Risk and benefit perceptions of human enhancement technologies: The effects of Facebook comments on the acceptance of nanodesigned food

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Abstract
The introduction of a new technology, such as a human enhancement technology, may induce apprehension and concern among the general public. Social media enable individuals to find information and share their insights and concerns regarding new technologies. This results in an abundance of viewpoints that guides the individual’s acceptance and decision-making. A relevant question for this special issue is to what extent attitudes toward human enhancement technologies are influenced by online cues that signal the views of other people without obvious relevant expertise, such as online comments (social proof). An online experiment focusing on the enhancement of human health and the functioning of the human body through the application of nanotechnology in food was conducted. The study investigated to what extent social proof impacted views on the application of nanotechnology in food. The valence of comments on a fake Facebook image with four comments was manipulated (positive, negative, mixed). A representative sample of Dutch Internet users (n = 289) completed the study. Perceptions, feelings, behavior, and information need were measured. Results showed that comment valence had a significant effect on risk perception, benefit perception and attitude: the more positive the comments read by the participants, the lower risk perception, the higher benefit perception and the more positive the attitude toward nanodesigned food. Significant interaction effects of initial feelings of dread and comment valence were further found for risk perception and willingness to buy. In contrast, there were no significant interactions of initial feelings of optimism and comment valence. Implications for risk communication regarding human enhancement technologies are discussed.

KEYWORDS
affect heuristic, attitude, benefit perception, Facebook, human enhancement technology, information processing, nanotechnology in food, risk perception, social proof, willingness to buy
1 INTRODUCTION

The development of new technologies is among the most important factors that shaped the modern world (Yan, Gaspar, & Zhu, 2019). Originally, these technologies focused on the adaptation of the physical environment to human needs, and the development of associated tools. In more recent years, technologies have been developed that addressed the social element in life and focused on improving the communication between human beings, for example, through digital technologies such as the Internet. Another line of technologies, such as medical technologies, focuses on the human body, and seeks to improve human health and the functioning of the body. A growing trend is the non-medical use of biomedical technologies that aim to enhance the individual’s physical or mental capabilities by altering the human body (Dijkstra & Schuijff, 2016).

Some of these so-called human enhancement technologies attempt to realize their effects through the food we eat. An important approach within this category is the use of nanotechnology. Nanotechnology refers to a range of different processes, materials and applications with the common theme of the manufacture and use of materials on a nanometer-size scale (Chaudhry, Watkins, & Castle, 2017). Examples are nanosized ingredients and additives, and nano-scale carriers for the delivery of nutrients and supplements (Chaudhry et al., 2017).

Public health agencies expect that the application of nanotechnology in the food sector will contribute to a safe, healthy and sustainable diet (Zantinge, van Bakel, van Loon, & Ocke, 2017) and hence to a better health and enhanced functioning of the body. Yet, as with all technologies, risks accompany benefits. In the case of the application of nanotechnology in food (nanodesigned food), the most relevant one is the possibility that very small insoluble and bio-persistent particles may cross the gut wall (Chaudhry et al., 2017).

Nanodesigned food can only be effective in enhancing human health and the functioning of the human body, if the technology is accepted, and if the created products are purchased and consumed. There is ample evidence that the introduction of a new technology may induce apprehension and concern (Frewer et al., 2016). This seems particularly the case in relation to technologies that impact the human body, such as nanodesigned food (Capon, Gillespie, Rolfe, & Smith, 2015; Frewer, Fischer, & Van Trijp, 2011; Siegrist, Cousin, Kastenholz, & Wiek, 2007; Siegrist, Stampfl, Kastenholz, & Keller, 2008). If this apprehension leads individuals to abstain from consuming the respective product, individuals will also miss out on their benefits (Frewer, 2017). This makes it extremely relevant to understand how individuals form their opinion and take decisions regarding food in which nanotechnology has been applied.

With the dominance of the Internet and social media, individuals are nowadays not only exposed to communications by experts, journalists and their organizations, but also to views by people on social media without an ostensible expertise or background. Evidence on the effect of such social media expressions on the risks and benefits of human enhancement technologies is scarce. This article aims to fill this gap by reporting the results of an online experiment examining the effect social media expressions by ordinary people without specific expertise on the individual’s perceptions, attitudes and willingness to buy nanodesigned food. The topic of the study thus relates to the indirect enhancement of human health and the functioning of the human body through the enhancement of food by nanotechnology.

1.1 Nanotechnology: Acceptance and decision-making

Research showed attitudes toward nanotechnology to be moderately positive across many areas of application. Benefits were expected to occur predominantly in relation to medicines and health, and technological development, rather than to agriculture and food (Boholm & Larsson, 2019; Capon et al., 2015; Conti, Satterfield, & Harthorn, 2011; Frewer, 2017; Frewer et al., 2014; Giles, Kuznesof, Clark, Hubbard, & Frewer, 2015; Priest, 2009; Siegrist et al., 2007; Yue, Zhao, Cummings, & Kuzma, 2015). Food-related applications were also more likely to raise societal concern than other applications, and the application of nanotechnology in food was perceived to be less beneficial than in food packaging (Capon et al., 2015; Siegrist et al., 2007; Siegrist et al., 2008).

In the acceptance of nanotechnology in foods, risk and benefit perceptions play an important role, as do perceived controllability, ethical concerns regarding environmental impact and animal welfare. Factors that affect acceptance at the individual level include risk and benefit perceptions, emotions, the perceived ability to cope with the risk, trust in the food industry and confidence in the competence of governmental technology management (Capon et al., 2015; Frewer et al., 2014; Kuttschreuter, 2006; Martensen, Brockenhuis-Schack, & Zahid, 2018; Siegrist et al., 2007; Siegrist et al., 2008; Viscecchia, De Devitiis, Carlucci, Nardone, & Santeramo, 2018; Yue et al., 2015).

1.2 Information processing and decision-making regarding food choice

Introducing new foods on the market involves providing consumers with information on their nutritional value and other qualities. In their decision-making, consumers need to make sense of this information to generate meaning and understanding. This includes thoughts, emotions and actions (Dervin, 1998; Piroli & Russell, 2011; Weick, Sutcliffe, & Obstfeld, 2005). Fundamental processes that contribute to consumer decision-making are information seeking, processing and sharing (Berger, 2014; Caughron et al., 2013; Hilverda, Kuttschreuter, & Giebels, 2017; Rimal & Real, 2003).

Theoretical models as the Heuristic Systematic Model (HSM) and the Elaboration Likelihood Model (ELM) have distinguished two forms of information processing: heuristic processing and systematic processing (Chaiken, 1980; Griffin, Dunwoody, & Neuwirth, 1999; Kahlor, Dunwoody, Griffin, Neuwirth, & Giese, 2003; Trumbo, 1999). Heuristic processing is defined by the use of cues to arrive more easily at a judgment such as the source of the information and other non-
content characteristics of a message. It is more likely to take place with low issue involvement. Systematic processing, on the other hand, involves the effortful scrutiny and comparison of information. It takes place when an individual encounters information of significant personal importance. Information often contains contradictory elements. If individuals focus on these contradictory elements, they are engaging in systematic information processing. In such cases, a need for further information may arise. An emerging information need may thus point to the systematically processing of information (Griffin et al., 1999).

### 1.3 Decision-making under uncertainty: Social proof

Key aspects to the introduction of new technologies seem to be a lack of knowledge and a high level of uncertainty among the target audience regarding the weighing of the risks and benefits of the technology. A relevant theory in this respect is the principle of social proof. This principle can be understood as a form of heuristic information processing where individuals assimilate the behaviors of others and rely on their judgments and behavior, in case they are uncertain about an appropriate course of action (Cialdini, 2001).

In line with recent studies (Amblee & Bui, 2011; Lee, Shi, Cheung, Lim, & Sia, 2011), we define social proof as any type of social information to infer a course of action. Defined in this way, social proof is not limited to behavior of others, but also includes collaboratively shared information and experiences of others that help individuals to form their opinion or decide upon an appropriate action. This type of social influence is also referred to as informational social influence. It differs from normative social influence, which occurs when individuals conform to social norms and expectations (Cialdini, 2001). Facebook comments that provide information about the use of a technology, such as nanotechnology in food products, that may help individuals form their opinion, and that do not express any expectations by other people on how to behave, can thus be viewed as informational social influence, and thus as social proof.

The reasoning behind the principle of social proof is that the likelihood of making an incorrect response is smaller, when one behaves in the same manner as other people who might be more knowledgeable in responding to the situation (Lee, Park, & Han, 2008; Okdie, Guadagno, Petrova, & Shreves, 2013). Based on this principle, one might reason that information on the risks and benefits of nanodesigned foods might generate uncertainty among consumers, which makes them susceptible to social proof.

In line with the affect heuristic, one might also assume that such information on risks or benefits affects risk perception as well as benefit perception (Finucane, Alhakami, Slovic, & Johnson, 2000; Siegrist et al., 2008). The risk as feelings perspective further suggests that the interaction of these cognitions and the feelings associated with the technology mutually influence each other and that their interplay determines the individual's attitude and willingness to buy (Loewenstein, Weber, Hsee, & Welch, 2001).

### 1.4 Social proof through social media

Social proof can be very influential in an online setting where information potentially reaches a very large audience. Nowadays, the Internet is one of the main sources of food information (Jacob, Mathiasen, & Powell, 2010; Kuttschreuter et al., 2014; Ma, Almanza, Ghiselli, Vorvoreanu, & Sydnor, 2017; Redmond & Griffith, 2006; Tian & Robinson, 2008). Social media provide individuals with an easy-to-use tool to communicate with others which they use to find information and share their insights and concerns regarding new technologies (Barnett et al., 2011; Hamshaw, 2018; Kornelis, de Jonge, Frewer, & Dagevos, 2007; Kuttschreuter et al., 2014; Runge et al., 2013; Vidal, Ares, Machin, & Jaeger, 2015). This abundance of available viewpoints may be helpful as well as confusing (Regan et al., 2014). The information is then processed, either systematically or heuristically, and guides the individual's acceptance and decision-making (Caughron et al., 2013; Erkan & Evans, 2016; King, Racherla, & Bush, 2014; Vermeulen & Seegers, 2009; Winterbottom, Bekker, Conner, & Mooney, 2008).

A key aspect of a statement or behavior that might lead to social proof is its valence: in favor or against. Most research into online social proof focused on Facebook as the most relevant social media platform. This research demonstrated effects of online social proof in a large variety of contexts, such as organic food (Hilverda, Kuttschreuter, & Giebels, 2018), breastfeeding attitudes (Jin, Phua, & Lee, 2015), marihuana legalization (Winter, Bruckner, & Kramer, 2015), brand engagement and sales (Kim & Johnson, 2016), and vaccination (Peter, Rossmann, & Keyling, 2014). There is also empirical evidence with respect to other social media, such as YouTube (Shi, Messaris, & Cappella, 2014; Walther, DeAndrea, Kim, & Anthony, 2010).

Most of these studies investigated the impact of viewing exclusively negative or exclusively positive expressions. Individuals are however most likely exposed to both positive and negative opinions from various sources at the same time (Lee et al., 2008). Research findings suggested that a higher percentage of narratives reporting adverse consequences led to a higher risk perception, which in turn led to a lower intention to vaccinate (Betsch, Ulshofer, Renkewitz, & Betsch, 2011). Similar results were found for a Facebook page with food safety information on restaurants (Seo, Almanza, Miao, & Powell, 2010; Kuttschreuter et al., 2014; Ma, Almanza, Ghiselli, Vorvoreanu, & Sydnor, 2017). Similar results were found for a Facebook page with food safety information on restaurants (Seo, Almanza, Miao, & Powell, 2010; Kuttschreuter et al., 2014; Ma, Almanza, Ghiselli, Vorvoreanu, & Sydnor, 2017). Similar results were found for a Facebook page with food safety information on restaurants (Seo, Almanza, Miao, & Powell, 2010; Kuttschreuter et al., 2014; Ma, Almanza, Ghiselli, Vorvoreanu, & Sydnor, 2017).

The evidence so far thus supports the idea that individuals may be influenced by the valence of what they read on social media. Evidence on the effects of online comments of mixed valence is scarce.

### 1.5 Potential moderators: Initial attitudes

Initial attitudes affect cognitions, feelings, attitudes and behavior following provision of information in two ways. Firstly, there is the main effect of initial attitudes: the more positive the initial attitudes, the more positive cognitions, feelings, attitudes and behavior following information provision (Freewer, Howard, Hedderley, & Shepherd, 1999; Frewer, Scholderer, & Bredahl, 2003; Van Dijk, Fischer, de Jonge, Rowe, & Frewer, 2012).
Secondly, initial attitudes may affect the impact of the provided information. Cognitive dissonance theory suggests that individuals are likely to stick to their opinions, which might affect the way they seek, process and avoid new information (Delone & Kahlor, 2019; Gaspar et al., 2016; Kuhn, 2000; Narayan, Case, & Edwards, 2011). The empirical evidence on the effects of prior attitude in risk communication is fragmented (Frewer et al., 2016). There is however qualitative as well as quantitative experimental data to support an interaction effect of initial attitudes and provided information (McFadden & Lusk, 2015; Vainio, Irz, & Hartikainen, 2018; Vardeman & Aldoory, 2008). Adapted to our context: exposure to positive information on a human enhancement technology might strengthen the benefit perception among individuals with a positive initial attitude, whereas exposure to negative information might strengthen the risk perceptions among individuals with a negative initial attitude toward the technology.

There is hardly any evidence on the interaction effects in case of information of mixed valence. Evidence by Van Dijk et al. (2012) suggested that initial attitudes might become less strong when information on risks as well as benefits is given. Whether this also holds for information posted on social media by ordinary people is still unclear. Another reasoning is that information of mixed valence contains contradictory elements. As contradictory information leads to uncertainty (Boholm & Larsson, 2019) and as uncertainty increases risk perception, one might hypothesize that information of mixed valence would have a similar effect as negative information.

1.6 | Current study, research question and hypotheses

A relevant question for this special issue is to what extent attitudes toward human enhancement technologies are influenced by online cues that signal the views of other people without obvious relevant expertise, such as online comments at a statement. An example of such a cue would be a comment on Facebook saying, “I am very much in favor of the use of nanotechnology to add extra vitamins to food. This enhances my health.”

To answer this question, we conducted an experiment involving a fictitious Facebook page on the application of nanodesigned food, that included four comments beneath a broad question that differed in valence (all positive, all negative, mixed [2 positive, 2 negative]). Dependent variables were risk perception, benefit perception, perceived retail safety, anxiety, positive emotions, attitude and willingness to buy. Information need was added to the dependent variables to examine whether observed effects could be ascribed to heuristic information processing as opposed to the systematic processing of the contents of the comments. Prior attitudes were taken into account, split into initial feelings of dread and initial feelings of optimism.

1.6.1 | Main effect of comment valence (H1)

A main effect of comment valence was hypothesized: the more positive comments the individual read, the higher benefit perception, perceived retail safety, evoked positive emotions, attitude and willingness to buy, and the lower risk perception and anxiety. It was further hypothesized that the mixed set of comments would induce uncertainty and hence lead to a higher need for information than exclusively positive or exclusively negative comments.

1.6.2 | Main effect of initial dread (H2)

A main effect of initial dread was hypothesized: the higher initial dread, the higher risk perception and anxiety, and the lower benefit perception, perceived retail safety, evoked positive emotions, attitude and willingness to buy. It was further hypothesized that a higher initial dread would be associated with a higher level of uncertainty and hence a higher level of information need.

1.6.3 | Interaction effect of comment valence and initial dread (H3)

Departing from the idea that information that is congruent with the individual’s initial attitude, carries more weight than incongruent information, a significant interaction between comment valence and initial dread was hypothesized. Risk perception and anxiety were expected to be highest among participants with a high initial dread who read the negative comments. In contrast, benefit perception, perceived retail safety, evoked positive emotions, attitude and willingness to buy were expected to be highest among participants with a low initial dread who read the positive comments. It was further hypothesized that a high number of negative comments would strengthen the effect of the initial dread on information need: information need was expected to the highest among participants with a high initial dread who read the negative comments.

1.6.4 | Main effect of initial optimism (H4)

A main effect of initial optimism was hypothesized: the higher the initial optimism, the higher benefit perception, perceived retail safety, evoked positive emotions, attitude and willingness to buy, and the lower risk perception and anxiety. It was further hypothesized that a higher initial optimism would be associated with a lower level of uncertainty and hence a lower level of information need.

1.6.5 | Interaction effect of comment valence and initial optimism (H5)

The reasoning that congruent information carries more weight also applies to positive feelings. It was therefore hypothesized that there was a significant interaction between comment valence and initial optimism. Benefit perception, perceived retail safety, evoked positive emotions, attitude and willingness to buy were expected to be highest among participants with a high initial optimism who read the positive comments. In contrast, risk perception and anxiety were expected to be highest among participants with a low initial optimism who read the negative comments. It was further hypothesized that a high
number of positive comments would strengthen the effect of initial optimism on information need: information need was expected to be the highest among participants with a low initial optimism who read the negative comments.

2 | METHOD

2.1 | Participants

Participants were recruited by a certified research agency that acted in accordance with the ethical standards of the Ethics Board of the University. The sample was representative of the Dutch population of Internet users with respect to age and gender. Data collection took place in June 2015. The participants completed an online questionnaire that included a screenshot of a manipulated fictitious Facebook page with four comments that differed in valence regarding nanodesigned food. Completing the study took the participants about 15 minutes.

A manipulation check was carried out. Only the participants who correctly filled out the question on the comment valence (80% overall: 89% in the negative condition, 66% in the mixed condition and 85% in the positive condition) were included in the study. This resulted in a sample of 289 participants: 107 in the negative valence condition, 80 in the mixed valence condition and 102 in the positive valence condition.²

The sample consisted of 139 males (48%) and 150 females (52%).

Age ranged from 18 to 77 with a mean age of 47 years. All participants were familiar with Facebook. Including themselves, they mostly lived in households of two (43%), three (16%) or four persons or more (19%), whereas 21% lived on their own. In the month prior to the study, almost all participants had been responsible for grocery shopping (96%) and for cooking the main meal of the day at least once a week (91%).

Sample selectivity was assessed by comparing the participants who answered the manipulation check question correctly to those who did not. There were no differences with respect to gender, age, education, daily occupation, income, number of household members, grocery shopping, cooking and Facebook use. The differences in initial dread and initial optimism and the perceived emotionality and helpfulness of the comments were also insignificant. Three significant differences were found. The participants perceived themselves significantly less well informed on nanodesigned food (M = 2.19, SD = 1.18) than those who filled out the manipulation questions incorrectly (M = 2.74, SD = 1.70, t [90.41] = −2.58, p ≤ .05). They further considered the comments to be clearer, Mann–Whitney U-test, Z = 4.21, p ≤ .0005, and more biased, Mann–Whitney U-test, Z = 2.16, p ≤ .05, than those who filled out the manipulation check incorrectly. The analyzed sample thus seemed to be selective with respect to their perceived knowledge on nanodesigned food and the appreciation of the comments, but not with regard to background characteristics and initial attitudes.

The participants were randomly assigned to three conditions. A randomization check showed a significant difference between conditions for only 1 out of 15 tested variables, gender. There were, relatively speaking, more females among the participants who read the positive comments (64%) than among those who read the negative comments (47%) or the mixed set of comments (44%). There were no differences between the three conditions with respect to age, education, daily occupation, income, number of household members, grocery shopping, cooking, online media use (Facebook, Twitter, Skype, fora and blogs), initial dread, initial optimism, and the perceived knowledge on nanodesigned food.

2.2 | Design and manipulation

A randomized one factor between subjects experiment with two moderators was carried out. Participants viewed screenshots of an alleged Facebook post asking for opinions on nanodesigned food. Facebook was chosen because of its large number of users and its use in information seeking (Basilisco & Cha, 2015; Cheung & Lee, 2012; Hilverda & Kuttschreuter, 2018). The three conditions differed in the valence of the four comments that were positioned just below the post: 4 positive comments, 4 negative comments or a mixed set of 2 positive and 2 negative comments (Figure 1). The comments in the mixed set were rotated to avoid bias as a result of the presentation order of the comments. In the conditions, four alleged Facebook users expressed their views regarding the weighing of the risks and the benefits of nanodesigned food, and their (un)willingness to eat nanodesigned food (see Appendix A).³ Comments were selected on the basis of a pilot study.

Participants in the main study evaluated the comments. Ratings for perceived clearness (M = 4.91, SD = 1.27) and perceived partiality (M = 4.48, SD = 1.40) were above the mean of the scale, whereas the rating for perceived emotionality (M = 4.21, SD = 1.35) was slightly above the mean of the scale, and that for perceived helpfulness in advising a friend (M = 3.39, SD = 1.37) below the middle of the scale. Comparison of the ratings in the three conditions showed a significant difference with respect to partiality, Kruskall–Wallis, χ² (2, N = 289) = 30.91, p ≤ .0005: participants who read the set of mixed valence comments considered the comments to be less biased than those who read only positive or only negative comments. There were also significant differences in emotionality, Kruskall–Wallis χ² (2, N = 289) = 29.11, p ≤ .0005, and perceived clearness, Kruskall–Wallis χ² (2, N = 289) = 8.46, p ≤ .05: the participants who read the positive comments considered the comments to be less emotional and less clear than those who read the negative or set of mixed comments. There was no difference with respect to the helpfulness of the comments in advising a friend.

2.3 | Measures

Instruments were based on prior research (Hilverda et al., 2018; Kuttschreuter et al., 2014; Kuttschreuter & Hilverda, 2019). Please see Appendix B.
Dependent variables

Risk perception. To measure risk perception, participants were requested to indicate to what extent they agreed with four statements regarding the hazardousness of nanotechnology in foods to their health (4 items, $\alpha = .94$, 7-point-Likert scale, 1 = strongly disagree to 7 = strongly agree).

Benefit perception: We measured benefit perception with four statements about the advantages of the application of nanotechnology in foods to the participant's health (4 items, $\alpha = .94$, 7-point-Likert scale, 1 = strongly disagree to 7 = strongly agree).

Perceived retail safety: Participants indicated to what extent they had confidence in the safety of food products that were sold in retail (3 items, $\alpha = .94$, 7-point-Likert scale, 1 = strongly disagree to 7 = strongly agree).

Anxiety: Anxiety was measured by asking the participants to what extent they experienced anxiety when thinking about eating foods in which nanotechnology had been applied (4 items, $\alpha = .94$, 7-point scale ranging from 1 = not at all to 7 = very much).

Positive emotions: Participants indicated to what extent they experienced positive emotions when thinking about eating foods in which nanotechnology had been applied (4 items, $\alpha = .96$, 7-point scale ranging from 1 = not at all to 7 = very much).

Attitude toward nanodesigned food: Participants indicated their overall attitude toward nanodesigned food on a 7-point semantic differential-type scale (3 item-pairs, $\alpha = .95$, 7-point scale).

Willingness to buy: As research attitudes are more reliably measured when focused on specific foods rather than food categories (Bredahl, 1999), willingness to buy was measured by asking the participants to what extent they were inclined to purchase a variety of seven nanodesigned food products (7 items, $\alpha = .94$, 7-point scale ranging from 1 = not at all to 7 = very much).

Information need: Participants filled out to what extent they wanted to know more about nanodesigned foods (3 items, $\alpha = .95$, 7-point scale, 1 = strongly disagree to 7 = strongly agree).

2.3.2 | Moderators

Initial dread: Initial dread was measured before the participants viewed the screenshot. Participants were asked to what extent they dreaded the application of nanodesigned food (4 items, $\alpha = .87$, 7-point scale; 1 = strongly disagree to 7 = strongly agree).

Initial optimism: Initial optimism was also measured before the participants viewed the screenshot. They were asked to what extent they expected the application of nanodesigned food to have advantages (4 items, $\alpha = .90$, 7-point scale; 1 = strongly disagree to 7 = strongly agree).

2.3.3 | Additional variables

Manipulation check: Participants were asked to indicate the valence of the majority of the comments on the Facebook page (positive, negative, about equal).

Evaluation of the comments: Participants were asked to rate the comments on the Facebook page for clearness, emotionality, partiality and helpfulness in advising a friend (individual items, 7-point scale, 1 = strongly disagree to 7 = strongly agree).

Perceived knowledge on nanodesigned food: Participants were asked to indicate to what extent they agreed with statements that their level of knowledge on the application of nanotechnology in food was satisfactory (3 items, $\alpha = .88$, 7-point scale; 1 = strongly disagree to 7 = strongly agree).

Online media use: Participants were questioned on the frequency of their online media use: Facebook, Twitter, Skype, and fora and blogs (4 items, 7-point frequency measure, 1 = less than once a month to 7 = multiple times a day).

Sociodemographics: Gender, age, education, income and household composition were measured. The participants were further asked how often they did the grocery shopping and cooked the main meal of the day.
2.4 Procedure

After indicating their consent, participants filled out an online questionnaire. They were first given a short description of nanotechnology and told that nanotechnology is to a greater or lesser extent applied in food products and food packages. The description of the benefits mentioned increased shelf life, but focused on the benefits for the human body: improved absorption of vitamins and stimulating the defense against germs and diseases. It was further indicated that little was known about the long-term effects of the use of nanotechnology.

To increase involvement, a request by a friend for advice about eating foods created on the bases of nanotechnology was used as a cover story. After filling out the questions about their knowledge and initial attitude regarding nanodesigned foods, the participants viewed the alleged Facebook screenshot. They then indicated their evaluation of the comments, and filled out the manipulation check question. The hypotheses were tested by means of multivariate analysis variance (GLM), followed by univariate analysis. The analysis was conducted by means of SPSS (version 25). Descriptive statistics were established to describe the sample. To obtain an indication of the reliability of the instruments, Cronbach’s alpha was calculated. The hypotheses were tested by means of multivariate analysis variance, and the hypotheses were tested by means of regression analysis as well.

2.5 Analysis

The analysis was conducted by means of SPSS (version 25). Descriptive statistics were established to describe the sample. To obtain an indication of the reliability of the instruments, Cronbach’s alpha was calculated. Next, composite variables were computed, and means and correlations were calculated. The hypotheses were tested by means of multivariate analysis variance (GLM), followed by univariate analysis if applicable. Three main effects were included in the analysis (comment valence, initial dread and initial optimism) as well as two interaction terms (valence by initial dread, valence by initial optimism). Regression analysis was applied to further examine the significant interaction effects. To correct for differences between the three conditions, gender was included as a covariate. Additional analyses were carried to examine the role of perceived knowledge on nanodesigned food and online media use.

3 RESULTS

3.1 Means and correlations

Means, standard deviation and correlations of the main variables are reported in Table 1. Before reading the Facebook comments, the participants expressed some concern about nanodesigned food ($M = 4.58, SD = 1.01$), but also perceived some advantages ($M = 4.15, SD = .97$). They considered their knowledge on nanodesigned food as quite insufficient ($M = 2.19, SD = 1.18$).

After the participants read the Facebook comments, risk perception was in the middle of the scale ($M = 4.16, SD = 1.08$), while benefit perception ($M = 3.66, SD = 1.08$) was below the middle of the scale. Perceived retail safety was high ($M = 4.45, SD = 1.34$), anxiety ($M = 3.59, SD = 1.48$), positive emotions ($M = 3.05, SD = 1.34$), attitude ($M = 3.59, SD = 1.21$) and willingness to buy ($M = 3.04, SD = 1.49$) were all below the middle of the scale. Participants further indicated that they wanted to know more about nanodesigned food ($M = 5.23, SD = 1.32$). The overall picture was thus one of a high level of confidence in the safety of food products, a low level of concern coupled with a low level of expectation regarding nanodesigned food, and a high need for information.

Correlations were as expected. Initial dread, risk perception and anxiety correlated highly positively with each other, as did initial

| TABLE 1 | Means and SD of the constructs and their correlations (N = 289) |
|---------|--------------------------------------------------|
|         | Cognitions | Emotions and attitude | Behavior | Needs | Other variables |
|         | Mean | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1 | Risk perception | 4.16 | 1.08 | 1.00 |
| 2 | Benefit perception | 3.66 | 1.08 | -.78*** | 1.00 |
| 3 | Perceived retail safety | 4.45 | 1.34 | -.37*** | .39*** | 1.00 |
| 4 | Anxiety | 3.59 | 1.48 | .57*** | -.54*** | -.26*** | 1.00 |
| 5 | Positive emotions | 3.05 | 1.34 | -.62*** | .67*** | .33*** | -.19*** | 1.00 |
| 6 | Attitude | 3.59 | 1.21 | -.77*** | .80*** | .40*** | -.52*** | .73*** | 1.00 |
| 7 | Willingness to buy | 3.04 | 1.49 | -.54*** | .63*** | .43*** | -.33*** | .63*** | .67*** | 1.00 |
| 8 | Information need | 5.23 | 1.32 | .04 | .01 | .02 | .13* | -.01 | .01 | .01 | 1.00 |
| 9 | Initial dread | 4.58 | 1.01 | .60*** | -.50*** | -.36*** | .38*** | -.51*** | -.57*** | -.47*** | .19*** | 1.00 |
| 10 | Initial optimism | 4.15 | 0.97 | -.59*** | .66*** | .34*** | -.39*** | .53*** | .64*** | .47*** | .12* | -.33*** | 1.00 |
| 11 | Knowledge Nano | 2.19 | 1.18 | -.25*** | .27*** | .08 | -.18** | .25*** | .26*** | .19*** | -.03 | -.12* | .31*** | 1.00 |

Note: All variables: 7-point scales, ranging from 1 to 7. ***p ≤ .001, **p ≤ .01, *p ≤ .05, two-tailed.
optimism, benefit perception, attitude, positive emotions and willingness to buy, and, to a lesser extent, perceived retail safety and perceived knowledge on nanodesigned food. The correlations between these two groups of variables were highly negative. Information need correlated significantly and positively with initial dread as well as initial optimism, but not significantly with any of the dependent variables, anxiety excepted.

3.2 | Hypotheses testing: Multivariate analysis of covariance

Multivariate analysis of covariance was applied to test the effect of valence (H1), initial dread (H2), the interaction of valence and initial dread (H3), initial optimism (H4) and the interaction of valence and initial optimism (H5). Given differences between the conditions, gender was included as a covariate.

Significant multivariate main and interaction effects were found for valence, Wilks’ $\lambda = .90$, $F(16, 544) = 1.91$, $p \leq .05$, $\eta^2 = .05$, initial dread, Wilks’ $\lambda = .61$, $F(8, 272) = 22.05$, $p \leq .0005$, $\eta^2 = .39$, the interaction of valence and initial dread, Wilks’ $\lambda = .90$, $F(16, 544) = 1.83$, $p \leq .05$, $\eta^2 = .05$, initial optimism, Wilks’ $\lambda = .57$, $F(8, 272) = 25.86$, $p \leq .0005$, $\eta^2 = .43$, and gender, Wilks’ $\lambda = .95$, $F(8, 272) = 1.97$, $p \leq .05$, $\eta^2 = .06$. The interaction of valence and initial optimism, however, was not significant, Wilks’ $\lambda = .94$, $F(16, 544) = 1.09$, ns, $\eta^2 = .03$.

3.3 | Hypotheses testing: Univariate analysis of covariance

Subsequent univariate analysis showed that these effects together explained 56% of the variance in risk perception, 56% in benefit perception, 21% in perceived retail safety, 24% in anxiety, 42% in positive emotions, 59% in attitude, 38% in willingness to buy and only .09% in information need (Table 2).

3.3.1 | Main effect of valence (H1)

Comment valence had a significant main effect on risk perception, benefit perception and attitude (Figure 2).

Correcting for the effects of gender, initial dread, initial optimism and both interaction effects, participants who read the negative comments scored highest on risk perception ($M_{estimated} = 4.32$, $SE = .07$), followed by those who read the mixed set ($M_{estimated} = 4.14$, $SE = .08$) and those who read the positive comments ($M_{estimated} = 4.02$, $SE = .07$).

Similar effects, but in the opposite direction, were found for benefit perception. Correcting for gender, initial dread, initial optimism and both interaction effects, participants who read the negative comments scored lowest on benefit perception ($M_{estimated} = 4.32$, $SE = .07$), followed by participants who read the mixed set of comments ($M_{estimated} = 4.14$, $SE = .08$) and those who read the positive ones ($M_{estimated} = 4.02$, $SE = .07$).

For attitude, there was a statistically significant main effect of comment valence, too. Correcting for gender, initial dread, initial

| Constructs | Covariate | Main effect (H1) | Main effect (H2) | Interaction with valence (H3) | Main effect (H4) | Interaction with valence (H5) |
|------------|-----------|-----------------|-----------------|-----------------------------|-----------------|-----------------------------|
| Risk perception | $R^2$ | $F$ | $p$ | $\eta^2$ | $F$ | $p$ | $\eta^2$ | $F$ | $p$ | $\eta^2$ | $F$ | $p$ | $\eta^2$ |
| Gender | .56 | 0.11 | ns | .000 | 110.85 | .005 | 2.84 | 4.50 | .05 | .031 | 98.41 | .0005 | .261 | 1.11 |
| Initial dread | .56 | 3.80 | ns | .000 | 5.51 | .01 | 2.42 | 3.31 | .01 | .001 | 51.30 | .0005 | .351 | 1.17 |
| Initial optimism | .56 | .05 | ns | .000 | 0.00 | .0001 | 0.00 | 0.00 | .00 | .001 | 24.62 | .0005 | .050 | 0.66 |
| Positive emotions | .56 | 4.49 | 0.01 | 0.02 | 22.83 | .005 | 0.076 | 1.90 | .09 | .001 | 66.46 | .0005 | .392 | 0.16 |
| Willingness to buy | .56 | 6.22 | 0.01 | 0.02 | 11.17 | .0005 | .074 | 9.47 | .0005 | .253 | 147.18 | .0005 | .330 | 0.42 |

Initial and final optimism have been transformed to Z-scores.

Partial $\eta^2$.
optimism and both interaction effects, participants who read the negative comments scored lowest on attitude ($M_{estimated} = 3.34$, SE = .08), followed by those who read the mixed set and ($M_{estimated} = 3.60$, SE = .09) and those who read the positive comments ($M_{estimated} = 3.86$, SE = .08).

For risk perception, benefit perception and attitude there was thus evidence of an effect of comment valence in the expected direction. The effect was medium-sized for attitude, and small to medium-sized for risk and benefit perception (Hedrick, Bickman, & Rog, 1993). For perceived retail safety, anxiety, positive emotions, willingness to buy and information need, the main effect of comment valence was not significant. H1 has thus partly been confirmed.

### 3.3.2 Main effect of initial dread (H2)

The analysis showed highly significant main effects for initial dread on all the dependent variables. Following their viewing of the Facebook comments, the participants who already dreaded nanodesigned food scored significantly higher on risk perception ($\beta = .51$), anxiety ($\beta = .40$) and information need ($\beta = .27$), whereas they scored significantly lower on benefit perception ($\beta = -.44$), perceived retail safety ($\beta = -.36$), positive emotions ($\beta = -.39$), attitude ($\beta = -.46$) and willingness to buy ($\beta = -.52$). There were in particular strong effects for risk perception, benefit perception, positive emotions, attitude and willingness to buy; the effects for anxiety and information need were medium-sized (Hedrick et al., 1993). H2 has thus been confirmed.

### 3.3.3 Interaction effect of initial dread and comment valence (H3)

The analysis showed significant interaction effects between comment valence and initial dread for risk perception and willingness to buy. Both effects were small to medium-sized (Hedrick et al., 1993).

#### Risk perception

Subsequent examination showed that the positive relationship between initial dread and risk perception was strongest for the participants who read the mixed set of comments, $\beta = .71$, $t(78) = 11.08$, $p \leq .0005$, followed by the participants who read the positive, $\beta = .50$, $t(100) = 7.27$, $p \leq .0005$, and the negative comments, $\beta = .24$, $t(105) = 2.93$, $p \leq .01$. The effect of the initial dread on risk perception was thus strongest for the participants who read the mixed set of comments, in the middle for the participants who read the positive comments and lowest for those who read the negative comments. The results further showed that risk perception was highest among the participants who scored high on initial dread and read the mixed set of comments, whereas it was lower among the participants who scored high on initial dread and read the negative comments (Figure 3).

H3 predicted a significant interaction of comment valence and initial dread, in the sense that information that is congruent with the individual’s initial attitude, would carry more weight than incongruent information. We did find a significant interaction; risk perception was however highest among participants who scored high on initial dread and read the mixed set of comments. H3 is thus partly confirmed.

#### Willingness to buy

Subsequent examination showed that the negative relationship between initial dread and willingness to buy was strongest for the participants who read the positive comments, $\beta = -.53$, $t(100) = -6.07$, $p \leq .0005$, whereas there was hardly any difference between the participants who read the negative, $\beta = -.24$, $t(105) = -2.83$, $p \leq .01$, and the mixed set of comments, $\beta = -.28$, $t(78) = -2.96$, $p \leq .01$. The effect of the initial dread on willingness to buy was thus strongest for the participants who read the positive comments, and approximately the same for the participants who read the negative or the mixed set of comments.

Results further showed that willingness to buy was highest among participants who scored low on initial dread and read the positive comments, whereas as it was lower among the participants who scored low on initial dread and read the negative or mixed set of comments (Figure 4).

H3 predicted a significant interaction of comment valence and initial dread, in the sense that information that is congruent with the individual’s initial attitude, would carry more weight than incongruent information. We did find a significant interaction. We also found that

![FIGURE 2 Estimated means for risk perception, benefit perception and attitude, correcting for the effects of gender, initial dread, initial optimism, and both interaction effects](image-url)
willingness to buy was highest among those participants who scored low on initial dread and read the positive comments. This supports H3.

### 3.3.4 Main effect of initial optimism (H4)

There were significant main effects of initial optimism on all the dependent variables. Following their viewing of the Facebook comments, the participants who already perceived nanodesigned food in a positive way, scored higher on benefit perception ($\beta = .54$), perceived retail safety ($\beta = .32$), positive emotions ($\beta = .40$), attitude ($\beta = .51$), willingness to buy ($\beta = .18$), and information need ($\beta = .18$), and lower on risk perception ($\beta = -.45$) and anxiety ($\beta = -.28$). There were strong effects for risk perception, benefit perception, positive emotions, attitude and willingness to buy, while those for perceived retail safety, anxiety and information need were medium-sized (Hedrick et al., 1993). H4 was thus confirmed with respect to perceptions, emotions, attitude and willingness to buy. For information need, H4 was rejected: instead of the hypothesized negative effect a positive one was found.

### 3.3.5 Interaction effect of initial optimism and comment valence (H5)

In line with the insignificant multivariate result, all univariately tested interaction effects of initial optimism and comment valence were insignificant (all $p$'s > .05). There was thus no empirical support for H5.

### 3.3.6 Effect of the covariate

The covariate gender was found to have a small, significant effect on three variables: positive emotions, attitude and willingness to buy (Hedrick et al., 1993). Adjusting for all main and interaction effects, men were more positive about nanodesigned food than women.
3.4 | Additional analyses

3.4.1 | Perceived knowledge on nanodesigned food

Social proof is assumed to take place in case individuals are uncertain about an appropriate course of action (Cialdini, 2001). This would imply that the effect of comment valence would be stronger among individuals who perceived themselves less informed about nanodesigned food. This hypothesis was tested by adding perceived knowledge on nanodesigned food, and its interaction with comment valence, to the analysis. Tested multivariately, neither the main effect of perceived knowledge, Wilks' $\lambda = .95$, $F(8, 268) = 0.87$, ns, $\eta^2 = .03$, nor the interaction effect of comment valence and perceived knowledge, Wilks' $\lambda = .95$, $F(116, 536) = 0.95$, ns, $\eta^2 = .03$, was significant. There was thus no support for the hypothesis that the effect of comment valence was stronger among individuals who scored lower on perceived knowledge on nanodesigned food.

3.4.2 | Online media use

The frequency of Facebook use was not related to any of the dependent variables. Experience with Facebook thus did not moderate the relationship between comment valence and the dependent variables.

4 | GENERAL DISCUSSION

4.1 | Summary of the results and theoretical implications

This study examined the effects of online social proof with respect to nanodesigned food by manipulating the valence of four comments to a fictitious Facebook page (4 positive; 2 positive +2 negative; 4 negative). A randomized-one-factor-between-subjects-experiment with two moderators, initial dread and initial optimism, was carried out. The study was conducted in the Netherlands on a sample that was a representative of the population of Dutch Internet users with respect to age and gender. Randomization was successful for all examined variables, except gender. Including gender as a covariate in the analysis corrected for this. Variables were reliably measured.

4.1.1 | Main effect of comment valence

Results showed a significant, small to medium-sized effect of comment valence in the expected direction on risk perception, benefit perception and attitude. The more positive the comments read by the participants, the lower risk perception, the higher benefit perception and the more positive the attitude toward nanodesigned food. The effects on perceived retail safety, anxiety, positive emotions, willingness to buy and information need were not significant. This might perhaps be attributable to the focus of the comments on the risks, benefits and evaluation of nanodesigned food. Another explanation could be that the comments did not arouse an affective response because the participants perceived a high level of control over their exposure to the risk.

In line with previous research on Facebook comments (Betsch et al., 2011; Seo et al., 2015; Winterbottom et al., 2008), there was thus some evidence to support Hypothesis 1 and the principle of social proof as operationalized in the valence of comments below a Facebook post. This finding is the more remarkable, because the alleged authors were characterized by a name only, and neither background information nor picture was provided. The effect was thus not attributable to the author being presented as an expert or as someone to whom the participant was similar. Granted that it is the perceived expertise of or similarity with an author that often counts (Hilverda et al., 2017), the authority principle and the similarity principle do not seem to provide a plausible explanation of our results.

The principle of social proof specifies uncertainty about an appropriate course of action as a relevant condition (Cialdini, 2001). This suggests that the effects of the comments would depend on the individual's level of knowledge. We found no evidence for this. An explanation might be that anxiety related to nanodesigned food was not high (Kuttschreuter & Hilverda, 2019). To better understand the conditions that lead to social proof future research should focus on a human enhancement technology that generates a higher level of anxiety and concern.

The affect heuristic suggests another mechanism underlying the effect of comment valence. This heuristic states that a risk-related message may generate an affective response in the message's recipient, which would result in effects on the perception of the risks as well as the benefits of the message's topic (Finucane et al., 2000). As our comments were mostly risk-related, our result that comment valence affected risk and benefit perception lends some support for the affect heuristic. To further explore the mechanisms behind the effect of comment valence, future research might include an instrument to measure the affect aroused by the comments.

4.1.2 | Main effects of initial dread and initial optimism

As new technologies carry the expectation of potential benefits at the expense of potential risks, initial attitudes were split into feelings of dread and optimism. Results showed highly significant main effects for initial dread and initial optimism on all the dependent variables. This is in line with the literature (Frewer et al., 1999; Frewer et al., 2003; Van Dijk et al., 2012) and confirmed hypotheses 2 and 4.

Interestingly, for all variables, both main effects were significant. All dependent variables thus reflected both the potential benefits as well as the potential negative consequences of the technology. This suggests that in the case of new human enhancement technologies, individuals base their cognitions, feelings and behavior on the anticipated positive as well as on the potential negative consequences (Frewer, 2017).
4.1.4 | Interaction effects of comment valence and initial dread and initial optimism

Cognitive dissonance theory and empirical evidence demonstrated that initial attitudes may moderate the effect of risk–benefit messages (Frewer et al., 2016; Gaspar et al., 2016; Narayan et al., 2011). Distinguishing between initial feelings of dread and optimism, we studied whether this also held for nanodesigned food.

For two variables, a small to medium-sized, but significant interaction between comment valence and initial dread was observed. For risk perception, the relationship between initial dread and risk perception was strongest for the participants who read the set of comments of mixed valence, followed by those who read the positive, and the negative comments. This suggests that the participants who read comments of mixed valence relied the most on their initial feelings of dread. An explanation could be that comments of the mixed valence did not motivate participants high on initial dread to re-evaluate their ideas, whereas exclusively positive or exclusively negative comments did.

Among the participants high on initial dread, those who read the mixed set of comments scored highest on risk perception. This might perhaps be due to the uncertainty or negative affect evoked by the comments of mixed valence (Boholm & Larsson, 2019). Contrary to expectation, among participants high on initial dread, those who read the negative comments scored lowest. Following the Extended Parallel Processing model, this could be indicative of a coping process where individuals apply a fear-reduction strategy instead of risk-reducing behavior (Witte, 1992).

Willingness to buy was highest for the participants low on initial dread who read the positive comments. This supported the idea that congruent information carried more weight than incongruent information. At the same time, the effect of initial dread on willingness to buy was strongest for the participants who read the positive comments. An explanation could be that the information in the positive comments was already familiar to the participants and already included in their attitude toward nanodesigned food.

All in all, results partly confirmed H3: we did find two significant interactions, and one of these suggested that comments that were congruent to initial feelings of dread carried more weight. The explanation given above are however highly speculative and in need of corroborated future research.

There was no significant interaction between comment valence and initial optimism. H5 was thus rejected. Perhaps processes based on positive attitudes or emotions are simpler than those that involve negative attitudes and emotions.

4.1.4 | Information need

Systematic information processing involves the effortful comparison of information and resolving inconsistencies as opposed to the use of peripheral cues that characterizes heuristic processing (Chaiken, 1980; Griffin et al., 1999; Kahlor et al., 2003; Trumbo, 1999). In our view, information need plays an important role in systematic processing, but not as much in heuristic processing. To find out whether our findings could be attributed to the systematic processing of the contents of the comments as opposed to the heuristic processing, we studied the effect of comment valence on information need. The participants expressed a high need for information, yet comment valence did not affect their information need. Information need was further only very weakly related to just one of the other dependent variables. The effects of the comments should thus not be attributed to the participants’ systematic processing of the comments’ content, but rather to heuristic processes.

An unexpected and intriguing result regarding information need was that it was significantly positively related to initial dread as well as initial optimism. This suggests that feelings of dread and optimism may both motivate a need for information. While the former is in line with the Risk Information Seeking and Processing model (Griffin et al., 1999), the role of positive feelings in information need and information seeking has been given little attention (Savolainen, 2014). New technologies are designed to create some kind of benefits. To extent the RISP model to apply to new technologies, such as human enhancement technologies, benefit perception should be included alongside risk perception. Further research into the role of positive feelings and feelings of anticipation in information seeking is advised.

4.2 | Generalization of the findings

An important question is to what extent results of our study can be generalized to other human enhancement technologies, other forms of social proof and other countries.

4.2.1 | Other technologies

Statements on the generalizability of our results to other human enhancement technologies are highly speculative. Main reasons are the lack of empirical evidence and the broad range of existing human enhancement technologies (Dijkstra & Schuijf, 2016). Concerns about new technologies are, at least partly, issue-specific (Besley & McComas, 2015). This is further complicated by the inconsistent relationships between the determinant of the acceptance of a technology such as risk and benefit perception (Bearth & Siegrist, 2016). Further research is needed.

4.2.2 | Other conceptualizations and operationalizations of “social proof”

Following Amblee and Bui (2011) and Lee et al. (2011), we defined social proof as any form of social information, including behavior, experiences and viewpoints. In the current information, landscape individuals can also be influenced by information from other people through social media, such as Facebook comments or Twitter posts. In line with the principle of social proof as defined here, our study showed that such online messages that are written in an informative way by expressing viewpoints and behavioral intentions of other people might influence the individual’s perceptions and attitude. Facebook messages might however also be framed as expectations by other people who state what they think ought to be done. It is not clear to what extent findings on the informational social influence of
Facebook comments, such as those in our study, can be generalized to Facebook comments that reflect normative social influence by communicating values and behavioral norms. Future research is needed to examine whether assimilation of injunctive social norms may occur when Facebook comments related to a human enhancement technology are written in a normative manner.

Our operationalization of social proof consisted of plain, short, risk-related texts on Facebook with a single emotion issued by an character identified by a name only; no images. Familiarity with an author affects a message’s effect (Martensen et al., 2018). We might therefore assume that effects of Facebook comments will be stronger when they are issued by someone to whom the individual is familiar. One might further expect that an image draws the attention away from the text. That would imply that a text with an image would have a smaller effect than a text without one. Unless, of course, the image underlines the text. A related aspect is the clarity of the proof shown by others. Social proof in terms of the number of likes associated with a text seemed too subtle for platform users to notice (Hilverda et al., 2018). Finally, as the authors of the comments were presented as ordinary people without any obvious expertise on nanodesigned food, one should be careful to generalize the findings to social media platforms, such as LinkedIn and Twitter that are often used by professionals to disseminate profession-related information. Further research seems indicated.

4.2.3 | Other countries

There are two important aspects to the generalization of our findings to other countries: social media usage and the level of knowledge and attitude related to nanodesigned food.

In the Netherlands, Internet penetration and the social media usage are both high (CBS, 2013, 2015). The Dutch thus have ample experience with social media expressions, what might mean that Dutch people are more aware of their potential influences and less prone to be influenced by them. The impact of social media expressions might thus be stronger in countries, where the level of experience with social media is lower. Our results, however, also showed that the frequency of Facebook use did not play a role in the responses to the comments. This suggests that the high level of experience with social media does not detrimentally affect the generalizability of our results.

Regarding the level of knowledge on nanodesigned food and the attitude toward it, the situation in the Netherlands seems to correspond to the international scene. Knowledge on nanotechnology is low and attitudes are not yet strongly established (Van Giesen, Fischer, & Van Trijp, 2018). The generalizability of our findings is thus not detrimentally affected by the level of knowledge on nanodesigned food in the Netherlands.

4.3 | Implication for risk communication practice

Our study showed that social media expressions by other people without obvious expertise may affect the individual’s views regarding a human enhancement technology. Risk communicators should be aware of this phenomenon. They should not ignore the discourse on social media, but monitor it and intervene, if applicable, by entering the conversation, spreading their arguments and views, and, if applicable, correct inaccurate or false information (Veil, Buehner, & Palenchar, 2011). This would provide platform users with information that might assist them in a better understanding the risks and benefits of the technology and would increase informed decision-making.

One scenario is that the social media discourse disproportionally focuses on the risks of a new human enhancement technology. Monitoring the discourse would enable risk communicators who want to avoid that the public misses out on the benefits of the technology to counter potential detrimental effects of negative expressions on social media. Another scenario is that the social media discourse disproportionally focuses on the benefits of a new human enhancement technology. In that case, monitoring the discourse would alert risk communicators and enable those who want to increase public awareness of the risks of the technology, to respond timely.

4.4 | Final comments

This is one of the first studies that examined the effects of comments on Facebook regarding nanodesigned food. This study thus focused on indirect enhancement of human health and the functioning of the human body through the enhancement of food by nanotechnology. It investigated to what extent social proof impacted views on the application of nanotechnology in food. Main finding was that the valence of the comments on Facebook on nanodesigned food affected the individual’s risk perception, benefit perception and attitude regarding this technology.

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ENDNOTES

1 In the food sector, nanotechnology is also used for different purposes, such as to improve food color, texture or flavor; to improve food packaging by adding nanosensors to detect contamination; and to increase product shelf life (Frewer et al., 2011; Hayes & Sahu, 2017).
2 Randomization was successful (χ² (2, N = 362) = 0.02, p = .99). There were, however, more participants in the mixed condition who incorrectly answered the manipulation check question. It is unclear why this was the case. As these participants were excluded from the data analysis, the number of participants in the mixed condition decreased more than those in the positive and negative condition (χ² (2, N = 263) = 23.89, p ≤ .0005). In the final data set, there was however no significant statistical difference in the number of participants in the three valence conditions (χ² (2, N = 289) = 4.28, p = .12).
3 In the study, the number of likes beneath the comments was also manipulated. For each of the three conditions, there was a high-number-of-
likes version and a low-number-of-likes version. The manipulation check showed that this manipulation was not successful: participants just did not seem to pay attention to the number of likes. Analysis showed that there were no significant relationships between the number of likes beneath the comments and (a) comment valence, (b) the dependent variables, (c) the moderators initial dread and initial optimism, (d) the perceived knowledge on nano-designed food, and (e) socio-demographics. The distinction between the high-number-of-likes and the low-number-of-likes condition could therefore be dropped from the study.

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Dr. Margot Kutscherreuter is assistant professor at the University of Twente, Netherlands. Her research interest and expertise lie with risk perception and risk communication. A first line of studies focuses on (1) how individuals perceive risks, (2) what determines their risk perception and (3) to what extent they use traditional and social media to seek and exchange risk related information. A second research line focuses on the way individuals respond to risk information. This relates to (4) the effects of risk information on the individual’s perceptions, attitudes and behaviors, and to (5) the effectiveness of providing risk information. In these respects, she is particularly interested in social media and the potentials of new communication strategies as serious games. She is a fellow of the Society for Risk Analysis (SRA) and has served on its Council. She also served on the Board of the Society for Risk Analysis Europe (SRA-E).

Dr. Femke Hilverda is currently working as an assistant professor in social psychology and risk communication at Erasmus School of Health Policy and Management, Rotterdam, the Netherlands. Central to her line of research is the idea of informed decision-making about health-related topics. In her PhD project, she examined how individuals make sense of food risk information in an online context in order to help risk communicators better tailor information provision, which would ultimately enable individuals to make well-informed decisions. She obtained her PhD in 2017 at the department of Psychology of Conflict, Risk, and Safety at Twente University, Enschede, the Netherlands. Her current research focuses on three main themes: (1) the role of new information channels such as the Internet and more specifically social media in risk communication, (2) the concept of social influence in relation to health behavior, and (3) hard-to-reach target groups for health communication.
APPENDIX A - CRUCIAL WORDING THAT CHARACTERIZES THE VALENCE OF THE COMMENTS

What do you think about the application of nanotechnology in foods?

Positive comments
- Comment 1: I saw once on TV how we can use nanotechnology and I am happy about the application of nanotechnology in foods!
- Comment 2: I think people get ill less often because of the nanotechnology in foods; therefore it is safe!
- Comment 3: I am very much convinced that nanotechnology in foods makes food products healthier.
- Comment 4: To the best of my knowledge, nanotechnology in food products is not harmful and I will just eat it!!

Negative comments
- Comment 1: I saw once on TV how we can use nanotechnology and I am unhappy about the application of nanotechnology in foods! 😞
- Comment 2: I think people get ill more often because of the nanotechnology in foods; therefore it is dangerous!
- Comment 3: I am very much convinced that nanotechnology in foods makes food products unhealthier.
- Comment 4: To the best of my knowledge, nanotechnology in food products is harmful and I just won't eat it!!
### APPENDIX B - DETAILS ON THE MEASURING INSTRUMENTS

#### Table A Scales, Items and Reliabilities of the Constructs ($n = 289$)

| Measures                          | Characteristics                                                                 | Scale                                                                 | Reliability |
|----------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------|-------------|
| 1. Risk perception               | What do you think about food products in which nanotechnology has been applied? | 7-point Likert scale from 1 = strongly disagree to 7 = strongly agree | .94         |
|                                  | 1. I think that food products in which nanotechnology has been applied are bad for my health |                                                                      |             |
|                                  | 2. I think that there are many risks attached to food products in which nanotechnology has been applied |                                                                      |             |
|                                  | 3. I think food products in which nanotechnology has been applied have many downsides |                                                                      |             |
|                                  | 4. I think that food products in which nanotechnology has been applied are hazardous to my health |                                                                      |             |
| 2. Benefit perception            | What do you think about food products in which nanotechnology has been applied? | 7-point Likert scale from 1 = not at all to 7 = very much             | .94         |
|                                  | 1. I think that food products in which nanotechnology has been applied have many benefits |                                                                      |             |
|                                  | 2. I think that food products in which nanotechnology has been applied are good for my health |                                                                      |             |
|                                  | 3. I think that food products in which nanotechnology has been applied are beneficial to my health |                                                                      |             |
|                                  | 4. I think that there are many benefits attached to food products in which nanotechnology has been applied |                                                                      |             |
| 3. Perceived retail safety       | To what extent do you think supermarkets are able to adequately handle risks attached to food products? | 7-point Likert scale from 1 = strongly disagree to 7 = strongly agree | .94         |
|                                  | 1. I can rely on it that all food products that are for sale in supermarkets are adequately checked |                                                                      |             |
|                                  | 2. I have complete confidence in the safety of the food products that are for sale |                                                                      |             |
|                                  | 3. Food products for sale in supermarkets are safe to eat |                                                                      |             |
| 4. Anxiety                       | When I think of eating food products in which nanotechnology has been used, I feel ... | 7-point Likert scale from 1 = not at all to 7 = very much             | .94         |
|                                  | 1. Anxious                                                                       |                                                                      |             |
|                                  | 2. Worried                                                                       |                                                                      |             |
|                                  | 3. Afraid                                                                        |                                                                      |             |
|                                  | 4. Concerned                                                                     |                                                                      |             |
| 5. Positive emotions             | When I think of eating food products in which nanotechnology has been used, I feel ... | 7-point Likert scale from 1 = not at all to 7 = very much             | .96         |
|                                  | 1. Satisfied                                                                     |                                                                      |             |
|                                  | 2. Positive                                                                      |                                                                      |             |
|                                  | 3. Happy                                                                         |                                                                      |             |
|                                  | 4. Optimistic                                                                    |                                                                      |             |
| 6. Attitude toward nanotechnology| Thinking of benefits as well as the downsides of the application of nanotechnology in food, what is your overall view of this application? | 7-point bipolar scale                                               | .95         |
|                                  | 1. Negative - positive                                                           |                                                                      |             |
|                                  | 2. Bad - good                                                                   |                                                                      |             |
|                                  | 3. Detrimental to my health - beneficial for my health                            |                                                                      |             |

(Continues)
| Measures                        | Characteristics                                                                 | Scale                                                                 | Reliability |
|--------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------|-------------|
| 7.                             | **Willingness to buy**                                                           | Suppose you would like to buy the following food products. How likely would you be to buy the kind that was been enhanced by the application of nanotechnology? | 7-point Likert scale from $1 = \text{not likely at all}$ to $7 = \text{very likely}$ | .94         |
|                                | 1. An apple with additional vitamins                                             |                                                                      |             |
|                                | 2. Potato chips that remain crispy for a longer period of time                    |                                                                      |             |
|                                | 3. Milk that is better preservable                                               |                                                                      |             |
|                                | 4. Mayonnaise low on calories, but with similar taste                            |                                                                      |             |
|                                | 5. Orange juice with additional vitamin C                                        |                                                                      |             |
|                                | 6. Bread with additional Omega-3                                                 |                                                                      |             |
|                                | 7. Coffee creamer that does not lump together                                     |                                                                      |             |
| 8.                             | **Information need**                                                            | Would you like to know more about food products in which nanotechnology had been used? | 7-point Likert scale from $1 = \text{strongly disagree}$ to $7 = \text{strongly agree}$ | .95         |
|                                | 1. I would like to learn more about the advantages and disadvantages of nanotechnology in food products |                                                                      |             |
|                                | 2. I would like to know more about the most important differences between products in which nanotechnology has been used and those in which it has not been used |                                                                      |             |
|                                | 3. I would like to know more about how I can recognise a product in which nanotechnology has been used |                                                                      |             |
| 9.                             | **Initial dread**                                                               | What do you think of the application of nanotechnology in food?      | 7-point Likert scale from $1 = \text{strongly disagree}$ to $7 = \text{strongly agree}$ | .87         |
|                                | 1. As far as I know, the risks of nanotechnology are still rather unknown among the scientists who study it. |                                                                      |             |
|                                | 2. I am afraid that the application of nanotechnology in food products has negative consequences |                                                                      |             |
|                                | 3. I fear that we will involuntarily be exposed to the risks of food products in which nanotechnology has been applied |                                                                      |             |
|                                | 4. I am afraid that, in the case of the application of nanotechnology in food, we cannot timely interfere if something goes wrong. |                                                                      |             |
| 10.                            | **Initial optimism**                                                            | What do you think of the application of nanotechnology in food?     | 7-point Likert scale from $1 = \text{strongly disagree}$ to $7 = \text{strongly agree}$ | .90         |
|                                | 1. I think that nanotechnology in food can lead to better products              |                                                                      |             |
|                                | 2. I am convinced that nanotechnology in food offers many opportunities         |                                                                      |             |
|                                | 3. I think many people may profit from the application of nanotechnology in food |                                                                      |             |
|                                | 4. The application of nanotechnology in food means scientific progress          |                                                                      |             |
| 11.                            | **Perceived knowledge on nanotechnology in food**                               | How well informed are you about nanotechnology in food products?    | 7-point Likert scale from $1 = \text{strongly disagree}$ to $7 = \text{strongly agree}$ | .88         |
|                                | 1. My knowledge on nanotechnology in food products is sufficient                |                                                                      |             |
|                                | 2. I am sufficiently informed on the benefits and downsides of nanotechnology in food products |                                                                      |             |
|                                | 3. I am satisfied with what I know about nanotechnology in food products        |                                                                      |             |
| 12.                            | **Evaluation of the comments**                                                  | What do you think about the Facebook page?                          | 7-point Likert scale from $1 = \text{strongly disagree}$ to $7 = \text{strongly agree}$ | Not applicable |
|                                | 1. I perceive the statements in the comments to be clear                        |                                                                      |             |
|                                | 2. I consider the comments to be emotionally laden                             |                                                                      |             |
|                                | 3. I can used these comments to advise a friend on this topic                   |                                                                      |             |
|                                | 4. In my opinion, the comments come across as being biased                     |                                                                      |             |
| Measures | Characteristics |
|----------|-----------------|
| 13. Online media use | How frequently do you use the following online media? |
| | 1. Facebook |
| | 2. Twitter |
| | 3. Skype |
| | 4. Forums or blogs |
| Scale | 7-point frequency measure from 1 = less than once a month to 7 = multiple times a day |
| Reliability | Not applicable |