

# The influence of information on consumers' risk and benefit perceptions of nanotechnology

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# Introduction

A new technological innovation is the use of nanotechnology. Nanotechnology is a technology which is executed at an atomic or molecular scale, in a range between 1 and 100 nm. There are distinct differences between the properties of a material on nanoscale and the same material on a conventional scale, for example in the strength of the material (Siegrist, Stampfli, Kastenholz & Keller, 2008). Nanomaterials are stronger than conventional materials (Phys.org, 2013), and this can be beneficial (Kahan, Braman, Slovic, Gastil & Cohen, 2009). Nanotechnology is already applied in various fields such as the pharmaceuticals, the production of energy and electronics. It creates benefits for consumers, for example making sportswear odour-free by adding silver particles that serve as anti-bacterial agents (Science Editor, 2008). Nanotechnology is expected to become more and more widespread in the future (Siegrist et al., 2008). An example of this spreading is its recent introduction in the food sector (Sozer & Kokini, 2009). Scientists have found that there is potential for the application of nanotechnology in practically any sector of the food industry (agriculture, processing, products and nutrition). Possible applications are for example in new pesticides, UV protection and drinking water purification (Duncan, 2011).

It is expected that the use of nanotechnology in the food(-related) industry will bring major benefits and that it will add value as well (Rossi et al., 2014). Examples of those benefits for the industry are new tastes and textures, less use of fat, better packaging and security of food products (Chaudhry et al., 2008).

These products with nanotechnology will only become a success if the public sees them as beneficial as well. However, since nanotechnology is a new technology, the public has a relatively low level of knowledge about it (Lee & Scheufele, 2006). A lack of knowledge causes risk perceptions (Toumey, 2009), which can cause problems for the market breakthrough of these innovative products. Providing information can be of great influence on the perceptions of the consumers (Smed, 2012), thus it is important to know which kind of information works best to increase benefit perceptions and lower risk perceptions. With higher benefit perceptions than risk perceptions, consumers get a positive attitude towards nanotechnology. A positive attitude can lead to a higher willingness-to-buy (McCarthy & Vilie, 2002), which is desirable for the upcoming nanotechnology industry. However, an attitude can only be formed if the consumers have some knowledge about nanotechnology.

This study will contribute to this problem by doing research on the influence of different kinds of information. If that is known, it can be used in marketing strategies to change the public's attitude via risk and benefit perceptions.

To reach this goal, this study will answer the following research question: "*To what extent do different kinds of information influence the risk and benefit perceptions of the consumer towards nanotechnology?*".

This question will be answered by doing a literature study and an experimental survey. The data of the experiment will be analysed using the statistical program SPSS.

The results of this study can give insights into the effects that different kinds of provided information can have on the risk and benefit perceptions of consumers. These perceptions will, in turn, affect the attitude of the public towards nanotechnology. This is useful

information, especially for companies who produce consumer products with nanotechnology in it, because they can adjust their marketing strategies to more effective ones. They should provide their target segment with the information that works best in creating positive attitudes towards the products that the companies offer. Ultimately, this might lead to a widespread acceptance of nanotechnology and a market breakthrough for the products with nanotechnology in it.

# Literature overview

To investigate what literature already exists concerning nanotechnology and risk and benefit perceptions, and what results this literature already has found, a literature overview has been made.

There has been made use of the search engine Scopus, and there is searched on the following keywords: "role" AND "affect" AND "nanotech\*" AND "consumer\*", "role" AND "emotion" AND "new technolog\*" AND "consumer\*", "consumer acceptance" AND "nanotechnology", "risk perception" AND "new technolog\*" AND "consumer", "benefit" AND "perception\*" AND "risk" AND "information", "information" AND "consumer perception, "risk" AND "benefit" AND "perception" AND "nanotechnology".

These searches led to the following useful articles. An overview of what these articles are about can be found in table 1.

**Table 1** Results of the literature overview

<i>Study</i>	<i>Findings on risk perceptions</i>	<i>Findings on benefit perceptions</i>	<i>Main results</i>
Matin et al. (2011)	Nanotechnology raises environmental issues.	Supporters of nanotechnology believe that science and technology are beneficial for society.	Food neophobia plays a role in consumers' risk and benefit perceptions towards new technologies, for example nanotechnology.
Lusk, Roosen & Bieberstein (2014)	New food technologies are perceived riskier when people feel not in control, when the product has unfamiliar characteristics.	Benefit perceptions are highly (negatively) correlated with risk perceptions.	Benefits are less obvious to see for new technologies such as nanotechnology.
Giles, Kuznesof, Clark, Hubbard & Frewer (2015)	Concerns under consumers are raised, underpinned by a fear for the unknown.	Agri-food related nanotechnology is mostly accepted when benefits can be identified.	Providing information to gain an informed public can lead to less consumer concerns.
Sodano, Gorgitano, Verneau & Vitale (2016)	There is a higher perception for risks than for benefits, concerning new technologies.	In case of food products with nanotechnology, benefits could be perceived negatively.	It is important to provide information to the public (especially about benefits), to increase public acceptance.

<i>Study</i>	<i>Findings on risk perceptions</i>	<i>Findings on benefit perceptions</i>	<i>Main results</i>
Siegrist, Stampfli, Kastenholz & Keller (2008)	Some companies do not adequately address possible risks of nanotechnology.	People who perceive more benefits perceive less risks than people who perceive less benefits.	Perceived control and affect are important factors that influence consumers' risk and benefit perceptions.
Verbeke & Liu (2014)	Negative information significantly increases risk perceptions (on GM).	Benefit information leads to a higher intention to eat pork.	Information provision can make a difference in consumer attitudes.
Smed (2012)	Risks are considered more important than benefits.	Perceived benefits can contribute to consumers' willingness to buy.	Direct obtained information has most effect.
Cobb & Macoubrie (2004)	A nanotechnology arms race is seen as the most important risk.	The American public sees more benefits than risks in nanotechnology.	When people have more knowledge on nanotechnology, they perceive more benefits than risks.
Siegrist & Keller (2011)	Labelling products with nanotechnology leads to higher risk perceptions. Consumers see a label as a sign of danger.	Benefit perceptions get reduced by labelling products with nanotechnology.	Providing information about general (health) benefits or risks of nanotechnology influences the publics' perceptions towards nanotechnology.
Steenis & Fischer (2016)	Risk perceptions increase when nanotechnology comes closer to the consumer.	Benefit perceptions remain the same, regardless the proximity of nanotechnology to the consumer.	Proximity of nanotechnology plays a role in the consumers' risk and benefit perceptions.

The results of this literature overview show that it is useful to research the influence of information on risk and benefit perceptions, since the results suggest that knowledge can be an important factor in risk and benefit perceptions. Previous literature showed that risk and benefit perceptions are for example influenced by unfamiliarity or neophobia. Information can decrease these factors, thus influence risk and benefit perceptions. Siegrist et al. (2008) pointed out that different information about nanotechnology might lead to differences in risk perceptions, but they were not sure about this. This study therefore contributes to the already existing literature about risk and benefit perceptions towards nanotechnology, by researching the influence of different kinds of information on these perceptions.

# Theoretical framework

Information that is provided to consumers can play an important role in their perceptions of products, this counts especially for products with unobservable attributes (Smed, 2012). This means that provided information is an important factor that influences how people view food products with nanotechnology (Vandermoere, Blanchemanche, Bieberstein, Marette & Roosen, 2011), since nanotechnology is unobservable. Provided information can increase people's knowledge about the product concerned. An increase in public knowledge on science is believed to lead to a higher public support (Ho, Brossard & Scheufele, 2008). However, there is a general lack of knowledge and awareness of new food technologies such as nanotechnology (Matin et al., 2012). A study in the United States showed that nanotechnology was not well known across different age-groups (Waldron, Spencer & Batt, 2006). These results suggest that the general level of knowledge of the public about nanotechnology is low, and this may imply a low public support of nanotechnology in food products.

To increase the public support, it is important to know what kind of information influences the consumers positively in the case of nanotechnology, so that the public can be provided with the right kind of information. When it is known what the best kind of information to be provided is, useful strategies can be applied to increase the knowledge of the public by providing the best kind of information, and thereby increase the public support of food products with nanotechnology.

Provided information can be positive or negative towards the subject, and it can come in little or in high amounts. So there are four possibilities of different types of information that people can receive, namely, little positive and little negative information, much positive and little negative information, little positive and much negative information, and much positive and much negative information. These conditions are also presented in figure 1.

		POSITIVE	
		Little	Much
NEGATIVE	Little	Little information	Much positive information
	Much	Much negative information	Much positive and negative information

**Figure 1** Different conditions on what types of information people can get on nanotechnology

The influence of these different types of provided information on people's risk and benefit perceptions, and their attitude, will each be discussed.

### *Little information*

Knowledge is a critical factor in creating attitudes, because people use their knowledge to create and maintain stable attitudes (Petty & Krosnick, 1995). Thus, it can be said that people with little knowledge, and who get little information, will have weaker attitudes towards the object concerned. A weak attitude can lead to people having low concern about the product.

Also, when people have a low level of knowledge, it will lead to less understanding of the information that scientist communicate to the public (Castellini et al., 2007). This means that it is not very like that people who receive little information will increase their level of knowledge a lot, because they might not clearly understand the information that they receive. Risk perceptions can be affected by the level of knowledge. When people are having little knowledge, they can perceive higher risk perceptions (Slovic, 1987). People who have little knowledge also anticipate less benefits than people who have more knowledge (Cobb & Macoubrie, 2004).

A weak attitude may imply that the consumers do not really bother the product concerned. In case they are, they probably have a neutral attitude. Combined with higher risk perceptions, people's attitude can also be slightly negative.

### *Positive information*

People who mainly receive positive information, are more likely to perceive benefits of the object concerned. These higher benefit perceptions lead to a more positive attitude (Zhu & Xie, 2015).

A study conducted in China, which studied the consumer perceptions of eating pork after being communicated with different kinds of information, showed that providing people only with positive information increased a positive change in the intention to eat pork. The consumers perceived more benefits of the pork, they got more positive about the healthiness and safety of eating pork (Verbeke & Liu, 2014).

However, it may take some time before these behavioural changes occur, since the acceptance of positive information as trustworthy information goes gradually (Liu, Huang & Brown, 1998).

A study from Lion & Meertens (2001) researched whether risk-taking people were more prone to positive information, but no evidence was found. This may imply that positive information can influence all consumers, regardless what their attitude towards risks is.

### *Negative information*

Provided negative information may lead to lower perceptions of the product quality (lower benefit perceptions), and thus it may lead to a reduction in the intention to buy the product, or a reduction in the actual consumption (Verbeke & Liu, 2014). Negative information leads to higher risks perceptions, which affects the attitudes of the consumers in a negative way (Zhu & Xie, 2015). Provided negative information has a greater impact than provided positive information on consumers' perceptions, because people find it more important to avoid chances of harm than the possibility of gaining a benefit (Verbeke & Liu, 2014). This effect is also found in a Danish study on the willingness to buy organic food. Negative information about conventional fruit led to more people buying organic fruits and vegetables than positive information about these organic foods (Smed, 2012).

Negative information has not only a greater impact than positive (or mixed) information, but this information has also a longer lasting impact (Zhu & Xie, 2015). Negative information may particularly increase risk perceptions in the agri-food sector (George, Kaptan, Lee, & Frewer,

2014). This means that food products with nanotechnology are even more sensitive to negative information than other products with nanotechnology.

### *Mixed information*

Next to gaining no information, only positive or only negative information, consumer can also get a mix of both. In this case, it is called mixed information. Mixed information can lead to ambivalent attitudes, and occurs when (available or provided) information is incongruent (van Harreveld, van der Pligt, & de Liver, 2009).

It can mean that people see positive and negative sides to the product, but it can also be that people become neutral. This depends on the amount of provided information that people get. When the people's attitude is ambivalent, it is not only possible that their attitude will be neutral, it can also be that they will lean more towards a negative or positive attitude. If that happens, the ambivalence of the consumers get reduced, and they get more extreme attitudes (Fischer, van Dijk, de Jonge, Rowe, & Frewer, 2012). This is likely to happen, since ambivalent attitudes are weak (Nordgren, van Harreveld & van der Pligt, 2006). This might be due the fact that consumers can find it hard to balance the mix of positive and negative information (Verbeke & Liu, 2014), which can lead to uncertainty and frustration (Chang, 2013). To solve this discomfort, people start processing biased information (Nordgren, van Harreveld, & van der Pligt, 2006). When this happens, it is more likely that people process more negative information, and that the ambivalent attitude will change into a negative attitude (Verbeke & Liu, 2014). People tend to seek for negative information to reduce their ambivalent attitude (Yang & Unnava, 2016). When consumers gain and process more negative information, this means that the consumers will perceive risks slightly higher than benefits.

### *Hypotheses*

According to the literature, it can be stated that different kinds and amounts of information influence risk and benefit perceptions to a certain extent.

The following can be hypothesized.

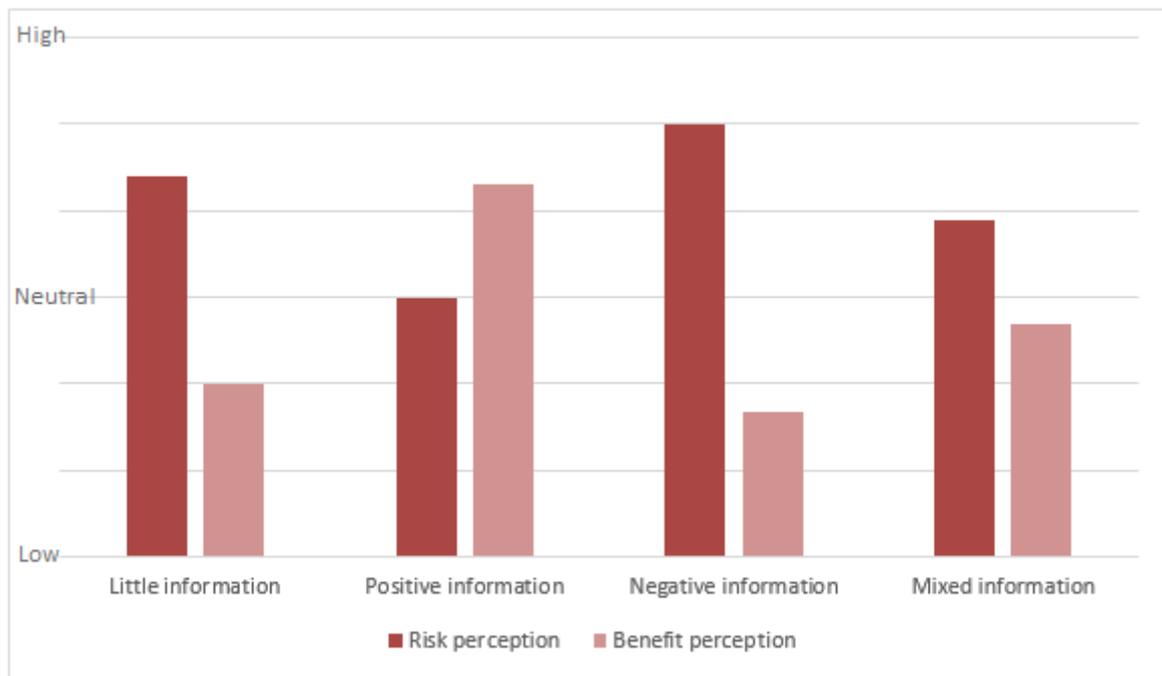
If people are communicated with little information (little positive and little negative information), they perceive higher risks and less benefits compared to a neutral state.

If people get a lot of positive information and no negative information, people will perceive a lot of benefits, and the perceptions of risks will stay neutral.

When people get a lot of negative information and no positive information, people will perceive a lot of risks and the benefits will be perceived as less than neutral.

Lastly, when people perceive both positive and negative information in equal amounts, they will get an ambivalent attitude, but to reduce this, they will lean more to negative side which means that they will perceive more risks than benefits.

This is graphical shown in figure 2.



**Figure 2** The hypothesized influence of different types of information on risk and benefit perceptions.

In short, the following hypotheses are given.

*H1*: Little information increases risk perceptions and lowers benefit perceptions.

*H2*: Providing positive information compared to not providing positive information leads to higher benefit perceptions, and no difference in risk perceptions.

*H3*: Providing negative information compared to not providing negative information leads to higher risk perceptions and lower benefit perceptions.

*H4*: Providing mixed information leads to higher risk perceptions than based on individual effects.

# Methods

An experiment is carried out to find out to what extent the different kinds of information influence the consumers' perceived risk and benefits.

## *Design and stimuli*

The study is a 2 (positive) x 2 (negative) between subjects design. There are four conditions. The *little information* condition only gets neutral information. The *positive information* condition has some positive information about nanotechnology added to it. This is the same for the *negative information* condition, but this condition has some negative information added to the neutral information. Finally, the *mixed information* condition gets both positive and negative information added.

The neutral information consists of the following lines:

*“Consider buying this bottle of juice. The plastic bottle contains nanoparticles. Nanoparticles are one form of nanotechnology. This technology is executed at atomic or molecular level and cannot be seen with the human eye. Nanotechnology creates materials that differ in properties from conventional materials. Nanoparticles are used in different industries already, for example in the clothing industry and the food industry. It can be used in food packings, such as this plastic juice bottle.”*

In the *positive information* condition, the following lines are added: *“Nanoparticles have beneficial properties over conventional materials. This bottle with nanoparticles is stronger and has specific properties. For example, this bottle is antimicrobial and can detect when the juice inside is expired.”*

In the *negative information* condition, the following lines are added: *“There can be health risks when the nanoparticles get into the juice and hence inside the human body. Nanoparticles might also cause a risk for the environment since the bottle with nanoparticles might become non-recyclable waste.”*

The *mixed information* condition gets both positive and negative information lines added to the neutral information. The four conditions (in Dutch, since the survey was held under Dutch students), together with the picture used, can be found in Appendix 1.

## *Measures*

After the manipulation, the respondents get questions about their risk and benefit perceptions towards nanotechnology, and their attitude. The attitude questions are based on Fischer et al. (2012). All questions can be found in Appendix 2.

The risk and benefit perception questions are answered on a 7 points Likert-scale, ranging from 1 (“extremely disagree”) to 7 (“extremely agree”). The attitude questions are answered on a 7 points semantic differential scale.

The survey ends with general questions, concerning gender, age and prior knowledge (which is answered on a 7 points Likert-scale, ranging from “Nothing” to “A lot”).

### *Participants*

One participant filled in the survey as pilot. The survey was clear and fully understood, so no changes were made. The results of this pilot are not used in the analysis.

Participants were recruited via Facebook. The web link to the survey was sent to various Facebook groups, but many participants were also recruited with an individual message. The survey was online for 7 days.

All 173 participants were Dutch speaking.

### *Analyses*

To analyse the results, a factorial ANOVA is carried out in SPSS.

There are two linear regression analyses conducted. One to check whether prior knowledge predicts attitude, and one to check whether the risk perception and benefit perception predict attitude.

A one-way ANOVA is done to check the contrasts between the little information condition and the other conditions, to see whether there is a contrast between those conditions.

Finally, to see which kinds of information influence the attitude, and via which route (risk or benefit perceptions), a mediation analysis is carried out.

# Results

## *Descriptive statistics*

In total, 173 persons started the survey. It was completed by 137 persons. The data of the incomplete 36 surveys was deleted from the dataset in SPSS.

Of the respondents, 55 were male (40.1%) and 82 were female (59.9%). Age ranged from 17 to 28 ( $M= 22.04$ ;  $SD= 3.82$ ), with two outliers aged 47.

The level of prior knowledge of the participants about nanotechnology was low to moderate ( $M= 3.09$ ;  $SD= 1.82$ ). Prior knowledge predicts attitude significantly ( $F(16.004)=19.929$ ,  $p<0.01$ ), with an R Square of 0.106 and an Unstandardized Coefficient (B) of 0.210.

All four conditions were roughly equally represented. 34 respondents got the *little information* condition (24.8%), 33 respondents got the *positive information* condition (24.1%), 38 respondents got the *negative information* condition (27.7%), and 32 respondents got the *mixed information* condition (23.4%).

## *Data preparation*

The four conditions were put in a 2 (positive) x 2 (negative) design.

A factor analysis with varimax rotation was carried out to check the structure of the questions. The analysis was conducted three times. One for the risk perception questions, one for the benefit perception questions and one for the attitude questions.

The questions for risk perception scored as first and second Eigenvalues 3.993 and 0.832, which accounts for 57.05% of the variance. The benefit perception questions scored as first two Eigenvalues 4.143 and 0.845, which accounts for 59.19% of the variance. The first two Eigenvalues for the attitude questions were 4.748 and 0.412, which accounts for 79.14% of the variance. These results indicate that risk perception, benefit perception and attitude are all single constructs.

Cronbach's alpha is used to test for scale reliability. All constructs scored a Cronbach's alpha higher than 0.7 (risk perception 0.874, benefit perception 0.883 and attitude 0.946), so it can be concluded that the scale is reliable.

New variables were made after this conclusion, one variable for each construct.

For the one-way ANOVA test, a new variable was computed which created a separate group again for all four conditions. Having four separate groups creates the ability to check for the contrasts between the different conditions.

## *Analyses*

### **Univariate analysis of variance**

Firstly, an univariate analysis of variance was carried out for each of the constructs.

The results of the ANOVA for the risk perception show that providing people with only positive information has no significant effect on the risk perception ( $F(0.282)=0.311$ ,  $p=0.596$ ). Providing people with only negative information has significant effect on their risk perception ( $F(12.578)=13.887$ ,  $p<0.01$ ). The interaction between positive and negative information has no significant effect regarding risk perception ( $F(1.667)=1.841$ ,  $p>0.01$ ).

Concerning benefit perception, the results show that providing positive information has a significant effect on the benefit perceptions ( $F(7.372)=6.883, p<0.01$ ), as well as providing people with negative information ( $F(13.720)=12.810, p<0.01$ ). The interaction between positive and negative information has no significant effect regarding benefit perception ( $F(1.637)=1.528, p=0.203$ ).

Positive information has no significant effect on attitude ( $F(1.928)=2.519, p=0.167$ ). Providing negative information has a significant effect on attitude ( $F(6.899)=9.015, p<0.05$ ), and the interaction between positive and negative information has no significant effect concerning attitude ( $F(2.273)=2.970, p=0.134$ ).

The results indicate that negative information has the most influence, it influences not only risk perception significantly, but also benefit perception and attitude, whereas positive information only significantly influences benefit perceptions. The interaction between positive and negative information is not significant in any construct.

All these results are also shown in table 2.

**Table 2** ANOVA results for each construct, compared to the no information condition

<i>Construct</i>	<i>Information type</i>	<i>Sig.</i>	<i>Mean (SD)</i>
Risk Perception	Positive	0.596	3.567 (0.183)
	Negative	0.001**	4.301 (0.170)
	Mixed	0.199	4.437 (0.186)
Benefit Perception	Positive	0.008**	4.900 (0.168)
	Negative	0.000**	3.838 (0.157)
	Mixed	0.203	4.076 (0.171)
Attitude	Positive	0.167	4.773 (0.199)
	Negative	0.010*	3.987 (0.185)
	Mixed	0.134	3.964 (0.202)

\*  $p<0,05$  ; \*\*  $p<0,01$

### **Linear regression analysis**

To check whether the risk and benefit perceptions predict attitude, a linear regression is done.

The regression analysis shows significantly ( $F(128.602)=61.813, p<0.01$ ) that both perceptions predict attitude with an R Square of 0.657. They predict attitude approximately equally strong (Unstandardized Coefficients (B) are -0.464 and 0.569 for risk perception and benefit perception respectively).

### One-way ANOVA

Before doing the one-way ANOVA test, an independent samples t-test was done to check whether the variances should be assumed as equal, or not as equal. The t-test was done for positive information and negative information, across all conditions. For positive information, equal variances are assumed ( $p=0.692$ ). For negative information, equal variances are assumed as well ( $p=0.505$ ). This means that for the results of the one-way ANOVA, the results for 'assume equal variances' can be taken.

The one-way ANOVA test is done for two contrasts. The first contrast sets little information off against all other conditions (coefficients: little information -3, negative information 1, positive information 1, mixed information 1). The second contrast sets little information off against mixed information (coefficients: little information -1, negative information 0, positive information 0, mixed information 1). The design of the contrasts for the test can be found in table 3.

**Table 3** Contrast coefficients

Contrast	Condition			
	Little information	Negative information	Positive information	Mixed information
1	-3	1	1	1
2	-1	0	0	1

The test shows that the first contrast is not significant ( $t(133)=0.155$ ,  $p=0.877$ ). The value of this contrast is 0.1055. The second contrast is not significant either ( $t(133)=-0.861$ ,  $p=0.391$ ), with a value of -0.2423. These results suggest that there is no significant difference between receiving little information or receiving information in forming attitudes (via risk and benefit perceptions).

### Mediation analysis

The results of the mediation analysis, using the Andrew F. Hayes PROCESS module, show that there is no direct effect of the different kinds of information on attitude, for both positive and negative information ( $p>0.01$ ). The p-values can be found in table 4.

Attitude is indirectly influenced by positive information via benefit perception (effect size 0.2678), but not via risk perception (effect size 0.0525). For negative information, attitude is influenced via both benefit perception (effect size -0.3003) and risk perception (effect size -0.3612) roughly equally. These results are also presented in table 5.

**Table 4** Direct effects on attitude

<i>Information</i>	<i>Sig.</i>
Positive	0.7678
Negative	0.2270

**Table 5** Indirect effects on attitude

<i>Information</i>	<i>Route</i>	<i>Effect</i>
Positive	Risk perception	0.0525
	Benefit perception	0.2678
Negative	Risk perception	-0.3003
	Benefit perception	-0.3612

# General Discussion

The results of this study support the second and third hypothesis, so it can be concluded that positive information leads to higher benefit perceptions, and no difference in risk perceptions. Negative information in turn, influences both risk and benefit perceptions. Risk perceptions increase and benefit perceptions decrease. The first and fourth hypothesis are not confirmed. Providing the public with mixed information has no significant effect on risk and benefit perceptions, and providing little information is not in contrast with this outcome. Both conditions did not have a significant effect.

These results are partially in line with other literature.

Slovic (1987) and Cobb & Macoubrie (2004) found that little information increases risk perceptions and lowers benefit perceptions. The results of this study show however that there is no effect in perceptions when people have little information. Differences between these findings can be due to the huge technological developments from the past few years. The findings of Slovic and Cobb & Macoubrie are from more than a decade ago, and since then, the use of technology by consumers increased a lot. Consumers might be more comfortable with technological innovations compared to years ago, so it might be that they are comfortable with nanotechnology as development as well, even if they have not a lot of information about it.

For positive and negative information, the results of this study are in line with results that other studies found. For positive information, Zhu & Xie (2015) also found that positive information leads to higher benefit perceptions and no change in risk perceptions. For negative information, the same study of Zhu & Xie (2015) found that this kind of information leads to higher risk perceptions. Verbeke & Liu (2014) found that negative information leads to lower benefit perceptions. These results imply that one sided information can be effective, but negative information is more effective since it affects both risk and benefit perceptions. Even though it was expected that mixed information would lead to higher risk perceptions, no significant effect was found. This is in line with the results of Verbeke & Liu (2014), who also did not find significant results for mixed information. An explanation for these effects might be that mixed information is more honest information than one-sided marketing information (only positive or only negative). People then get information from both sides, which balances the risk and benefit perceptions. Another possible explanation comes from Fischer et al. (2012). They argued that mixed information can still have an effect on individuals, even if the effect on the overall group is not significant. Influenced by mixed information, some people might get higher benefit perceptions and others might get higher risk perceptions, without changing the mean of the group's perceptions significantly. The mediation analysis showed that there is an indirect effect of information on attitude (via risk and benefit perceptions), and that there is no direct effect between information and attitude. This means that people use their risk and benefit perceptions in order to create an attitude towards nanotechnology. This might however not always be the case. Siegrist, Cousin, Kastenholtz, & Wiek (2007) found that there is a direct effect between affect and perceived risks on nanotechnology, but these direct effects were not important. Thus it can be said that people use their risk and benefit perceptions to create an attitude towards nanotechnology.

The results of this study can be useful for companies who produce and sell (food related) products with nanotechnology in it. Even though one sided information has significant effects, providing mixed information can be effective as well since that might be perceived as more trustworthy. Companies should also be aware of negative information, because it has a greater influence on the perceptions of the consumers than positive information. That means that even though mixed information can be effective since it might be trustworthy, companies

should be aware of providing (too much) negative information, because negative information can have a stronger effect than is thought in advance. Also, organizations who campaign against nanotechnology in food(-related) products can cause damage for companies who sell nanotechnology products, so it can be useful to create and maintain good relations with other companies and organizations. By cooperating, companies can inform the public in an honest and non-damaging way.

### *Limitations*

This study has some limitations to it. First of all, this study only used one juice bottle to measure the risk and benefit perceptions towards nanotechnology in food(-related) products. Thus, the results cannot be generalized to the whole food industry. Especially not since people perceive risks higher when the nanotechnology comes physically closer to them, for example inside a food product itself (Steenis & Fischer, 2016). There were also limitations to the mixed information condition, since there were no measurements included in this study to measure ambivalence.

Next to this, this study is held under students. Even though the level of prior knowledge was low to moderate, students are highly educated and possibly also more willing to accept new technologies quicker than lower educated people. Thus, the results of this study are only representative for the highly educated layer of the population. Without confirmation, the results cannot be generalized to lower educated layers of the population.

### *Future research*

For future research, it is suggested to do the same research but then for more and other food related products, especially research on food itself might be very useful to do. Since that is the biggest hurdle for consumers, it is also useful to research how consumers can get to perceive less risks for food products with nanotechnology in it.

To get a good overview of the perceptions of the whole public, it is also suggested to do research under more different parts of the public, not only students. Different age groups and different (educational) backgrounds are advised to recruit as target groups. Finally, the link between attitude and willingness to buy products with nanotechnology can also be interesting to study, these results will be especially interesting for the companies who produce these products.

### *Final conclusion*

Despite the limitations of this research, this study has found important findings on especially negative information. Even though one sided information (positive or negative) has significant effects on risk and benefit perceptions, the effect of negative information is stronger. Also, negative information influences attitude via both risk and benefit perceptions, whereas positive information only influences attitude via benefit perceptions. These results suggest that the industry for nanotechnology should be careful with negative information, since it might be more harmful than initially thought.

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# Appendix

## Appendix 1: The four conditions used in the experiment

### Weinig informatie



Overweeg om deze fles sap te kopen. De plastic fles bevat nanodeeltjes. Nanodeeltjes zijn een vorm van nanotechnologie. Deze technologie wordt uitgevoerd op atomair of moleculair niveau, en is niet zichtbaar met het blote oog. Nanotechnologie creëert materialen die in eigenschappen verschillen van conventionele materialen. Nanodeeltjes worden al in verschillende industrieën gebruikt, zoals de kledingindustrie en de voedselindustrie. Het kan worden gebruikt in voedselverpakkingen, zoals dit plastic sap flesje.

### Positieve informatie



Overweeg om deze fles sap te kopen. De plastic fles bevat nanodeeltjes. Nanodeeltjes zijn een vorm van nanotechnologie. Deze technologie wordt uitgevoerd op atomair of moleculair niveau, en is niet zichtbaar met het blote oog. Nanotechnologie creëert materialen die in eigenschappen verschillen van conventionele materialen. Nanodeeltjes worden al in verschillende industrieën gebruikt, zoals de kledingindustrie en de voedselindustrie. Het kan worden gebruikt in voedselverpakkingen, zoals dit plastic sap flesje. Nanodeeltjes hebben gunstige eigenschappen ten opzichte van conventionele materialen. Dit flesje met nanodeeltjes is sterker en heeft specifieke eigenschappen. Zo is dit flesje bijvoorbeeld antibacterieel en kan het detecteren wanneer het sap erin over datum is.

### Negatieve informatie



Overweeg om deze fles sap te kopen. De plastic fles bevat nanodeeltjes. Nanodeeltjes zijn een vorm van nanotechnologie. Deze technologie wordt uitgevoerd op atomair of moleculair niveau, en is niet zichtbaar met het blote oog. Nanotechnologie creëert materialen die in eigenschappen verschillen van conventionele materialen. Nanodeeltjes worden al in verschillende industrieën gebruikt, zoals de kledingindustrie en de voedselindustrie. Het kan worden gebruikt in voedselverpakkingen, zoals dit plastic sap flesje. Er kunnen gezondheidsrisico's optreden wanneer de nanodeeltjes in het sap terechtkomen, en daarmee in het menselijk lichaam komen. Ook kunnen nanodeeltjes een risico voor het milieu vormen, omdat het flesje met nanodeeltjes niet-recyclebaar afval kan worden.

### Gemixte informatie



Overweeg om deze fles sap te kopen. De plastic fles bevat nanodeeltjes. Nanodeeltjes zijn een vorm van nanotechnologie. Deze technologie wordt uitgevoerd op atomair of moleculair niveau, en is niet zichtbaar met het blote oog. Nanotechnologie creëert materialen die in eigenschappen verschillen van conventionele materialen. Nanodeeltjes worden al in verschillende industrieën gebruikt, zoals de kledingindustrie en de voedselindustrie. Het kan worden gebruikt in voedselverpakkingen, zoals dit plastic sap flesje. Nanodeeltjes hebben gunstige eigenschappen ten opzichte van conventionele materialen. Dit flesje met nanodeeltjes is sterker en heeft specifieke eigenschappen. Zo is dit flesje bijvoorbeeld antibacterieel en kan het detecteren wanneer het sap erin over datum is. Er kunnen gezondheidsrisico's optreden wanneer de nanodeeltjes in het sap terechtkomen, en daarmee in het menselijk lichaam komen. Ook kunnen nanodeeltjes een risico voor het milieu vormen, omdat het flesje met nanodeeltjes niet-recyclebaar afval kan worden.

## Appendix 2: Survey

### Questions risk perception

- “I think the nanotechnology in this bottle can cause harm to human health”
- “I think the nanotechnology in this bottle can cause harm to the environment”
- “I think the nanotechnology in this bottle can cause harm to the economy”
- “I think the nanotechnology in this bottle can cause harm to the society”
- “I think nanotechnology has risks”
- “I think this product has risks for me”
- “This bottle with nanotechnology has more risks than a conventional bottle”

### Questions benefit perception

- “I think the nanotechnology in this bottle can make improvements to human health”
- “I think the nanotechnology in this bottle can make improvements to the environment”
- “I think the nanotechnology in this bottle can make improvements to the economy”
- “I think the nanotechnology in this bottle can make improvements to the society”
- “I think nanotechnology has benefits”
- “I think this product has benefits for me”
- “This bottle with nanotechnology has more benefits than a conventional bottle”

### Questions attitude

- “My overall idea of this bottle is...”
  - Positive/Negative
  - Good/Bad
  - Like/Dislike
  - Desirable/Undesirable
  - Satisfying/Dissatisfying
  - Valuable/Worthless

### General questions

- Gender
- Age (in numbers)
- Level of prior knowledge
- Survey filled in on a mobile device or on a computer