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Tailored communication changes consumers' attitudes and product preferences for genetically modified food

Patrycja Sleboda *, Carl-Johan Lagerkvist

Swedish University of Agricultural Sciences, Almas Allé 8, 750 07 Uppsala, Sweden

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ABSTRACT

Despite scientific consensus, consumers' misperceptions about the risks of genetically modified (GM) food influence product rejection and the persistence of negative attitudes. Building on the mental models approach for risk communication and the Elaboration Likelihood Model for attitude change, a two-wave repeated measures randomized controlled experiment on a representative sample of Swedish consumers was used to test the effectiveness of tailored (to consumers' mental models of GM food) and persuasive (strong vs. weak) communication for attitudes and product preferences change. In wave 1 (N = 3,243) and wave 2 (N = 1,554), we measured consumers' attitudes and elicited product preferences using a discrete choice experiment. We found a positive effect of communication on attitudes and product preferences in two out of the four treatment groups, one of which initially held a negative attitude and perceived GM food as very risky.

1. Introduction

Consumer acceptance of gene technology for applications to food remains a conundrum. There is a widely held consensus among scientists that genetically modified (GM) food is as safe for human consumption as conventionally grown food (AAAS, 2012; Economidis, Cichocka, & Hoegel, 2010). Moreover, given the urgent need for climate change adaptations, the use of gene technology in food production can provide a number of environmental benefits (Phipps & Park, 2002) and play an important role in agriculture solutions for sustainable future (Abberton et al., 2016). In the discussion about the novel food production methods at the legislative level, and current high polarization over the issue, policymakers and communication specialists have to balance how to address and engage in consumers' concerns of the novel technologies in food production (Scott & Rozin, 2020; Siegrist & Hartmann, 2020). Nevertheless, extant research has reported a contention of consumer aversion to GM foods (Lusk, McFadden, & Wilson, 2018; Scott & Rozin, 2020). The negative attitudes and lack of acceptance of GM application in food are widely reported to be linked to perceptions about GM foods' high risks and low benefits (Frewer, Howard, & Shepherd, 1996; Frewer et al., 2013; Gaskell, Allum, & Stares, 2003; Magnusson & Koivisto Hursti, 2002; Royzman, Cusimano, Metas, & Leeman, 2020; Scott, Inbar, & Rozin, 2016). Scientists and communication specialists play a role in informing and changing attitudes for future acceptance of GM foods. Specifically, misperceptions about the risks and benefits can be addressed with communication that focuses on closing the knowledge gap in relation to the technology. As has been broadly reported in the literature, greater knowledge about GM food is linked to a more positive attitude (Costa-Font, Gil, & Traill, 2008; Hossain & Onyango, 2004) and greater likelihood of GM products' acceptance (Boccaletti & Moro, 2000), while opposition to GM often relates to a lack of knowledge and a high level of confidence (Fernbach, Light, Scott, Inbar, & Rozin, 2019). However, it may not be effective to only provide facts-based information while ignoring the risk of motivated reasoning triggered by existing beliefs or knowledge (Landrum and Hallman, 2017).

Previous research has tested the effectiveness of communication for attitude change, with either messages about benefits or risks of GM foods, and found either no change in attitudes (Frewer et al., 1996; Frewer, Scholderer, & Bredahl, 2003) or an unintended change toward more negative attitudes (Frewer, Howard, Hedderley, & Shepherd, 1999; Scholderer & Frewer, 2003; Valente & Chaves, 2018; Zhu & Xie, 2015). However, and as an alternative communication approach, existing research on risk communication has identified the effectiveness of the mental models approach (Morgan, Fischhoff, Bostrom, & Atman, 2002), which tailors the information to address the gap in knowledge in a targeted audience. In line with mental models approach, communication is considered to be an exchange of information, rather than proving completely new information without accounting for prior

* Corresponding author.
E-mail address: patrycja.sleboda@gmail.com (P. Sleboda).

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knowledge or beliefs (Bostrom, 2003; Bostrom, Fischhoff, & Morgan, 1992). The idea behind the mental models approach is that risk communication can change prior beliefs, attitudes, and knowledge of how things work, by revising errors, shifting importance, addressing knowledge gaps, and presenting specific information to unclear, vague, or general beliefs (Bostrom, 2003). The mental models approach has been found to be a successful communication method in the context of hazards and technologies with under- or over-rated perceived risks (Boase, White, Gaze, & Redshaw, 2017). However, to our knowledge this approach has not been previously tested in the context of GM food. Therefore, the objective of the present study is to test the effectiveness of mental models approach (Bostrom, 2003) in the GM food context when the information is designed in accordance with the Elaboration Likelihood Model (ELM) (Petty & Cacioppo, 1986) for attitude and product preferences. In particular, we then also test – conditional on prior perceptions about GM food – whether persuasive communication based on the central route in ELM is more effective than communication weak in persuasion in accordance with the peripheral route of processing within the ELM.

2. Theoretical background and research objectives

2.1. Perceived risks and benefits and consumer acceptance of GM foods

GM food products tend to evoke strong and mostly negative attitudes (Frewer et al., 1996, 2013; Gaskell et al., 2003; Magnusson & Koivisto Hursti, 2002; Scott et al., 2016). These negative attitudes towards GM foods are attributed to understandings of the risks and benefits that are different from what is scientifically accepted (De Steur, Blancquaert, Lambert, Van Der Straeten, & Gellynck, 2014). In contrast to scientific consensus, the general public overestimates the risk associated with GMO food (Sjöberg, 2008) while underestimating the potential benefits (Lusk, Mcfadden, & Rickard, 2015; Pidgeon et al., 2005). For example, Bredahl et al. (1998) interviewed European consumers to investigate the risks and benefits associated with the genetic modification attribute of yogurts and beers. For both products, Danish, German, Italian, and United Kingdom consumers associated genetic modification more with risks than with benefits. Bredahl et al. (1998) also reported that participants perceived the genetically modified products as unhealthy, with a wide range of negative consequences. Similarly, Dean and Shepherd (2007) found that consumers viewed genetically modified food as harmful, unethical, and unnatural.

Prior research has addressed whether and how subjective risks and benefits predict attitudes towards GM foods (Moon & Balasubramanian, 2001, 2004; Siegrist, 2000; Sjöberg, 2008). Frewer and Shepherd (1995) and Sparks, Shepherd and Frewer (1994) reported that perceived risks are the best predictors of consumers' attitudes. Similarly, Moon & Balasubramanian (2001, 2004) argued that perceived risks predict attitudes better than benefits do. On the other hand, Bredahl (2001) found that perceptions of both the risks and benefits of GM food were strongly embedded in the attitudes of UK consumers. Sjoberg (2008) also reported that perceived benefits were as predictive of GM attitudes as perceived risks. Some research suggests that low (or lack of) perception of benefits is a predictor of GM opposition. Gaskell et al. (2004) claimed that consumers' perception or rejection of GM foods is related only to a lack of perceived benefits, regardless of the associated risks.

Since attitudes mirror consumers' acceptance and willingness to buy (Kahneman & Ritov, 1994), research also examined the role of perceptions of both risks and benefits in acceptance of GM foods (Siegrist, 2000; Sjöberg, 2008). A recent meta-analysis on that topic (Bearth & Siegrist, 2016) showed that it is unclear whether risks or benefits are more influential in acceptance of food technologies.

The widely held misperception of risks and benefits constitutes a major obstacle to efforts to change consumers' attitudes toward biotechnology in food production (Lähteenmäki et al., 2002), which could lead to technology rejection all together (Bredahl, 2001). Indeed, previous research shows a low willingness to buy GM food. Grunert et al. (2004) noted that consumers' resistance to attitude change alters their preferences for GM foods. Only a few relatively recent studies have reported effectiveness in making attitudes about GMO more positive. However, these studies used different methods, such as persuasive refutation texts (Heddy, Danielson, Sinatra, & Graham, 2017; Thacker et al., 2020).

2.2. Attitude change through persuasion – The elaboration likelihood model

By their nature, strong attitudes are difficult to change (Petty, Wegener, & Leandre, 1997). The Elaboration Likelihood Model, proposed by Petty and Cacioppo (1986), provides a lens through which attitude change can be examined by employing the dual process model approach of persuasive messages. Specifically, the ELM emphasizes two routes of persuasion: a central route, which involves a high level of cognition and the careful analysis of presented message; and a peripheral route, which relies on general impressions, related to positive and negative cues, based on heuristics, unrelated to logical reasoning. The central route of persuasion relies on strong arguments, more informative messages, and high involvement in the content of persuasive matters. Studies have shown that the interplay between the content of a persuasive message (strong vs. weak arguments) and a recipient's attitude baseline is an important determinant of effective persuasion (Edwards, 1990; Mayer & Tormala, 2010; See, Petty, & Fabrigar, 2008). For example, Haughtvedt, Petty, and Cacioppo (1992) found that strong argument messages led to more favorable attitudes being formulated. Messages that present more arguments are more likely to be persuasive than messages with fewer arguments (Petty & Cacioppo, 1984; Silvera, Josephs, & Giesler, 2002).

Attitude change through the central route is abiding and resistant, lasts longer, is a better predictor of behavior (Ajzen, Brown, & Rosenthal, 1996; Petty & Cacioppo, 1986), and is more resistant to further change (Tenny, Brinol, & Petty, 2017). As emphasized within the ELM framework, elaboration through the central route is more likely if motivation is high. Motivation refers to the willingness to engage in information processing: the greater the involvement in topic information, such as controversial topics, the greater the likelihood of the central route information processing.

In the context of genetic engineering of food, Frewer et al. (1999) applied the ELM in order to test effect of different types of information on attitude change, but they found negative effects on attitude. In other words, Frewer et al. (1999) found that the designing persuasive communication allowed change in attitudes to become less favorable.

2.3. Mental models approach for risk communication

Research on communication revealed that people interpret new information by considering their existing beliefs while referring to their "mental models" (Chi, 2000; Gentner & Stevens, 1983; Meyer, Leventhal, & Gutmann, 1985). Here, following Bostrom et al. (1992), we refer to mental models as an individual's perception of an object of judgement, decision situations, alternative solutions, or decision premises.

The mental models approach (Bostrom et al., 1992; Bruine De Bruin & Bostrom, 2013; Morgan et al., 2002) emphasizes four steps for effective communication. First, based on experts' research and knowledge, communication designers need to establish information that needs to be presented to the general public. In the second step, people's knowledge, beliefs, and attitudes on that specific matter needs to be identified. Following that, in the third step, communication must be designed in a way that addresses Steps 1 and 2; that is, to compare what needs to be informed with the beliefs and attitudes of the matter among the recipients. Thus, communication needs to be tailored to the receivers' mental models. In the last step, the designed communication needs to be tested for its effectiveness. The mental models approach has

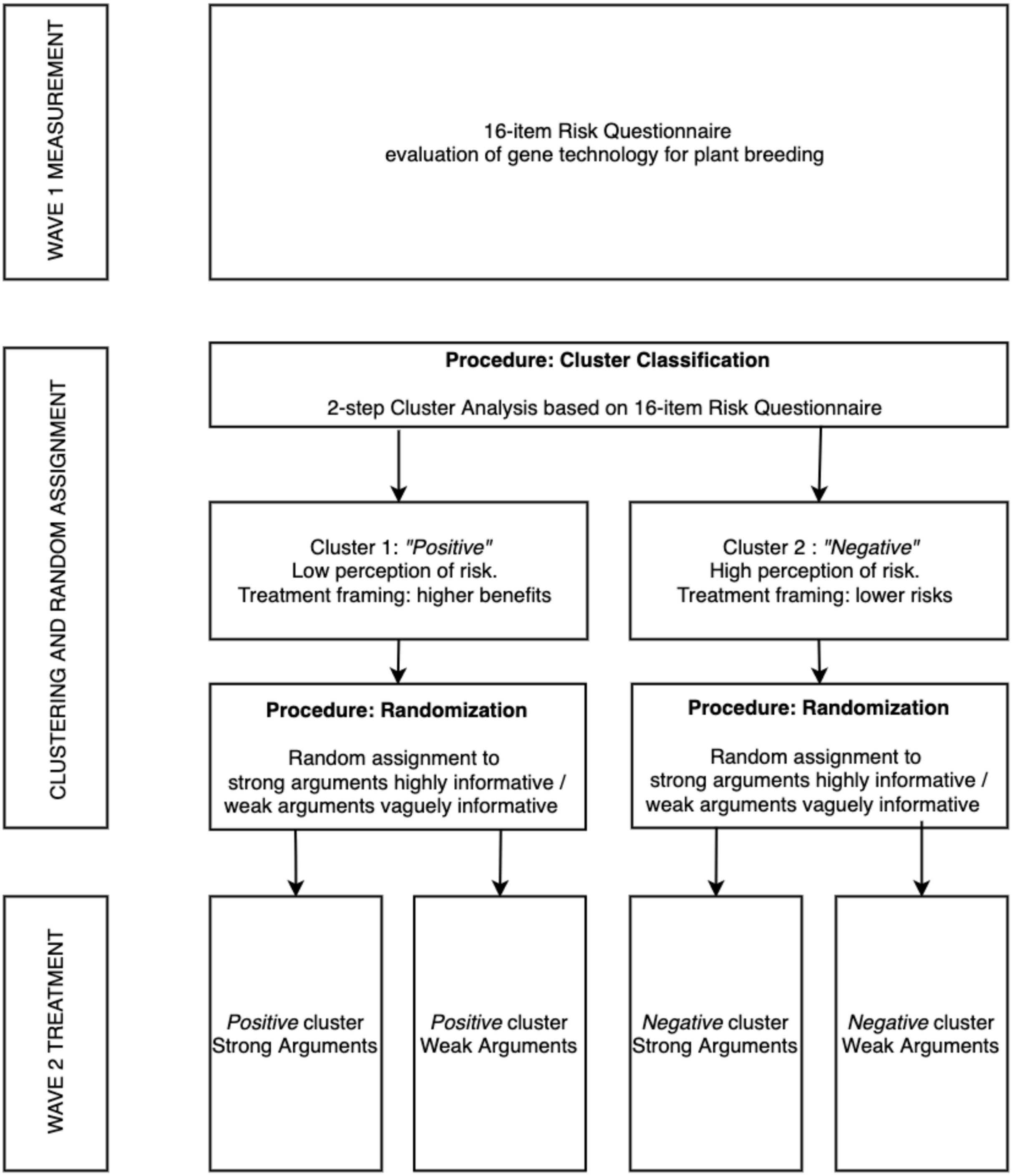

Fig. 1. Two-phase study design for the for the treatment groups. Note: *Positive cluster* refers to the group that emerged from the cluster analysis holding positive perception of gene technology for plant breeding; *negative cluster* refers to the group that emerged from the cluster analysis holding negative perception of gene technology for plant breeding; *Strong arguments* and *weak arguments* refer to strength of persuasion.

been successfully applied in risk communication (Morgan, Fischhoff, Bostrom, & Atman, 2001; Wong-Parodi & Bruine de Bruin, 2017), including health (Kreuter & Wray, 2003) and environmental (Lazrus, Morss, Demuth, Lazo, & Bostrom, 2016; Morss, Demuth, Bostrom, Lazo, & Lazrus, 2015; Morss, Mulder, Lazo, & Demuth, 2016) contexts. Although some scholars have argued that a mental models approach is a potentially effective methodological approach for exploring risk communication in GM foods (Siegrist, 2008; Visschers & Siegrist, 2018), to our knowledge no attempts have been made in that direction.

2.4. Objectives

Given recent developments in genome editing and other applications of biotechnology in sustainable agriculture, it is relevant to address the issue of misperception about risks and benefits, as well as consumers' rejection of genetically modified food in relation to attitudes and product preferences. Although we recognize that other methodologies are used to address misperception and/or knowledge deficits about GM with the aim of directing attitude change (Ruth & Rumble, 2017; Thacker et al., 2020; Yuan, Ma, & Besley, 2019), the present study aimed to examine the effect of tailored communication for GM food within a joint framework of the mental models approach and the ELM.

Specifically, in order to address the misperception of GM food's risks, we tailor information about a novel potato variety, where GM has the potential to provide a range of direct (health) and indirect environmental benefits to the pre-existing level of perceptions of risks and benefits of GM food (mental models approach), while applying the principles of the ELM for persuasive communication. Since general attitudes were found to be the most important predictor of product preferences in a broad range of choices (Kahneman, Ritov, & Schkade, 1999), as well as in the context of GM foods (Bredahl, 2001; Cook, Kerr, & Moore, 2002), we then examined the effect of tailored communication on changing attitudes as well as on product preferences for GM food.

Therefore, we hypothesize that:

H1: Tailored communication with strong arguments will change attitudes towards gene technology for plant breeding to more favorable.

H2: Tailored communication with strong arguments will increase preferences for GM products.

H3: Strong arguments will be more effective than weak arguments at changing attitudes and product preferences.

3. Materials and methods

3.1. Participants

The study was carried out as a longitudinal (with two repeated measurements) internet survey in May 2018 (after initial pre-testing) based on a convenience sample of 3,243 individuals recruited by a market research company in Sweden. An invitation for the second wave was sent to the respondents from Wave 1 after 7–10 days. In total, 1,554 respondents completed both waves and the following analysis includes only those respondents who completed both waves. The sample consisted of 52.6 percent women (49.8 percent of the Swedish population overall is female; (SCB, 2017)). The mean age was 43.56 (SD = 13.5, ranging from 15 to 73) and had a higher percentage of respondents aged 25–54 than the Swedish population overall (65.5 percent versus 47.7 percent). The group aged 15–24 was slightly underrepresented (7.9 percent versus 13.70 percent), with a slight overrepresentation of the 55–64 age group (21.9 percent versus 14.02 percent). The gender proportions among the age groups were similar in the 55–64 age group (51.2 percent of females in our sample compared to 50 percent in the Swedish population as a whole), as well as in the 25–54 age group (51.1 percent vs. 49.2 percent). Women were overrepresented in the 15–24 age group (76.4 percent vs. 48.4 percent). We took no further action to weigh these differences in our statistical analysis, as they were very small. Informed consent was obtained for every participant in the study. Participants were informed that they could opt out of the study at any point.

3.2. Study design

The study was based on a within-subjects design where 84 percent of the participants from Wave 1 (N = 3,243) were randomly assigned to receive the communication treatment, while 16 percent were assigned to a control group. The control group was not presented with any communication treatment. For the treatment group, a two-phase process was then applied to further assign participants into one of four treatment conditions: framing (higher benefits vs. lower risks) × persuasion (high vs. low). Classification into framing groups (Phase 1: cluster classification) was based on the participants' mental models: participants with a high perception of risk were assigned to lower risks of GM frames, while those with a low perception of GM risks were assigned to higher benefits frames. Persuasion strength was randomly assigned in Phase 2; for details, see the section on *Risk questionnaire: cluster classification*.

Repeated measures (baseline – pre-treatment and posttreatment) were taken on the two dependent variables: (1) attitude towards gene technology for plant breeding and (2) product preferences towards GM potatoes. Research on gene editing has made a potato variety available for market introduction, so we chose an existing GM potato to study in the choice experiment. As potatoes are the most common non-cereal food consumed worldwide (Zaheer & Akhtar, 2016), and play a significant role in the daily Swedish diet, research about the consumer acceptance of GM potatoes can have profound implications for market introduction of the product. Fig. 1 illustrates the two-phase process for forming the treatment groups of the study: first phase (cluster classification) and second phase (randomization).

3.2.1. Designing communication for wave 2

Experts specializing in plant breeding from the Swedish University of Agricultural Sciences helped develop five messages related to human health and environmental impacts of the genetically modified potato (see supplementary material). Each message was then aligned with the framing and persuasion route according to the experimental design and then presented in random order to respondents after a short introduction. Informative strong messages within the central route aimed to emphasize either greater benefits or lower risks, providing specific information about how exactly these specific characteristics of GM potato make it more beneficial (less risky). The messages for the weak arguments within the peripheral route were designed in the same vein of message framing, except that the message did not explain the mechanism or provide the specific reasons for higher benefits or lower danger.

3.3. Measurements

3.3.1. Risk questionnaire

In Wave 1, in order to identify participants' mental models of gene technology for plant breeding, the 16-item risk questionnaire (Savadori et al., 2004) was used. This is a psychometric paradigm-based (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978) risk questionnaire that, in line with the psychometric paradigm, assumes risk to be a psychological determinant and examines perceptions of a technology or activity, here gene technology for plant breeding, in relation to both global and dimensional evaluations. This measure was previously applied in research that examined risk perception of biotechnology in food application (Savadori et al., 2004). To validate the structure of the risk questionnaire adopted from Savadori et al. (2004), we ran principal components factor analyses (PCA) on a 3,228 (subjects) × 16 (dimensions) matrix. The number of factors to be extracted was not constrained. The PCA results revealed a two-factor solution for gene technology for plant breeding accounting for 59.7 percent of the total variance. For the factor loadings resulting after the Varimax rotation, please see the supplementary material (Table S1).

Participants were asked about 16 items related to risks, dread, severity of consequences, benefits, and others in relation to gene technology for plant breeding. The evaluations were used for clustering into treatment conditions. Participants were presented with the Swedish translation of the questionnaire and were asked to rate each hazard on a scale from 0 to 11 (Savadori et al., 2004).

3.3.2. Attitude measure

Recent *meta*-analyses on the validity of multi vs. single construct of attitude measure revealed no differences in validity (Ang & Eisend, 2018; Bergkvist & Rossiter, 2007); thus, a scale for the attitude construct consists of one item assessing overall gene technology evaluation on a scale from 0 to 100, anchored by 'very negative' and 'very positive'. The same measure of attitude was applied in both waves. The mean pre-treatment attitude (baseline) for the entire sample was M = 41.25 (SD = 28.24), and for post-treatment attitude it was M = 43.26 (SD = 29.21).

3.3.3. Choice experiment

A discrete choice experiment (CE) was conducted in both waves (the same design for both waves) to examine preferences for GM potatoes.

This CE allowed us to examine: (a) the stability of preferences (that is, the extent to which preferences are influenced by the communication treatment), and (b) the extent to which the communication treatment generates changes in the relative importance of attributes and levels (that is, complementarity or substitution effects).

Seven attributes were selected to describe potatoes (see Table 1). The gene technology attribute had four levels, one of which excluded gene modification in potato plant breeding, which then served as rejection of the GM potato. The three remaining attributes were chosen to represent possible application of gene modification in potato breeding (see Table 1). The 'type' and 'washed/not washed' attributes were added to provide attributes that were available in a real-life shopping situation. The vector of the price attribute was set to provide a range of prices of potatoes on the Swedish food retail market.

Respondents were presented with 12 choice sets, each of which included three unlabeled alternative potato packages (1 kg) with the ordering of attributes not altered to minimize effects of fatigue and choice complexity. In the design, the levels of the pesticide, fertilizer, and carbohydrates attributes were set to match the level of the GM attribute, respectively. Moreover, rather than including an opt-out alternative, there was always one alternative, with the GM levels set for "no gene modification", for which the other attributes varied according to the design. This choice alternative represents a feasible alternative with which consumers would be familiar.

3.3.4. *Need for cognition*

In order to account for individual differences in the tendency to engage in elaborative cognitions across experimental treatments, all respondents completed the Need for Cognition (NFC) scale (Cacioppo & Petty, 1982). Specifically, in line with ELM, those who are high in NFC engage in elaboration more, and could therefore be more likely to change their attitudes when presented with strong argument communication. Thus, to control if there were individual differences in cognitive elaborative engagement among treatment groups, the NFC scale was used. The Swedish adaptation and validation published by Dornic and collaborators (1991) was used (for recent validation, see Jonsson, Stenlund and Johnsson (2017)). The scale consists of 30 items on a five-point Likert-like scale (1 = strongly disagree, 3 = neutral, and 5 = strongly agree). Twelve of the statements are designed to indicate positive attitudes toward engaging and enjoying thinking, whereas 18 indicate negative attitudes. Therefore, items that indicated negative attitudes required reverse scoring in order to conclude that high scores indicate a high NFC.

4. Data analysis

4.1. *Risk questionnaire: Cluster classification*

A two-step cluster analysis was conducted with the 16-item risk questions to identify existing clusters of participants that differ on their risk–benefit perception of genetic modification. In the first step, original cases were grouped into pre-clusters by constructing a cluster features tree with the aid of Schwarz's Bayesian Criterion (BIC) statistics. In the second step, the standard hierarchical clustering algorithm on the pre-clusters was used (Norusis, 2011) with a forced maximum of four clusters. This procedure identified two clusters (Norusis, 2011). The items in the Table 2 are presented in order of importance for the cluster classification. As can be seen in Table 2, the classification was based on risk and harm items; thus, the clusters differed in their risk/harm perception of gene technology. The items that differed the most between the identified clusters related to harm to humans, harm to environment, risk to future generations, severity of negative consequences, and dread. Participants in Cluster 1 (67.3 percent) judged gene technology as less dreadful, less harmful, and less risky than participants within Cluster 2 did. Therefore, the Cluster 1 group was named the *positive* cluster. The Cluster 2 group perceived higher risks and harms related to gene technology for plant breeding and was therefore called the *negative* cluster.

In line with the mental models approach for effective commutation in the communication treatment, we tailored the communication by matching the frames to the baseline measure of risk–benefit perception of gene technology. Thus, the *positive* cluster was assigned into a *higher-benefits* frame treatment. The *negative* cluster perceived high risks and harms related to gene technology. In order to change their perception of gene technology more favorable and apply the mental models approach framework, this cluster was assigned to a *lower-risk* treatment frame. That is, both clusters received the same facts, which were either framed as high-benefit potatoes or not as dangerous or risky to eat.

4.2. *Choice experiment data analysis: Preferences and attributes importance*

We implemented a hierarchical Bayes (HB) approach (Huber & Train, 2001; Train, 2001; Train & McFadden, 2002) with 10,000 iterations for convergence and an additional 10,000 iterations for computing individual specific preference parameters (that is, posterior estimates of part-worth utilities for both waves of the Discrete Choice Experiments using CBCHB v.5.0.4 ("Sawtooth Software," 2003). HB modeling uses Markov Chain Monte Carlo simulations to specify the posteriors based on the population distribution at the upper level of the HB model (Danthurebandara, Yu, & Vandebroek, 2015).

We then used individual part-worth utilities to compute individual specific attribute importance. Attribute importance is ratio-scaled data that allows comparisons within and between individuals of the relative importance of attributes. For each attribute, we calculated the individual attribute importance scores as the ratio between: (a) the highest and lowest part-worth utility per attribute (that is, over levels of each attribute) and (b) the sum of attribute utility ranges across all attributes. Averages of individual attributes' importance were used when summarizing the attribute importance for each group of respondents.

5. Results

5.1. *Need for Cognition*

The mean score of the 30-item scale was 107.93 (SD = 18.28), with scores ranging from 64 to 150 (Skewness = 0.23, Kurtosis = -0.95). This corroborates results from previous studies (Dornic et al., 1991). Cronbach's alpha coefficient was $\alpha = 0.92$.

An independent samples non-parametric test for *k* independent samples (Kruskal-Wallis test) was conducted to check for differences in NFC scores among the treatment and control groups. No significant differences were found ($p = 0.41$), which implies that the further results could not be explained by difference among groups in engagement in elaborative information processing.

5.2. *Manipulation check*

As expected, participants from the two treatment groups (*positive* strong and *negative* strong) who were assigned to strong arguments informative treatment overall perceived the presented message as highly informative (M = 8.21; SD = 2.26; N = 628). Furthermore, we examined whether there were differences in involvement due to Need for Cognition (NFC). Using 1 SD below/above the average NFC score, we tested for the differences between high NFC and low NFC and found statistically significant differences ($F(1,234) = 4.57$; $p = 0.03$; $\eta 2 = 0.02$). In particular, respondents who were lower in NFC found the message less informative (M = 8.06; SD = 2.40; N = 104) than respondents who were higher in NFC (M = 8.72; SD = 2.31; N = 131).

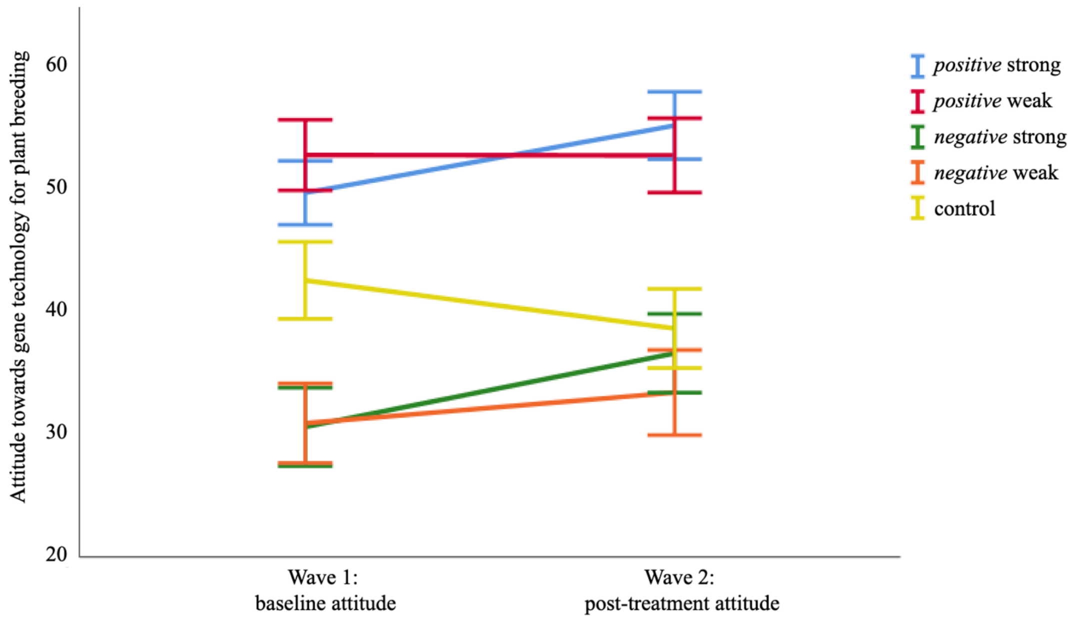

Fig. 2. Baseline and post-treatment attitudes across groups. Note: Error bars 95% Cl; *positive* refers to the group that emerged from the cluster analysis holding positive perception of gene technology for plant breeding; *negative* refers to the group that emerged from the cluster analysis holding negative perception of gene technology for plant breeding; *strong* refers to strength of persuasion – strong arguments; *weak* refers to strength of persuasion – weak arguments.

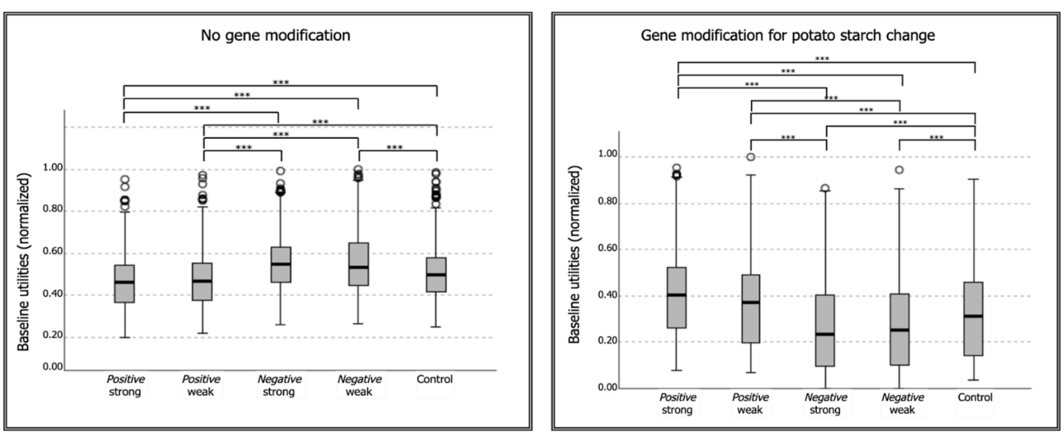

Fig. 3. Part-worth utilities (normalized) per attribute at baseline. No gene modification attribute level on the left-hand side and gene modification for potato starch change attribute level on the right-hand side. Note: *Positive* refers to the group that emerged from the cluster analysis holding positive perception of gene technology for plant breeding; *negative* refers to the group that emerged from the cluster analysis holding negative perception of gene technology for plant breeding; *strong* refers to strength of persuasion – strong arguments; *weak* refers to strength of persuasion – weak arguments.

5.3. *Attitude*

5.3.1. *Baseline*

As Phase 1 of the treatment classification (cluster analysis) was conducted based on the 16-item risk questionnaire, we examined whether the groups derived from the cluster analysis differed in their attitudes (ANOVA test between subject $F(4,1549) = 45.37$; $p < 0.001$; $\eta 2 = 0.105$). As predicted, Table 3 shows significant differences for the mean value of baseline attitudes between *positive* and *negative* clusters. In line with our expectations, the ANOVA post hoc analysis revealed no differences within the two clusters: participants who were randomly assigned to strong arguments did not differ in their base-level attitudes from those randomly assigned to weak arguments. As for the control group, the initial attitude significantly differed from all the rest of the groups, as expected. (Note that the control group consisted of randomly assigned participants, which we expected to have both negative and positive perception of GT; thus it was expected that this group would differ from the treatment groups.)

5.3.2. *Attitude change: Baseline and post-treatment measure*

A mixed model ANOVA for repeated measures (pre- and post-treatment attitudes, respectively) was used to examine support for attitude change between the study groups (treatment groups and control group). There was a significant difference between baseline/pre-treatment and post-treatment attitude measure ($F(1,1549) = 8.48$; $p < 0.005$; $\eta 2 = 0.005$) and significant differences between groups ($F(4, 1549) = 53.50$, $p < 0.001$; $\eta 2 = 0.121$). The interaction between attitude change and treatment groups was also found to be significant ($F(4,1549) = 7.10$, $p < 0.001$; $\eta 2 = 0.018$).

Table 4 and Fig. 2 shows that the mean attitude scores increased for the two treatment groups, with strong arguments informative treatment among both the *negative* and *positive* clusters. No significant changes were observed for the study groups receiving weak arguments, irrespective of whether the communication was framed as *positive* or

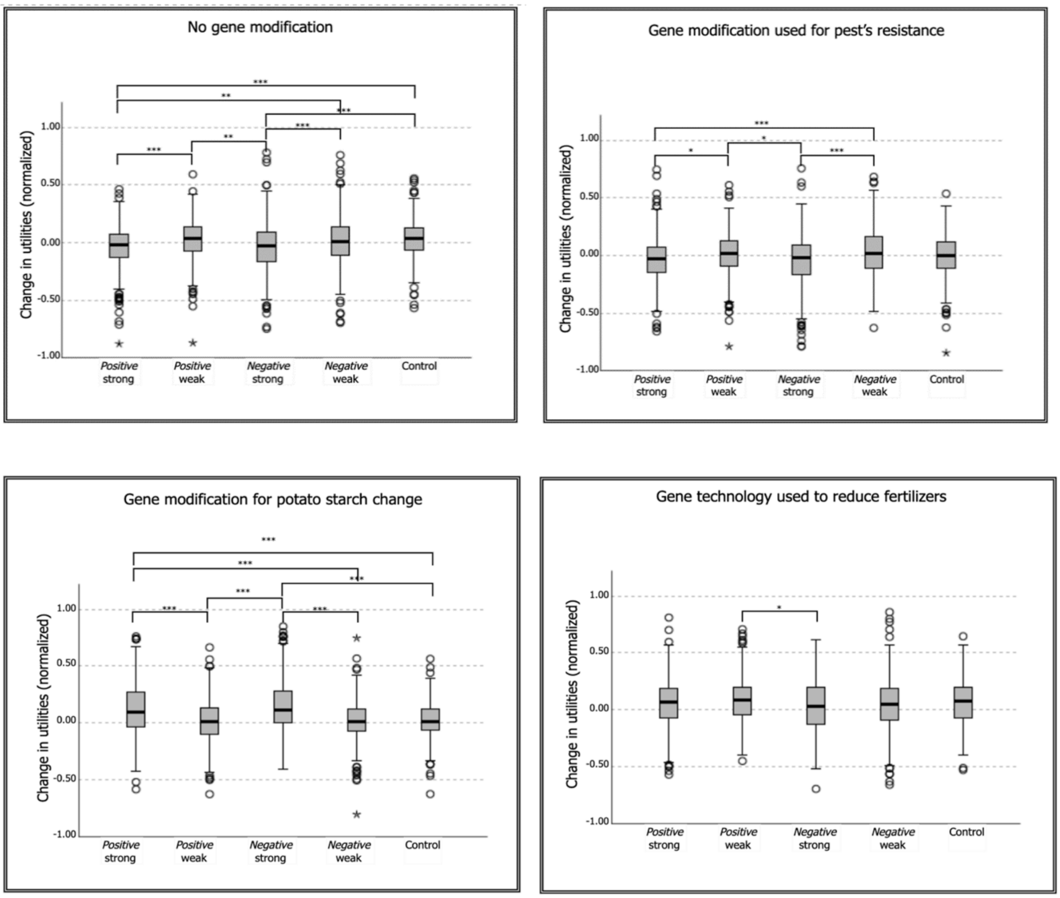

Fig. 4. Difference in part-worth utilities (normalized) per GM attribute between post-treatment and baseline utilities (normalized). (Upper left) No gene modification attribute level; (upper right) gene modification used for pest's resistance attribute level; (lower left) gene modification for potato starch change attribute level; (lower right) gene modification used to reduce fertilizer's attribute level. Note: *Positive* refers to the group that emerged from cluster analysis and holds a positive perception of gene technology for plant breeding; *negative* refers to the group that emerged from cluster analysis and holds a negative perception of gene technology for plant breeding; *strong* indicates persuasion with strong arguments; *weak* indicates persuasion with weak arguments.

Table 1
Choice attributes levels.

Attributes	Attributes' levels
Genetic modification	No gene modification
	Used for resistance to plant diseases and pests
	Used to reduce fertilization and negative environmental effects
	Used to change of potato starch type (carbohydrates) for health benefits
Pesticides	No pesticide used
	Pesticides used against diseases and pests
Type of fertilizers	Chemical fertilizers
	Organic fertilizers
Type of carbohydrates	Faster carbs (higher GI index)
	Slower carbs (lower GI index)
Type of texture	Soft
	Hard
Washed	Washed
	Not washed
Price[a]	6.90 SEK/kg
	8.50 SEK/kg
	9.90 SEK/kg
	11.50 SEK/kg
	12.90 SEK/kg

Note: [a] At the time of the study 1 SEK = 0.11 USD.

negative. A negative change – that is, change for a less favorable attitude – was observed among the control group. Note that the control group did not receive any communication treatment between waves; thus, this finding emphasizes the relative effect of a treatment vs. control group.

5.4. Product preferences

5.4.1. Baseline

Next, we examined whether there were pre-treatment differences in baseline attribute preferences for the levels related to gene technology for plant breeding. To do this, utility part-worths of the levels for the gene modification attribute were normalized (min–max) for a comparison. Utilities were normalized to values between 0 and 1, with 1 representing the highest part-worth utility. For each of the four levels of the gene modification attribute, statistical differences among the groups were compared using a non-parametric test; that is, the Kruskal– Wallis test. Significant differences were found among the study groups for two levels of the gene modification attribute: the "no gene modification" ($p < 0.001$) and "gene modification for potato starch change" ($p < 0.001$), but not for "gene modification used for pest's resistance" ($p = 0.711$) or for "gene technology used to reduce fertilizers" ($p = 0.362$). The pairwise two-tailed Mann–Whitney U tests for the "no gene modification" and "gene modification for potato starch change" confirmed that the *negative* cluster groups differed from *positive* cluster groups on both attributes. However, and as expected, no differences were found between those assigned to either strong or weak arguments within clusters; see Fig. 3. There was no evidence of differences for the other two levels of the gene modification attribute "gene modification used for pest's resistance" ($p = 0.711$) and "gene technology used to reduce fertilizers" ($p = 0.362$).

Table 2
Two-Step Cluster analysis for the 16-item risk questionnaire – perception of gene technology for plant breeding.

Item	Cluster 1 (*positive*)		Cluster 2 (*negative*)	
	Wave 1 (N = 1,736)	Wave 2 (N = 633)	Wave 1 (N = 988)	Wave 2 (N = 612)
Dread (1.00)	4.60	4.45	8.67	8.74
Harm to environment (1.00)	5.09	5.06	8.48	8.55
Harm to humans (1.00)	4.89	4.74	8.27	8.34
Risk to future generations (1.00)	5.32	5.28	8.87	8.99
Severity of negative consequences (1.00)	5.13	5.13	8.48	8.51
Collective exposure to risk (0.80)	5.63	5.71	8.45	8.59
Personal exposure to risk (0.60)	4.82	4.76	6.88	6.76
Personal knowledge about risk (0.60)	4.26	4.01	6.32	6.14
New: is it a new or an old and familiar risk? (0.60)	5.61	5.58	7.63	7.69
Observability of damage (0.40)	5.23	5.11	6.78	6.76
Scientific knowledge of risk (0.40)	5.66	5.74	7.13	7.00
Voluntary extent exposure to risk (0.00)	4.98	4.88	5.46	5.28
Risk acceptability (0.00)	5.80	5.94	5.39	5.16
Benefits for the environment (0.00)	5.69	5.67	5.39	5.09
Benefits for human (0.00)	6.53	6.76	6.72	6.52
Personal benefits (0.00)	5.42	5.42	5.50	5.25

Note: Means for each item by cluster; the number in parentheses after each item represents the importance of the variable in cluster formation. This is between 1.0 and 0.0. The closer to 1.0, the more important it is (SPSS Inc. 2001).

*Note: Kruskal-Wallis (omnibus) and pairwise Mann-Whitney U tests. Statistical significance denoted as: *** $p < 0.001$; **$p < 0.01$; *$p < 0.05$*

5.4.2. Product preferences change: Baseline and post treatment measure of preferences for GM product

To test the effect of communication treatment within the study groups on the product preferences, we calculated the differences between posttreatment and pretreatment of normalized part-worth utilities for the "gene modification" attributes' levels. To address this issue, a non-parametric Kruskal-Wallis test was applied for *K* number of samples. There was evidence of significant omnibus differences for change in utilities in the "no gene modification" ($p < 0.001$), "gene modification for potato starch change" ($p < 0.001$), "gene technology used for pests' resistance" ($p < 0.001$), and "gene technology used to reduce fertilizers" attribute levels ($p = 0.042$). Furthermore, as shown in Fig. 4, the pairwise two-tailed Mann-Whitney U tests revealed differences within clusters; that is, *positive* strong and *positive* weak significantly differed from each other in utility change on all attributes levels, except for "GM used to reduce fertilizers". Similarly, *negative* strong and *negative* weak differed in utility change for the same three attributes and no such differences were found for "GM to reduce fertilizers". Interestingly, no differences in change of utilities were observed between the *positive* strong and *negative* strong groups.

*Note: Kruskal-Wallis (omnibus) and pairwise Mann-Whitney U tests. Statistical significance denoted as: *** $p < 0.001$; **$p < 0.01$; *$p < 0.05$*

5.5. Product attribute importance: Baseline and post-treatment

Table 5 shows the means for attributes' importance for each group at the baseline and at post-treatment. Across all treatment groups, gene modification was the most important attribute, and this importance was the highest for the negative cluster. On the other hand, the price attribute was the second-most important attribute across all groups, but with a higher level of importance for the positive cluster. Wilcoxon Signed-Ranks tests were then conducted to test for significant differences between waves within each of the treatment groups. A Bonferroni

Table 4
Pairwise comparisons of attitude mean differences in Wave 1 and Wave 2.

Group	Difference in Attitude Means	Std. Error	95% CI for Difference	
Positive - strong	**5.44*** **	1.51	2.48	8.39
Positive - weak	−0.03	1.52	−3.02	2.96
Negative - strong	**5.95*** **	1.54	2.93	8.97
Negative - weak	2.48	1.54	−0.54	5.50
Control	**−3.88***	1.53	−6.89	−0.88

***$p < 0.001$, **$p < 0.01$; *$p < 0.05$.
Note: *Positive* refers to the group that emerged from the cluster analysis holding positive perception of gene technology for plant breeding; *negative* refers to the group that emerged from the cluster analysis holding negative perception of gene technology for plant breeding; *strong* refers to strength of persuasion – strong arguments; *weak* refers to strength of persuasion – weak arguments.

Table 3
Post hoc LSC test for group comparisons of pre-treatment attitudes means.

Attitude:		Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Positive strong						
	Control	7.08	2.134	0.001	2.89	11.26
	Negative - strong	18.91	2.139	<0.001	14.72	23.11
	Positive - weak	−3.05	2.127	0.151	−7.23	1.12
	Negative - weak	18.62	2.139	<0.001	14.42	22.82
Positive weak	Control	10.13	2.146	<0.001	5.92	14.34
	Positive - strong	3.05	2.127	0.151	−1.12	7.23
	Negative - strong	21.97	2.151	<0.001	17.75	26.19
	Negative - weak	21.68	2.151	<0.001	17.46	25.89
Negative strong	Control	−11.84	2.158	<0.001	−16.07	−7.61
	Positive - strong	−18.91	2.139	<0.001	−23.11	−14.72
	Positive - weak	−21.97	2.151	<0.001	−26.19	−17.75
	Negative - weak	−0.29	2.163	0.892	−4.54	3.95
Negative weak	Control	−11.55	2.158	<0.001	−15.78	−7.31
	Positive - strong	−18.62	2.139	<0.001	−22.82	−14.42
	Negative - strong	0.29	2.163	0.892	−3.95	4.54
	Positive - weak	−21.68	2.151	<0.001	−25.89	−17.46

Note: *Positive* refers to the group that emerged from the cluster analysis holding positive perception of gene technology for plant breeding; *negative* refers to the group that emerged from the cluster analysis holding negative perception of gene technology for plant breeding; *strong* refers to strength of persuasion – strong arguments; *weak* refer to strength of persuasion – weak arguments.

Table 5
Baseline and post-treatment means for attributes importance by treatment groups.

Attribute Treatment	Genetic modification		Type of texture		Washed/not washed		Price	
	wave 1	wave 2	wave 1	wave 2	wave 1	wave 2	wave 1	wave 2
Positive strong	0.51	0.49	0.15	0.12	0.05	0.05	0.29	0.34
Positive weak	0.51	0.46	0.15	0.15	0.05	0.05	0.28	0.34
Negative strong	0.60	0.57	0.12	0.12	0.05	0.05	0.22	0.25
Negative weak	0.63	0.57	0.11	0.11	0.05	0.06	0.21	0.25
Control	0.55	0.49	0.13	0.15	0.05	0.05	0.26	0.31

Note: Each attribute importance is between 0 and 1 with the sum across each attribute equal to 1.
Positive refers to the group that emerged from cluster analysis and holds a positive perception of gene technology for plant breeding; *negative* refers to the group that emerged from cluster analysis and holds a negative perception of gene technology for plant breeding; *strong* indicates persuasion with strong arguments; *weak* indicates persuasion with weak arguments.

Table 6
Wilcoxon's Signed Ranks Tests for differences in attributes importance between waves within each study group.

Group	Attribute	Test statistics (Z)	2-tailed p-value	Hodges-Lehman Estimate (95% CI)
Positive strong	Genetic modification	−1.22	0.223	−0.016 (-0.041, 0.010)
	Type of texture	**−4.00**	**<0.001**	**−0.025 (-0.037, −0.013)**
	Washed/not washed	**−2.41**	**0.016**	**−0.006 (-0.011, −0.001)**
	Price	**3.90**	**<0.001**	**0.045 (0.023, 0.068)**
Positive weak	**Genetic modification**	**−3.46**	**0.001**	**−0.045 (-0.071, −0.020)**
	Type of texture	−1.00	0.317	−0.007 (-0.020, 0.006)
	Washed/not washed	−1.50	0.134	−0.004 (-0.0009, 0.001)
	Price	**4.31**	**<0.001**	**0.052 (0.029, 0.075)**
Negative strong	**Genetic modification**	**−2.67**	**0.008**	**−0.034 (-0.059, −0.009)**
	Type of texture	0.41	0.685	0.003 (-0.011, 0.016)
	Washed/not washed	−0.37	0.714	−0.001 (-0.007, 0.005)
	Price	1.88	0.059	0.021 (-0.001, 0.043)
Negative weak	**Genetic modification**	**−3.44**	**0.001**	**−0.045 (-0.071, −0.019)**
	Type of texture	0.56	0.576	0.003 (-0.008, 0.015)
	Washed/not washed	−0.73	0.465	−0.002 (-0.008, 0.004)
	Price	**3.00**	**0.003**	**0.034 (0.012, 0.056)**
Control	**Genetic modification**	**−5.53**	**<0.001**	**−0.063 (-0.085, −0.041)**
	Type of texture	1.86	0.062	0.012 (-0.001, 0.025)
	Washed/not washed	−0.41	0.681	−0.001 (-0.007, 0.004)
	Price	**4.22**	**<0.001**	**0.044 (0.024, 0.065)**

Note: *Positive* refers to the group that emerged from the cluster analysis and holds a positive perception of gene technology for plant breeding; *negative* refers to the group that emerged from cluster analysis and holds a negative perception of gene technology for plant breeding; *strong* indicates persuasion with strong arguments; *weak* indicates persuasion with weak arguments.

correction was applied to control for Type I errors across these comparisons. The results, presented in Table 6, confirm significant differences in attribute importance between waves for genetic modifications and price attributes for all groups, except for the *positive*-strong group, which suggests that gene modification becomes less important and price becomes more important. For the *positive*-strong group, there was instead evidence that texture as well as washing became less important and price became more important.

6. Discussion and conclusion

This study tested a communication approach for attitude change and acceptance of GM food. In a joint framework of the mental models approach and the Elaboration Likelihood Model, we examined the effect of communication tailored to perceptions of risks and benefits of GM for attitudes and product preferences change against the pre-existing baseline. This study makes several contributions.

First, after controlling that the results could not be explained by individual differences in engagement in elaborative information processing, the key finding was that attitude change, as induced by communication with strong arguments tailored to the pre-existing perceptions of risk and benefits if GM-food, was observed both among individuals who initially held more favorable (*positive*) views, and more importantly, among those who, at the baseline, were strongly against (*negative* towards) gene-technology. Hence, our results provide implications for practitioners in risk management and communication in relation to novel food product technologies. Consumers' pre-existing perceptions of risks and benefits of product technology hazards may spur extreme attitudes that are difficult to change later. However, by adapting the communication design to pre-existing perceptions among end-users with insights from the mental models approach, there is potential to overcome the inertia regarding the effectiveness of information for attitude change for GM food that has been reported in extant literature (for example, Frewer et al., 1996; Frewer et al., 1999; Scholderer & Frewer, 2003). Moreover, it is important to highlight the role of strength of argument in relation to GM food attitude change. As changes in attitudes were found only in the commutation treatments with strong arguments, one might conclude the importance of informative and highly explanatory communication in the context of GM and perhaps other similarly controversial contexts. Note that the persuasive treatment regardless of strength consisted of five different communications. Nevertheless, regardless of individual differences in information processing, the weak arguments within the peripheral route persuasion was not effective.

Second, tailored communication with strong arguments also led to changed product preferences towards a larger acceptance of GM food with direct health benefit and, at the same time decreased the importance of a non-GM product attribute. Moreover, the strong arguments, regardless of whether they were tailored to initially positive or initially negative perception of GM goods, led to a similar degree of change in the level of GM attributes. The first part of these findings is in agreement with the recent strand of research that indicates that GM food with direct benefits to consumers (that is, related to health, nutrition, and the environment) might be more acceptable to both European and US consumers (Lusk et al., 2015). Furthermore, Pham and Mandel (2019) reported that even though presenting messages about the safety or risk of GM to those who are strongly against GM food generally had a negative effect; messages with nutritious benefits have had a more favorable impact among the negative attitudinal group. These results, including our findings, indicate that future research in advertising GM food should leverage the health impact that food produced with use of the GM technology can bring and then specifically underline such direct benefits.

Third, in accordance with prior studies and theories, including the Theory of Planned Behavior (Ajzen, 1991), which show a link between attitudes and behavior intentions (Armitage & Conner, 2001; Kahneman et al., 1999), our results also suggest that stated attitudes were linked to product preferences. Importantly, the change in attitudes and product preferences were consonant to treatment type, which highlights the effectiveness of the communication design, providing a promising potential change in consumers' choices of GM products and contributes to the discussion on consumer purchase decisions and market behavior (Morwitz & Fitzsimons, 2004).

The present study has certain limitations. First, the study explored only one product in terms of a controversial application of new technologies. For direct comparison of the effect of the interventions between *positive* and *negative* groups, future research could explore the mental models approach in a randomized multi-product control trail. Furthermore, this study presents the results of hypothetical choices, which might differ from a real purchase (Chang, Lusk, & Norwood, 2009), and further research on this topic would benefit from understanding the applicability of the design to real choices. Having said that, it is important to mention that even though some countries, such as the USA, China, and Israel, have already launched gene editing in plant breeding, the Europe Union remains on the sidelines because of its legal standpoint to characterize gene-editing as GMO. Thus, conducting a field experiment with real purchases was not possible on the Swedish sample. As Sweden is still not open to GM food, including GM potatoes, being available for consumers, prior experience with GM food choices were not controlled in the study. However, experience could potentially increase the acceptance of food products (Tan et al., 2015; Tuorila, Lähteenmäki, Pohjalainen, & Lotti, 2001) and future research could explore this in a GM food context.

Author Contribution

The funders had no role in study design, data collection, and analysis, decision to publish, or preparation of the manuscript.

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.

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Appendix A. Supplementary data

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References

AAAS. (2012). *Statement by the AAAS Board of Directors On Labeling of Genetically Modified Foods*. https://doi.org/https://www.aaas.org/news/statement-aaas-board-directors-labeling-genetically-modified-foods.

Abberton, M., Batley, J., Bentley, A., Bryant, J., Cai, H., Cockram, J., et al. (2016). Global agricultural intensification during climate change: A role for genomics. *Plant Biotechnology Journal, 14*(4), 1095–1098. https://doi.org/10.1111/pbi.2016.14.issue-410.1111/pbi.12467

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Ajzen, I., Brown, T. C., & Rosenthal, L. H. (1996). Information bias in contingent valuation: Effects of personal relevance, quality of information, and motivational orientation. *Journal of Environmental Economics and Management, 30*(1), 43–57. https://doi.org/10.1006/jeem.1996.0004

Ang, L., & Eisend, M. (2018). Single versus multiple measurement of attitudes: A meta-analysis of advertising studies validates the single-item measure approach. *Journal of Advertising Research, 58*(2), 218–227. https://doi.org/10.2501/JAR-2017-001

Armitage, C. J., & Conner, M. (2001). Efficacy of the Theory of Planned Behaviour: A meta-analytic review. *British Journal of Social Psychology, 40*, 471–499.

Bearth, A., & Siegrist, M. (2016). Are risk or benefit perceptions more important for public acceptance of innovative food technologies: A meta-analysis. *Trends in Food Science and Technology, 49*, 14–23. https://doi.org/10.1016/j.tifs.2016.01.003

Bergkvist, L., & Rossiter, J. R. (2007). The predictive validity of multiple-item versus single-item measures of the same constructs. *Journal of Marketing Research, 44*(2), 175–184. https://doi.org/10.1509/jmkr.44.2.175

Boase, N., White, M., Gaze, W., & Redshaw, C. (2017). Evaluating the Mental Models Approach to Developing a Risk Communication: A Scoping Review of the Evidence. *Risk Analysis, 37*(11), 2132–2149.

Boccaletti, S., & Moro, D. (2000). Consumer willingness to pay for GM Food products in Italy. *AgBioForum, 3*(4), 259–267.

Bostrom, A. (2003). Future risk communication. *Futures, 35*(6), 553–573. https://doi.org/10.1016/S0016-3287(02)00100-3

Bostrom, A., Fischhoff, B., & Morgan, M. G. (1992). Characterizing Mental Models of Hazardous Processes: A Methodology and an Application to Radon. *Journal of Social Issues, 48*(4), 85–100.

Bredahl, L. (2001). Determinants of consumer attitudes and purchase intentions with regard to genetically modified food – results of a cross-national survey. *Journal of Consumer Policy, 24*(1), 23–61. https://doi.org/10.1023/A:1010950406128

Bredahl, L., Grunert, K., & Frewer, L. J. (1998). Consumer Attitudes and Decision-Making With Regard to Genetically Engineered Food Products – A Review of the Literature. *Journal of Consumer Policy, 21*, 251–277. https://doi.org/10.1023/A:1006940724167

Bruine de Bruin, W., & Bostrom, A. (2013). Assessing what to address in science communication. *Proceedings of the National Academy of Sciences, 110*(Supplement_3), 14062–14068. https://doi.org/10.1073/pnas.1212729110

Cacioppo, J. T., & Petty, R. E. (1982). The Need for Cognition. *Journal of Personality and Social Psychology, 42*(1), 116–131.

Chang, J. B., Lusk, J. L., & Norwood, F. B. (2009). How closely do hypothetical surveys and laboratory experiments predict field behavior? *American Journal of Agricultural Economics, 91*(2), 518–534. https://doi.org/10.1111/ajae.v91.210.1111/j.1467-8276.2008.01242.x

Chi, M. T. (2000). Self-explaining expository texts: The dual processes of generating inferences and repairing mental models. *Advances in Instructional Psychology, 5*, 161–238.

Cook, A. J., Kerr, G. N., & Moore, K. (2002). Attitudes and intentions towards purchasing GM food. *Journal of Economic Psychology, 23*(5), 557–572. https://doi.org/10.1016/S0167-4870(02)00117-4

Costa-Font, M., Gil, J. M., & Traill, W. B. (2008). Consumer acceptance, valuation of and attitudes towards genetically modified food: Review and implications for food policy. *Food Policy, 33*(2), 99–111. https://doi.org/10.1016/j.foodpol.2007.07.002

Danthurebandara, V., Yu, J., & Vandebroek, M. (2015). Designing choice experiments by optimizing the complexity level to individual abilities. *Quantitative Marketing and Economics, 13*(1), 1–26.

De Steur, H., Blancquaert, D., Lambert, W., Van Der Straeten, D., & Gellynck, X. (2014). Conceptual framework for ex-ante evaluation at the micro/macro level of GM crops with health benefits. *Trends in Food Science and Technology, 39*(2), 116–134.

Dean, M., & Shepherd, R. (2007). Effects of information from sources in conflict and in consensus on perceptions of genetically modified food. *Food Quality and Preference, 18*(2), 460–469. https://doi.org/10.1016/j.foodqual.2006.05.004

Dornic, S., Ekehammar, B., & Laaksonen, T. (1991). Tolerance for mental effort: Self-ratings related to perception, performance and personality. *Personality and Individual Differences, 12*(3), 313–319. https://doi.org/10.1016/0191-8869(91)90118-U

Economidis, I., Cichocka, D., & Hoegel, J. A. (2010). *A decade of EU-funded GMO research*.

Edwards, K. (1990). The interplay of affect and cognition in attitude formation and change. *Journal of Personality and Social Psychology, 59*(2), 202–216. https://doi.org/10.1037/0022-3514.59.2.202

Fernbach, P. M., Light, N., Scott, S. E., Inbar, Y., & Rozin, P. (2019). Extreme opponents of genetically modified foods know the least but think they know the most. *Nature Human Behavior, 3*(3), 251–256. https://doi.org/10.1038/s41562-018-0520-3

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., & Combs, B. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy Sciences, 9*(2), 127–152.

Frewer, L. J., Howard, C., Hedderley, D., & Shepherd, R. (1999). Reactions to information about genetic engineering: Impact of source characteristics, perceived personal relevance, and persuasiveness. *Public Understanding of Science, 8*(1), 35–50. https://doi.org/10.1088/0963-6625/8/1/003

Frewer, L. J., Howard, C., & Shepherd, R. (1996). The influence of realistic product exposure on attitudes towards genetic engineering of food. *Food Quality and Preference, 7*(1), 61–67. https://doi.org/10.1016/0950-3293(95)00017-8

Frewer, L. J., Scholderer, J., & Bredahl, L. (2003). Communicating about the risks and benefits of genetically modified foods: The mediating role of trust. *Risk Analysis, 23*(6), 1117–1133. https://doi.org/10.1111/j.0272-4332.2003.00385.x

Frewer, L. J., & Shepherd, R. (1995). Ethical concerns and risk perceptions associated with different applications of genetic engineering: Interrelationships with the perceived need for regulation of the technology. *Agriculture and Human Values, 12*(1), 48–57. https://doi.org/10.1007/BF02218074

Frewer, L. J., van der Lans, I. A., Fischer, A. R. H., Reinders, M. J., Menozzi, D., Zhang, X., et al. (2013). Public perceptions of agri-food applications of genetic modification – A systematic review and meta-analysis. *Trends in Food Science & Technology, 30*(2), 142–152. https://doi.org/10.1016/j.tifs.2013.01.003

Gaskell, G., Allum, N., & Stares, S. (2003). *Europeans and Biotechnology in 2002 (Eurobarometer 58.0): Report to the EC Directorate General for Research from the project Life Sciences in European Society*.

Gaskell, G., Allum, N., Wagner, W., Kronberger, N., Torgersen, H., Hampel, J., et al. (2004). GM foods and the misperception of risk perception. *Risk Analysis, 24*(1), 185–194. https://doi.org/10.1111/risk.2004.24.issue-110.1111/j.0272-4332.2004.00421.x

Gentner, D., & Stevens, A. (1983). *Mental models*. Hillsdale, NJ: Erlbaum.

Grunert, K. G., Bech-Larsen, T., Lähteenmäki, L., Ueland, Ø., & Åström, A. (2004). Attitudes towards the use of GMOs in food production and their impact on buying intention: The role of positive sensory experience. *Agribusiness, 20*(1), 95–107. https://doi.org/10.1002/agr.v20:110.1002/agr.10086

Haugtvedt, C. P., Petty, R. E., & Cacioppo, J. T. (1992). Need for cognition and advertising : Understanding the role of personality variables in consumer behavior. *Journal of Consumer Psychology, 1*(3), 239–260.

Heddy, B. C., Danielson, R. W., Sinatra, G. M., & Graham, J. (2017). Modifying knowledge, emotions, and attitudes regarding genetically modified foods. *Journal of Experimental Education, 85*(3), 513–533. https://doi.org/10.1080/00220973.2016.1260523

Hossain, F., & Onyango, B. (2004). Product attributes and consumer acceptance of nutritionally enhanced genetically modified foods. *International Journal of Consumer Studies, 28*(3), 255–267. https://doi.org/10.1111/ijc.2004.28.issue-310.1111/j.1470-6431.2004.00352.x

Huber, J., & Train, K. (2001). On the similarity of classical and bayesian estimates of individual mean partworths. *Marketing Letters, 12*(3), 259–269.

Jonsson, B., Stenlund, T., & Jonsson, B. (2017). *Assessing the Willingness to Elaborate among Young Students : Psychometric Evaluation of a Swedish Need for Cognition Scale*. (February). https://doi.org/10.3389/feduc.2017.00002.

Kahneman, D., & Ritov, I. (1994). Determinants of stated willingness to pay for public goods: A study in the headline method. *Journal of Risk and Uncertaintyrance: Mathematics and Economics, 9*, 5–38.

Kahneman, D., Ritov, I., & Schkade, D. (1999). Economic preferences or attitude expressions? An analysis of dollar responses to public issues. *Journal of Risk and Uncertainty, 19*(1–3), 203–235. https://doi.org/10.1017/cbo9780511803475.037

Kreuter, M. W., & Wray, R. J. (2003). Tailored and targeted health communication: Strategies for enhancing information relevance. *American Journal of Health Behaviour, 27*, 227–232. https://doi.org/10.5993/ajhb.27.1.s3.6

Lähteenmäki, L., Grunert, K., Ueland, Ø., Åström, A., Arvola, A., & Bech-Larsen, T. (2002). Acceptability of genetically modified cheese presented as real product alternative. *Food Quality and Preference, 13*(7–8), 523–533. https://doi.org/10.1016/S0950-3293(01)00077-5

Landrum, A. R., & Hallman, W. K. (2017). Engaging in Effective Science Communication: A Response to Blancke et al. on Deproblematizing GMOs. *Trends in Biotechnology, 35*(5), 378–379. https://doi.org/10.1016/j.tibtech.2017.01.006

Lazrus, H., Morss, R. E., Demuth, J. L., Lazo, J. K., & Bostrom, A. (2016). "Know What to Do If You Encounter a Flash Flood": Mental models analysis for improving flash flood risk communication and public decision making. *Risk Analysis, 36*(2), 411–427. https://doi.org/10.1111/risa:2016.36.issue-210.1111/risa:12480

Lusk, J. L., McFadden, B. R., & Rickard, B. J. (2015). Which biotech foods are most acceptable to the public? *Biotechnology Journal, 10*(1), 13–16.

Lusk, J. L., McFadden, B. R., & Wilson, N. (2018). Do consumers care how a genetically engineered food was created or who created it? *Food Policy, 78*, 81–90.

Magnusson, M. K., & Koivisto Hursti, U.-K. (2002). Consumer attitudes towards genetically modified foods. *Appetite, 39*(1), 9–24. https://doi.org/10.1006/APPE.2002.0486

Mayer, N. D., & Tormala, Z. L. (2010). "Think" versus "Feel" framing effects in persuasion. *Personality and Social Psychology Bulletin, 36*(4), 443–454. https://doi.org/10.1177/0146167210362981

Meyer, D., Leventhal, H., & Gutmann, M. (1985). Common-sense models of illness: The example of hypertension. *Health Psychology, 4*(2), 115–135.

Moon, W., & Balasubramanian, S. K. (2001). Public perceptions and willingness to pay a premium for non-GM foods in the US and UK. Retrieved from *AgBioforum, 4*, 221–231 http://www.agbioforum.org/v4n34/v4n34a10-moon.pdf.

Moon, W., & Balasubramanian, S. K. (2004). Public attitudes toward agrobiotechnology: The mediating role of risk perceptions on the impact of trust, awareness, and outrage. *Review of Agricultural Economics, 26*(2), 186–208.

Morgan, M. G., Fischhoff, B., Bostrom, A., & Atman, C. J. (2001). *Risk Communication*. https://doi.org/10.1017/CBO9780511814679

Morgan, M. G., Fishchhoff, B., Bostrom, A., & Atman, C. J. (2002). *Risk communication: A mental models approach*. New York, NY: Cambridge University Press.

Morss, R. E., Demuth, J. L., Bostrom, A., Lazo, J. K., & Lazrus, H. (2015). Flash Flood risks and warning decisions: A mental models study of forecasters, public officials, and media broadcasters in Boulder, Colorado. *Risk Analysis, 35*(11), 2009–2028. https://doi.org/10.1111/risa.12403

Morss, R. E., Mulder, K. J., Lazo, J. K., & Demuth, J. L. (2016). How do people perceive, understand, and anticipate responding to flash flood risks and warnings? Results from a public survey in Boulder, Colorado, USA. *Journal of Hydrology, 541*, 649–664. https://doi.org/10.1016/j.jhydrol.2015.11.047

Morwitz, V. G., & Fitzsimons, G. J. (2004). The mere-measurement effect: Why does measuring intentions change actual behavior? *Journal of Consumer Psychology, 14*, 64–73. https://doi.org/10.1103/PhysRev.17.624

Norusis, M. J. (2011). *IBM SPSS statistics 19 procedures companion*. Reading, MA: Addison-Wesley.

Petty, R. E., & Cacioppo, J. T. (1984). The effects of involvement on responses to argument quantity and quality: Central and peripheral routes to persuasion. *Journal of Personality and Social Psychology, 46*(1), 69–81. https://doi.org/10.1037/0022-3514.46.1.69

Petty, R. E., & Cacioppo, J. T. (1986). The elaboration likelihood model of Persuasion. *Communication and Persuasion, 19*, 1–24. https://doi.org/10.1007/978-1-4612-4964-1_1

Petty, R. E., Wegener, D. T., & Fabrigar, L. R. (1997). Attitudes and attitude change. *Annual Review of Psychology, 48*(1), 609–647.

Pham, N., & Mandel, N. (2019). What influences consumer evaluation of genetically modified foods? *Journal of Public Policy & Marketing, 38*(2), 263–279. https://doi.org/10.1177/0743915618818168

Phipps, R., & Park, J. (2002). Environmental benefits of genetically modified crops: Global and European perspectives on their ability to reduce pesticide use. *Journal of Animal and Feed Sciences, 11*(1), 1–18.

Pidgeon, N. F., Poortinga, W., Rowe, G., Horlick-Jones, T., Walls, J., & O'Riordan, T. (2005). Using surveys in public participation processes for risk decision making: The case of the 2003 British GM nation? Public debate. *Risk Analysis, 25*(2), 467–479. https://doi.org/10.1111/j.1539-6924.2005.00603.x

Royzman, E. B., Cusimano, C., Metas, S., & Leeman, R. F. (2020). Is opposition to genetically modified food "Morally Absolutist"? A consequence-based perspective. *Perspectives on Psychological Science, 15*(2), 250–272.

Ruth, T. K., & Rumble, J. N. (2017). What's in a Name ? The Influence of Persuasive communication on Florida Consumers' attitude toward genetically modified food. *Journal of Applied Communications, 101*(2).

Savadori, L., Savio, S., Nicotra, E., Rumiati, R., Finucane, M., & Slovic, P. (2004). Expert and public perception of risk from biotechnology. *Risk Analysis, 24*(5), 1289–1299. https://doi.org/10.1111/j.0272-4332.2004.00526.x

Sawtooth Software. (2003). Retrieved from www.sawtoothsoftware.com.

SCB. (2017). Statistics Sweden. Retrieved from https://www.scb.se/en/finding-statistics/statistics-by-subject-area/population/population-composition/population-statistics/pong/tables-and-graphs/monthly-statistics–the-whole-country/population-statistics-2018-2021-month-and-1998-2020-year/.

Scholderer, J., & Frewer, L. J. (2003). The biotechnology communication paradox: experimental evidence and the need for a new strategy. *Journal of Consumer Policy, 26*, 125–157. https://doi.org/10.1016/j.bbi.2008.05.010

Scott, S. E., Inbar, Y., & Rozin, P. (2016). Evidence for absolute moral opposition to genetically modified food in the United States. *Perspectives on Psychological Science, 11*(3), 315–324. https://doi.org/10.1177/1745691615621275

Scott, S. E., & Rozin, P. (2020). Actually, natural is neutral. *Nature Human Behaviour, 4*(10), 989–990. https://doi.org/10.1038/s41562-020-0891-0

See, Y. H. M., Petty, R. E., & Fabrigar, L. R. (2008). Affective and cognitive meta-bases of attitudes: Unique effects on information interest and Persuasion. *Journal of Personality and Social Psychology, 94*(6), 938–955. https://doi.org/10.1037/0022-3514.94.6.938

Siegrist, M. (2000). The influence of trust and perceptions of risk and benefits on the aceeptance of gene technology. *Risk Analysis, 20*(2), 195–203.

Siegrist, M. (2008). Factors influencing public acceptance of innovative food technologies and products. *Trends in Food Science and Technology, 19*(11), 603–608. https://doi.org/10.1016/j.tifs.2008.01.017

Siegrist, M., & Hartmann, C. (2020). Consumer acceptance of novel food technologies. *Nature Food, 1*(6), 343–350. https://doi.org/10.1038/s43016-020-0094-x

Silvera, D. H., Josephs, R. A., & Giesler, R. B. (2002). Bigger is Better: The influence of physical size on aesthetic preference judgments. *Journal of Behavioral Decision Making, 15*(3), 189–202. https://doi.org/10.1002/bdm.v15:310.1002/bdm.410

Sjöberg, L. (2008). Genetically modified food in the eyes of the public and experts. *Risk Management, 10*(3), 168–193. https://doi.org/10.1057/rm.2008.2

Sparks, P., Shepherd, R., & Frewer, L. J. (1994). Gene technology, food production, and public opinion: A UK study. *Agriculture and Human Values, 11*(1), 19–28. https://doi.org/10.1007/BF01534445

Tan, H. S. G., Fischer, A. R. H., Tinchan, P., Stieger, M., Steenbekkers, L. P. A., & van Trijp, H. C. M. (2015). Insects as food: Exploring cultural exposure and individual experience as determinants of acceptance. *Food Quality and Preference, 42*, 78–89. https://doi.org/10.1016/j.foodqual.2015.01.013

Tenny, J., Brinol, P., & Petty, R. E. (2017). The elaboration likelihood model: Understanding consumer attitude change. In C. V. Jansson-Boyd, & M. J. Zawisza (Eds.), *Routledge International Handbooks. Routledge International Handbook Of Consumer Psychology* (pp. 390–410). New York, NY: Routledge/Taylor & Francis Group.

Thacker, I., Sinatra, G. M., Muis, K. R., Danielson, R. W., Pekrun, R., Winne, P. H., et al. (2020). Using persuasive refutation texts to prompt attitudinal and conceptual change. *Journal of Educational Psychology, 112*(6), 1085–1099. https://doi.org/10.1037/edu0000434

K. Train A Comparison of Hierarchical Bayes and Maximum Simulated Likelihood for Mixed Logit Retrieved from https: / /eml.berkeley.edu /~train /%0Acompare.pdf 2001.

Train, K. E. (Ed.). (2003). *Discrete Choice Methods with Simulation*. Cambridge: Cambridge University Press.

Tuorila, H., Lähteenmäki, L., Pohjalainen, L., & Lotti, L. (2001). Food neophobia among the Finns and related responses to familiar and unfamiliar foods. *Food Quality and Preference, 12*(1), 29–37. https://doi.org/10.1016/S0950-3293(00)00025-2

Valente, M., & Chaves, C. (2018). Perceptions and valuation of GM food: A study on the impact and importance of information provision. *Journal of Cleaner Production, 172*, 4110–4118. https://doi.org/10.1016/j.jclepro.2017.02.042

Vivianne H. M. Visschers Michael Siegrist Martina Raue Eva Lermer Bernhard Streicher Psychological Perspectives on Risk and Risk Analysis: Theory, Models, and Applications 2018 Springer International Publishing Cham 63 80 10.1007/978-3-319-92478-6_3.

Wong-Parodi, G., & Bruine de Bruin, W. (2017). Informing Public Perceptions About Climate Change: A 'Mental Models' Approach. *Science and Engineering Ethics, 23*(5), 1369–1386. https://doi.org/10.1007/s11948-016-9816-8

Yuan, S., Ma, W., & Besley, J. C. (2019). Should Scientists Talk About GMOs Nicely? Exploring the Effects of Communication Styles, Source Expertise, and Preexisting Attitude. *Science Communication, 41*(3), 267–290. https://doi.org/10.1177/1075547019837623

Zaheer, K., & Akhtar, M. H. (2016). Potato Production, Usage, and Nutrition – A Review. *Critical Reviews in Food Science and Nutrition, 56*(5), 711–721. https://doi.org/10.1080/10408398.2012.724479

Zhu, X., & Xie, X. (2015). Effects of knowledge on attitude formation and change toward genetically modified foods. *Risk Analysis, 35*(5), 790–810. https://doi.org/10.1111/risa.12319