	0.097	0.452

Note: N = 727; dependent variable is logarithmic transformation of behavioral intentions, *SE* in parentheses. Method: simplex algorithm. *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$. "Text" treatment serves as reference category. "Educational attainment" is the effect of having (at least) the equivalent of a high-school degree. "Mean" presents OLS linear regression results for "average" of the population distribution; R-squared for "Mean" is adjusted rather than pseudo. Results for socio-demographic characteristics are not reported (i.e., age, gender, household income, geographic region) if the factor is not found to be significant for at least one quantile.

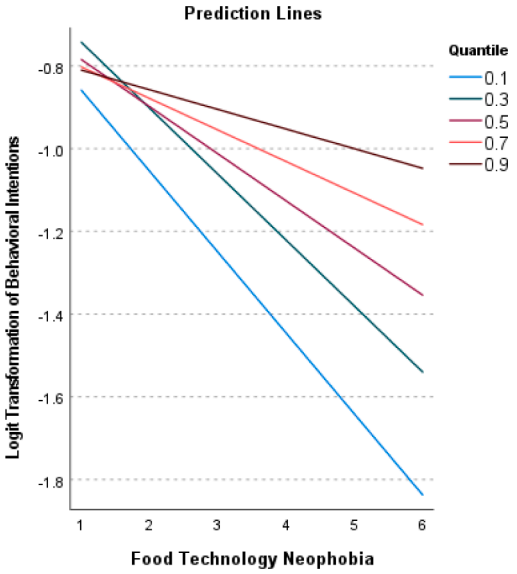


Fig. 1. Quantile regression lines for food technology neophobia for selected quantiles (θ = [0.10, 0.30, 0.50, 0.70, 0.90]).

rather supports inferences regarding the conditional effects of explanatory factors across the population distribution of the dependent variable. Finally, by including results for linear regression – "Mean" in final column of Table 3 and horizontal red lines in Fig. 1 – we can assess how conditional effects vary to those averaged across the entire population distribution.

Regarding *behavioral intentions* of cultivated meat, since there is high density at the bottom of the distribution (that is, participants strongly rejecting cultivated meat), we set the first quantile at $\theta_1 = 0.10$, with subsequent quantiles at intervals of 0.20: $\theta_2 = 0.30$, $\theta_3 = 0.50$, $\theta_4 = 0.70$, $\theta_5 = 0.90$. Quantiles were selected given their correspondence to higher-frequency areas of the population distribution, while avoiding segments closer to the extremes. Though "extreme" quantiles may be of interest, setting quantiles too close to the edges raises the possibility of asymptotic issues. Furthermore, as Buhai (2004) details, there are potential tradeoffs between the robustness and resolution of quantile regression: opting for too many quantiles and too fine of a resolution can make results overly sensitive to potential changes to the underlying conditional distribution.

Information effects are considered by means of dummy variables for the treatments, with the "Text" treatment taken as the reference category. We take "Text" as the reference to highlight differences with those receiving background information (i.e., "Control") and those receiving detailed information on prospective benefits *and* different images. Nonparametric independent-samples Kruskal-Wallis *H* testing however failed to find any significant differences between information treatments vis-à-vis *behavioral intentions*: $H(3) = 2.367$, $p = .500$, *explicit attitudes*, $H(3) = 3.925$, $p = .270$, and *implicit attitudes*, $H(3) = 0.862$, $p = .835$. The null effects also extended to pairwise differences between treatments, without any pairing of the above factors shown to significantly differ. Information treatments can thus be concluded not to have had any effect on attitudes and intentions. Still, the existence of treatment effects could prove conditional on local region of the distribution of *behavioral intentions*, so this factor is retained in the logistic quantile regression. While we had intended to use interaction terms of information treatments and food technology neophobia in the regression analysis, to examine whether the conditional effects of information treatments vary by degree of food technology neophobia, we now limit this discussion to Appendix II (Table A.7) given the insignificance of the treatments for the sample population as a whole.

We also considered correlations between attitudes, behavioral intentions, and covariates (Table A.7). Since the correlation between

behavioral intentions and *explicit attitudes* is rather high ($\rho = 0.802$), even exceeding that for *behavioral intentions* and the item on willingness to pay ($\rho = 0.618$), we do not include *explicit attitudes* in the logistic quantile regression analysis.

3. Results

3.1. Descriptive results

Means of behavioral intentions ($M = 4.77$, $SD = 1.74$) and explicit attitudes ($M = 4.92$, $SD = 1.48$) are above the mid-point of 4. The sample can be said to hold positive views of cultivated meat overall. Conversely, the mean for implicit attitudes (D-score) is near the mid-point of this scale at 0 ($M = 0.01$, $SD = 0.33$). Self-reported attitudes and evaluations thus appear to be more positive than their association-based attitude counterparts, suggesting individuals may not be as open to cultivated meat as they see themselves to be. Examining the respective items of behavioral intentions, almost three-quarters of participants said that they were likely to try cultivated meat, with nearly 60% likely to purchase regularly or buy it rather than conventional meat. Notably, the figures mark a slight increase from prior studies in Germany with about 60% of participants willing to try cultivated meat and typically no more than half to purchase it regularly (Baum et al. 2021; Bryant et al. 2020; Weinrich et al. 2020; Dupont and Fiebelkorn 2020).

3.2. Main results

Table 3 presents findings for the means and standard deviations (and levels of significance) for the covariates, information treatments, and socio-demographic factors vis-à-vis behavioral intentions (after logistic transformation) of cultivated meat. Findings are given for each focal quantile, representing the local regions of the distribution that are completely rejecting ($\theta = 0.10$) or accepting ($\theta = 0.90$) of cultivated meat as well as those neutral ($\theta = 0.30$) or broadly positive ($\theta = 0.50$, $\theta = 0.70$). By making results conditional on the quantile of the distribution, we explore how determinants vary in relation to their general location in the population distribution.

None of the information treatments were found to influence participants' intentions to consume or regularly purchase cultivated meat (Table 3). Whether they received detailed information on prospective benefits about cultivated meat or simply background details ("Control treatment") also had no effect. This suggests that, as far as evaluations of cultivated meat are concerned, the detail of information presented about potential benefits makes little difference. In addition, the inclusion of pictures alongside the information text, whether of a "familiar" or "high-tech" tone, did not have any significant effect. In sum, this offers evidence that, at least when it comes to information about prospective benefits of cultivated meat, the type of images that are utilized appears to not have any discernible impact - for any quantile of the distribution.

Of all the factors, *food technology neophobia* is the only one consistently significant across all quantiles, exercising a negative effect on *behavioral intentions* of cultivated meat. Even then, the parameter estimate of *food technology neophobia* becomes closer to zero as participants indicate that they are more likely to accept cultivated meat (Fig. 1). For the highest quantile, the difference between the *behavioral intentions* of those more versus less food technology neophobic is sizably reduced: while shifting from lowest to highest value of *food technology neophobia* is roughly predicted to decrease the dependent variable by 1.0 in the lowest quantile, this difference is only around 0.2 in the highest quantile. Recall that the total range of the logit transformation of the variable is around 1.1. As such, while a shift from the lowest to highest value of *food technology neophobia* yields a large difference in *behavioral intentions* for those rejecting cultivated meat, encompassing nearly the entire range of this factor, such a change would yield a much smaller difference for those with high levels of acceptance.

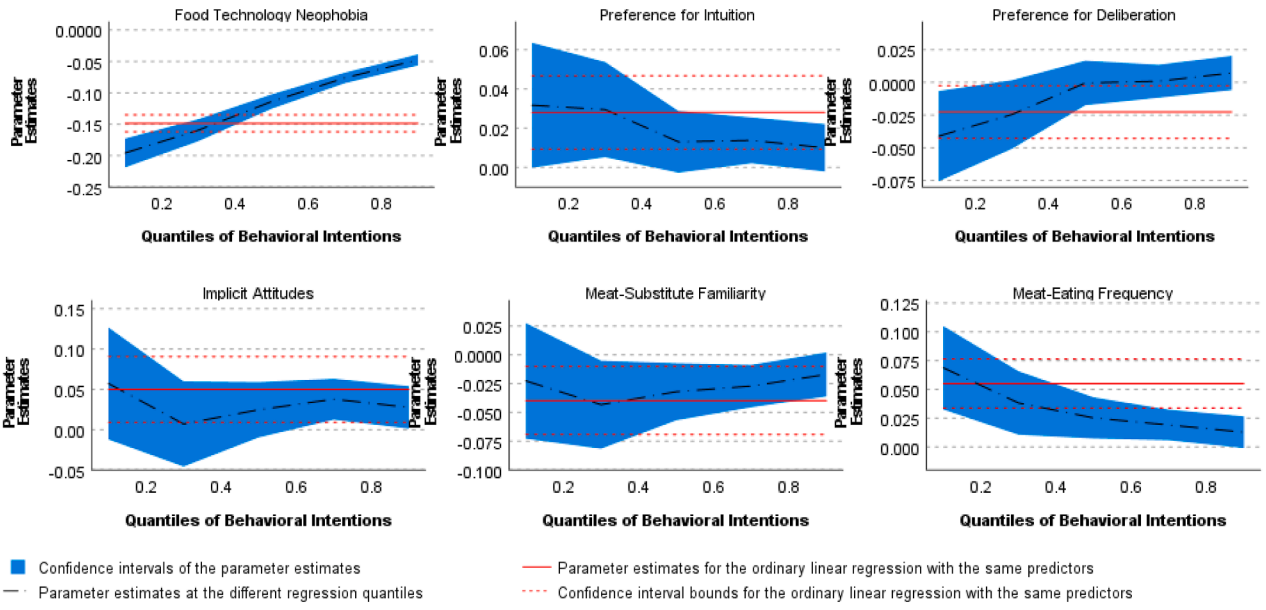
Meanwhile, the significance of the other covariates proves to be conditional across quantiles. For instance, *preference for intuition* is only significant for two of the five quantiles ($\theta = 0.30$, $\theta = 0.70$): individuals more likely to employ intuitive thinking styles are more likely to express positive *behavioral intentions* toward cultivated meat, so long as they have neutral or somewhat positive intentions. Rather similarly, *implicit attitudes* have a significant effect for the highest quantiles ($\theta = 0.70$, $\theta = 0.90$). Those more implicitly positive about cultivated meat are also more likely to express positive *behavioral intentions*, although this effect is limited to those broadly positive. Along with the results *preference for intuition*, this signals a critical, circumscribed role for intuitive and implicit processes of thinking. Conversely, *preference for deliberation* is only (negatively) significant for the lowest quantile ($\theta = 0.10$). Among those rejecting cultivated meat, those who employ deliberative thinking are more likely to express negative *behavioral intentions* towards cultivated meat. In total, the quantile-regression results demonstrate that the significance of the covariates is conditional to local regions of the population distribution and, thus, that some covariates prove more influential depending on individuals and their intentions. Notably, deliberative processes play a stronger role among those intending to reject cultivated meat whereas implicit or intuitive processes are more relevant among those more positive or, perhaps, neutral. The conditional nature of such findings draws a clear contrast from those from linear regression ("Mean" column). While the latter would indicate that many of the covariates are significant for the entire population distribution, the picture offered by quantile regression is richer in terms of caveats.

Lastly, while *food technology neophobia* stands out, there are two other factors related to eating behaviors with explanatory significance for most of the quantiles: *meat-substitute familiarity* and *meat-eating frequency*. Except for the highest quantile of those fully accepting cultivated meat, the more often one eats meat (beef, pork, lamb, poultry), the more positive are *behavioral intentions*. In addition, those who consume meat substitutes like tofu at least once a month have more positive *behavioral intentions* – this result only holds for those not completely rejecting or accepting cultivated meat. Thus, those eating meat more often and those at least somewhat familiar with meat substitutes emerge as key target groups. Overall, socio-demographic factors have little explanatory power. Those with liberal *political views* tend to express more positive *behavioral intentions* – only in the lower half of the distribution ($\theta = 0.10$, $\theta = 0.30$, $\theta = 0.50$). The other factors are generally insignificant or, in the case of *educational attainment* ($\theta = 0.30$) and *children at home* ($\theta = 0.10$), significant for only a single quantile.

Looking at a selection of the graphical representations for the input variables (Fig. 2; the rest in Fig. A.3), we can observe the ranges of the population distribution for which the factor is significant. For *food technology neophobia* and *meat-eating frequency*, this is true for the entire distribution – though the parameter estimates are closer to not being significantly different from zero as the value of *behavioral intentions* increase. For most variables, however, the coefficient bands are quite large – particularly for the lower quartiles – which indicates that standard errors of estimates are large, and there is a significant effect for only a small sub-set of the population.

4. Discussion and conclusion

The current research extends the understanding of consumer acceptance of cultivated meat in several ways. First, it helps to better investigate the importance of *food technology neophobia* as a determinant of cultivated meat acceptance (Baum et al. 2021; Asioli et al. 2022; Heidmeier and Teuber 2022; Krings et al. 2022; Wendt and Weinrich 2023). We particularly establish by using logistic quantile regression how the strength of this factor is conditional on the negativity of *behavioral intentions* towards cultivated meat. The more negative the intentions to consume or try cultivated meat, the greater is the explanatory power of *food technology neophobia*. For those producers or proponents looking to nurture interest and willingness to try cultivated meat, this underscores the need to be mindful of how communication



Note: Representations drawn based on parameter estimates for selected quantiles (θ=[0.10, 0.30, 0.50, 0.70, 0.90]). Confidence intervals represented are of a two-tailed 95% nature. Remaining graphical presentations available in Figure A.3.

Fig. 2. Graphical representations of OLS (horizontal solid red line) and Quantile regressions (dotted line) coefficients and related confidence intervals (blue area for QR coefficients and dotted horizontal lines for OLS).

materials or messages shared with the public might (unintentionally) trigger such concerns.

Secondly, for the first time in the literature on cultivated meat, we examined the role of image valence on attitudes and behavioral intentions. We failed to identify any significant differences between information treatments, whether the focus of the images employed or the detail of the information on potential benefits. On the one hand, the null effects are something of a surprise given the relevance of concerns of naturalness in the literature (Baum et al. 2021, 2022; Bekker et al. 2017; Bryant et al. 2019; Bryant and Dillard 2019; Rolland et al. 2020; Wilks et al. 2019; Zhang et al. 2022). The absence of such effects also appears to undercut concerns over reliance on laboratory-inflected images in the media and how this might adversely influence consumer perceptions (Bomkamp 2020). At the same time, we observe that the texts in the current study focused only on the prospective benefits of cultivated meat, instead of describing risks as well. This could explain the lack of any differential impact of the "*Text*" and "*Control*" treatments. Previously, Baum et al. (2021) identified, also in the German context, no difference on attitudes and evaluations of cultivated meat from increasing length or detail of information on benefits. One plausible interpretation of the null effects is that image valence fails to have a significant influence on attitudes and behavioral intentions of cultivated meat when coupled with positive information – though this signifies a departure from contexts such as news media and green advertising (Keib et al., 2018; Lee and Cho 2022). Importantly, this signals a need for future research that pairs differently valenced images with risk-focused information to examine the influence of images in such a setting. Such a design would enable more fruitful investigation of whether and how food technology neophobia might play a role in the uptake of information, notably, using interaction terms between the variables. While such interactions were of interest in the current study, the null effects of the information treatments precluded their consideration, owing to questions of reliability. For any interested, we do however provide a brief description of these findings in Appendix II, along with the modified results of the regression analysis after the inclusion of the interaction terms (Table A.7). We hope that such results, albeit preliminary, might support further research in this direction.

Another important contribution centers on the use of (logistic) quantile regression, another first for cultivated meat. So far, reliance on linear regression in the extant literature limits it to only providing insights for the "average" consumer, that is, one more or less neutral in terms of their *behavioral intentions* toward cultivated meat. Yet, among all the factors, only *food technology neophobia* was found to be consistently significant across all quantiles – still, the size of the parameter estimates of this factor varied substantially depending on *behavioral intentions*. As such, the scattered nature of the significance results provides several insights. First, it highlights how explanatory power can differ dramatically when it comes to behavioral intentions: whereas the model explained 43% of the variance for those rejecting cultivated meat, there is a continual decline in explanatory power as *behavioral intentions* rise. For individuals fully accepting of cultivated meat, the same factors could only explain 10% of variance. As such, the combination of *food technology neophobia*, *eating behaviors*, *preference for intuition* and *deliberation*, and the rest better clarify why people reject rather than accept cultivated meat. This partly reflects the diminishing relevance of *food technology neophobia*, and less so *meat-eating frequency*, as *behavioral intentions* become more positive (Fig. 1). For future research, it remains an open question to what extent the kinds of factors that have received the most attention in the literature (awareness, disgust, naturalness, food (technology) neophobia) (Siegrist and Hartmann 2020b; Pakseresht et al. 2022) are illustrative (unintentionally) of why individuals reject versus accept cultivated meat. As cultivated meat becomes more widely available, it will be crucial to explore how the importance of determinants can vary for different consumer segments, and in particular more emphasis to understanding those initially leaning toward accepting cultivated meat.

In addition, the (logistic) quantile regression results also demonstrate how linear regression can be misleading. Strikingly, the adjusted R-squared of linear regression, at 0.466, is higher than for any quantile, giving a distorted picture of the overall explanatory power of the model. In fact, the linear regression approach identifies six covariates (and one socio-demographic factor) as being significant for the entire population, though some covariates are significant for as few as one (*preference for deliberation*) or two quantiles (*preference for intuition*, *meat-substitute*

familiarity, *implicit attitudes*). If we aim to clarify why prospective consumers (notably those not at the extremes) are more or less likely to try or regularly purchase cultivated meat, these results suggest linear regression should be used with caution.

Furthermore, the current research adds to the list of determinants of cultivated meat acceptance by highlighting the relevance of *preferences for intuition* and *deliberation*. To our knowledge, no other study has established how thinking styles affect evaluations of cultivated meat – only Wu et al. (2020) have broadly done so for novel food technologies. We also failed to establish the significance of the *cognitive reflection test*, or *prior awareness* for that matter. In this vein, we note that Baum et al. (2021) found that need for cognition did not have a significant impact on attitudes and evaluations. Otherwise, the literature focuses on various fears, concerns related to the environment, animal welfare, and healthiness, and knowledge (Pakseresht et al. 2022). As other potential factors of interest, we also identified a significant role of *eating behaviors* for meat and/or meat substitutes, notably, for all quantiles other than those fully positive toward cultivated meat. Together with thinking styles, such behaviors provide insights into segments of consumers that are not yet (as they self-report) fully convinced about cultivated meat. Future research focusing on how individuals with such characteristics engage with novel information and novel food technologies would prove insightful.

Some limitations of the study should be considered, not least its hypothetical nature, given the current lack of commercial availability of cultivated meat. Of course, this renders such research necessary for understanding first impressions of the public and exploring the role of differently valenced images – even if the treatments in the current study turned out to have null effect. As mentioned above, it would be useful to see whether different presentations of textual and visual information differentially impact attitudes and evaluations if there is instead focus on possible risks of cultivated meat, whether on its own or together with potential benefits. We also observe that the control group in the current research was not initially intended but rather emerged due to an error in the data-collection process beyond our control – when randomized assignment to a treatment failed to occur during a follow-up wave (in May 2021). However, using chi-squared and one-way independent ANOVA tests, we could confirm that, in terms of sociodemographic factors and the covariates, the treatment groups only significantly differed by *geographic area* ($\chi^2(2) = 18.449$, $p < 0.001$): those in the control group were more likely to be from urban areas (Table A.2). We are thus confident there are quite minimal differences across treatment groups and in including the control group as part of the analysis.

To conclude, the present study demonstrates the crucial role of food technology neophobia for understanding the rejection and acceptance of cultivated meat, not to mention how the strength of its role differs for different consumer segments. Our findings thus display the need for further research into the diverse importance of food technology neophobia for attitudes and intentions of cultivated meat, especially regarding information provision. Moreover, by making first use of (logistic) quantile regression for cultivated meat, we illustrate how relevance of determinants varies in relation to the strength of behavioral intentions – as well as the potential for misleading inferences when relying on linear regression. For future research to understand why individuals are likely to accept (not simply reject) cultivated meat, greater use of quantile regression, along with an appreciation of the diversity of consumer segments, should be considered.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2023.104957.

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