Nanotechnology? What is that?

How can metaphors help consumers understand nanofiltration?

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Summary

Public understanding of new technologies is important in creating acceptance of these technologies in different application fields. Perception and knowledge are important for public understanding and can be quite influential (Macoubrie, 2004). When there is incomplete information or a lack of motivation to process provided information, people are likely to use cognitive shortcuts or heuristics to form their opinions (Scheufele & Lewenstein, 2005). Examples of these cognitive shortcuts are metaphors like *'Frankenfood'* and *'horror corn'*. Companies did not use strong metaphors to persuade people to believe their views and provided them with fact sheets. They did an appeal on people's rationality instead of their emotional involvement (Scheufele & Lewenstein, 2005; Crisp & Turner, 2007). So, how can metaphors be used to create support and understanding for new technologies, like nanotechnology?

Two types of metaphors were considered in this study, pure-matching and abstraction-first metaphors. Pure-matching metaphors involve a search for common properties between the base (e.g. the construct where properties are extracted from) and the target (e.g. an abstract construct on which properties of the base are applied). Abstraction-first metaphors involve a projection of properties from the base to the target. Information of the base is stored in categories in someone's mind. Once the category is either accessed or created, in either case it is used to attribute information from the base to the target and therefore providing an interpretation of the metaphor (Gentner & Wolff, 1997).

Three metaphors were developed that all needed to explain nanofiltration, an application of nanotechnology. Metaphors were based upon different types of metaphorical processing: literal (e.g. *'Nanofiltration is as percolating coffee'*), pure-matching (e.g. *'Nanofiltration is as making coffee with a paper coffee filter'*), and abstraction-first (e.g. *'Nanofiltration is a lot like pasteurization of milk'*). Participants were provided with only one of these types of metaphors or no metaphor (control) in a text on nanofiltration.

Results showed that that the metaphor coffee filter worked best. Although participants were provided with a different metaphor, coffee filter properties were considered more applicable than the other properties. However, the provided metaphors did guide participants in understanding nanofiltration with the metaphor *percolation*. Percolation is characterized by working with pressure. Participants provided with this metaphor found this characteristic more applicable than participants provided with another metaphor. A better example of this is participants' judgment. Participants scored the provided metaphor as most similar to nanofiltration. However, it should be noted that the metaphor *coffee filter* scored highest on average in all conditions. What could have happened here is reasoning by analogy where nanofilter properties were already compared to coffee filter properties before being provided with the metaphor in the text. A process that often occurs naturally by pre-learned analogies (Gick and Holyoak, 1983).

By studying the different paths of metaphor processing it became clear that pure-matching metaphors work best for new technologies, preferably a metaphor that is very close to the technology at hand (e.g. coffee filter and nanofilter). Using an abstraction-first metaphor can cause difficulties in extracting properties from the base and applying these on the target, since the target is unknown (e.g. nanotechnology). This may have happened with the metaphor pasteurization.

In the past metaphors have been used to illustrate negative aspects of new technologies by activist groups and NGO's, while companies have been stuck to fact sheets. Positive metaphors (especially pure-matching metaphors) can also help to create support and understanding for new technologies.

Introduction

Since the early 2000s increased scientific, political and commercial attention was paid to nanotechnology and its implications for the future. The Royal Society and Royal Academy of Engineering (2004) defined nanotechnology as follows: *"Nanotechnologies are the design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometre scale"*. Nanotechnology is applied in different ways like structural applications, skincare products, ICT, biotechnology, instruments, sensors, and environmental. Although nanotechnology is one of the most significant scientific developments of the last decades, the public is still largely unfamiliar with this new technology. This unfamiliarity is due to the limited knowledge of people on the subject and a lack of concrete factual information (Macoubrie, 2004; Lee, Scheufele et al., 2005). However, this does not necessarily imply that people do not develop an attitude towards nanotechnology.

Public understanding of new technologies is important in creating acceptance of these technologies in different application fields. Perception and knowledge are important for public understanding and can be quite influential. For example, during the debate on genetically modified foods public perception negatively affected sales of these foods (Macoubrie, 2004).

When there is incomplete information or a lack of motivation to process provided information, people are likely to use cognitive shortcuts or heuristics to form their opinions (Scheufele & Lewenstein, 2005). An example of the use of heuristics is the *'Frankenfood'* metaphor used by NGOs and interest groups during the discussion on genetic modified (GM) foods. 'Frankenfood' was derived from characteristics of the Frankenstein's monster and was used to concretize genetically modified foods (Hellsten 2003). Metaphors are restricting the complexity of issues by opening only one interpretation at a time. For example, *'Frankenfood'* is only one perspective on what genetic modification is about and how people should perceive these foods (Hellsten, 2003). Greenpeace also made use of metaphors in their protests against genetic modification. Instead of using a verbal metaphor, they used a picture to strongly visualize their message. These visual metaphors consisted of inter alia *'horror corn'* which they promoted on their website and used in public demonstrations[1]. These metaphors used strong visual cues and heuristics which seemed to have a great impact on perception of people towards genetic modification. Meanwhile, breeding companies like Monsanto were collecting expert opinions on genetic modifications in foods and published these on their websites[2]. They did not use strong metaphors to persuade people to believe their views on genetic modification in foods and did an appeal on people's rationality instead of their emotional involvement (Scheufele & Lewenstein, 2005; Crisp & Turner, 2007).

Providing people with metaphors, especially visual metaphors, seems to be a strong tool to influence people's perception on rather unknown topics. They are easy to comprehend and open one perspective at a time. This can result in giving incomplete information on a topic. However, topics like nanotechnology are difficult to understand as a whole. By providing people with a metaphor that gives them a first impression of an application of nanotechnology can help them understand such a difficult

[1] http://www.greenpeace.org/international/en/campaigns/agriculture/problem/genetic-engineering/ (Accessed: 15-10-2013)
[2] http://www.monsanto.com/newsviews/Pages/biotech-safety-gmo-advantages.aspx (Accessed: 15-10-2013)

technology. People prefer to avoid engaging in deeply mental processing, and probably like metaphors more than factual information, would it then be possible to give them sufficient information on a topic providing them with a metaphor?

Since nanotechnology is a broad topic and is applied in different fields, this study will focus on only one of these applications which is nanofiltration.

The following research question is developed in response to the questions earlier in the introduction:

"How can metaphors help consumers understand new technologies?"

This research questions will be supported by the following sub-question:

How are metaphors used as heuristics in information processing?

1. Literature review

1.1 Information processing

Processing information happens in different ways depending on for instance motivation and ability. Several dual-process models have been developed during the last decades which all state that there are two main ways in which information is processed. This can either be heuristic processing or systematic processing. Both ways of information processing have been extensively discussed in literature and over time several models have been developed.

1.1.1 Dual-process models

Three types of dual-process models are discussed below. After discussing these different models an overview is provided to summarize the three models.

Heuristic-systematic model (HSM)

One of these models is the heuristic-systematic model (HSM), developed by Chaiken (1980). This model differentiates between an effortless heuristic mode and a cognitively demanding systematic mode. In the systematic mode people exert considerable more cognitive effort in performing the task at hand. They are actively attempting to comprehend and evaluate the arguments of the message as well as they are assessing the validity of the arguments in relation to the message's conclusion. When people process information heuristically this model assumes that people exert, compared to systematic processing, little effort in judging the validity of the message. People are in the heuristic mode more relying on information directly accessible such as the identity of the source or other content cues. The heuristic view of information processing focuses on the role of simple rules or cognitive heuristics to come to a conclusion (Chaiken, 1980). One of the assumptions of the heuristic-systematic model is that people are economy-minded which means that they are guided by least effort motives in their information processing. Therefore, it is expected that heuristic processing will prevail over systematic processing because the latter is more cognitively demanding (Chen et al, 1999; Chaiken et al, 1999).

Elaboration Likelihood Model (ELM)

Another model is the Elaboration Likelihood model (ELM), developed by Petty & Cacioppe (1986). This model differentiates between a central and a peripheral route of information processing. The central route is more cognitively demanding and therefore takes more effort. The peripheral route is mostly taken when people only focus on cues and the information presented exerts enough confidence for the judgmental task at hand without engaging in deeply systematic processing (Petty & Cacioppe, 1986).

System 1 versus system 2

A more recent theory is the introduction of system 1 and system 2 thinking developed by Stanovich and West (2000). These two systems do not have specific definitions, but are defined by their characteristics. System 1 thinking is fast, automatic, effortless, associative, implicit, and often emotionally charged whereas system 2 thinking is about operations that are slow, serial, effortful, more likely to be consciously monitored and deliberately controlled, and share much with the central route in ELM and the systematic processing in HSM.

Sufficiency principle

Besides that people are often economically-minded, they also have the goal of having sufficient confidence in their judgments. This is called the sufficiency principle. This principle embodies the idea that people seek a balance between the goal of exerting least effort and the goal of having sufficient confidence in their judgments (Bohner et al, 2011). Heuristic processing is fulfilling the goal of least effort, while systematic processing generally produces greater amounts of confidence which implies that it is better able to satisfy the sufficiency principle. It is assumed that people process heuristically by default, which suggests that the trade-off between less effort and sufficient judgmental confidence is more than adequately met by heuristic processing. In many cases the sufficiency threshold is set low enough so that it can be reached by heuristic processing alone (Bohner et al, 2011); which implies that no further systematic processing is needed.

Concluding remarks

Although these models are quite similar there are some distinctions. For example, the Elaboration Likelihood model is focused on persuasion and assumes that people always start with systematic processing, or in this case, take the central route. When people are not motivated or not able to process the information presented, they switch to the peripheral route and information is heuristically processed (Petty & Cacioppe, 1986).The heuristic-systematic model and the system 1 vs. system 2 thinking assume that a person engages in heuristic information processing first and when this does not result in sufficient confidence in his judgment, he will switch to systematic processing of the information until the point he has sufficient confidence in his judgment.

But how does heuristic information processing actually work?

1.2.1 Heuristic information processing

When people are confronted with new concepts, products or anything else, these have to be processed by the brain to make sense of the new information and stimuli encountered. Heuristic processing is described as a process that is fast, automatic, effortless, associative, and emotional (Kahneman, 2003). In understanding heuristic processing it is necessary that one understands why some thoughts come to mind more easily than others, and why some ideas arise effortlessly and others demand work. Heuristics are knowledge structures which are presumably learned and stored in memory. Judgment formed on the basis of heuristic processing is reflected by easily processed heuristic cue information, rather than individualistic information. Heuristic processing makes minimal cognitive demands. However, heuristic information processing is constrained by basic principles of knowledge activation and use which are availability, accessibility, and applicability. Heuristic processing requires that heuristics are stored in memory and therefore *available*, are retrievable from memory (i.e. *accessible*), and are relevant (i.e. *applicable*) to the judgmental task at hand (Chaiken et al, 1999).

Availability and accessibility

Availability refers to whether or not a knowledge structure is stored in memory, since heuristic processing can only occur when judgment-relevant heuristics are available in memory for retrieval and use. Even though a judgment-relevant heuristic is available in memory, does not imply that it is used in a given judgmental context (Chen & Chaiken, 1999). An available heuristic must also be *accessible*. Accessibility refers to the activation potential of stored knowledge. In order for stored knowledge to exert an impact on processing and judgment, its activation potential must exceed a certain threshold level, above which the knowledge is ready for use. The activation potential of a heuristic will vary as a function of factors that can be internal and/or external to the perceiver. A factor that could be an internal source of activation potential is when the frequent use of a heuristic is likely to result in the chronic accessibility of the heuristic. Potential external sources of the accessibility of the heuristic are salient cues in the current judgmental context that are relevant to a stored heuristic (Chen & Chaiken, 1999).

The role of accessibility is not only instigating the heuristic mode of processing, but it may carry some important implications for the likelihood of systematic forms of processing. This means that the accessibility of a heuristic may not simply correspond to the likelihood of its use, but may also affect the confidence with which a judgment determined on the basis of the heuristic is held. This judgmental confidence can in return affect the likelihood of systematic processing in such a way that increasing confidence generally decreases perceivers' motivation to engage in more effortful forms of cognition. To summarize, the ease with which a heuristic comes to mind may heighten a perceiver's confidence in the judgment implied by the heuristic, lowering the need to process further to attain a sufficient level of judgmental confidence (Chen & Chaiken, 1999).

Applicability

A heuristic will only exert a judgmental impact to the extent that it is *applicable* to the current judgmental task. Applicability refers to the relevance of stored knowledge to a given judgmental task, and it exists at both non-conscious and conscious level. In its non-conscious form, applicability refers to the activation arising from overlap between a certain stimulus (e.g. object, person, etc.) and stored knowledge. The activation level of a stored knowledge construct (e.g. a heuristic) increases when there is greater overlap between features of the stored knowledge construct and features of the stimulus (Higgins, 1996). Applicability in its more conscious form refers to the conscious process of a person deciding on whether it is appropriate to use stored knowledge constructs to form a judgment (Chen & Chaiken, 1999).

The applicability of a heuristic to a judgmental task is based in part on the degree to which the heuristic somehow *"matches"* features of the task. For instance, the applicability of the heuristic *"Experts' statements can be trusted"* to the task of expressing one's attitude on capital punishment on the basis of a highly reputable newspaper article on the issue is relatively high, given the *"match"* between the heuristic and the article's source expertise features. In comparison, the applicability of the heuristic *"Consensus opinions are correct"* to the same task is likely to be considerably lower (Chen & Chaiken, 1999).

The degree to which a heuristic is applicable to a task is also determined by the extent to which it has been activated and when it was used in the past. Specifically, the applicability of a heuristic to a task should increase with its repeated activation and use for that typical task. This implies an increase in the likelihood and speed with which the heuristic will be activated on the same task in the future. (Chen & Chaiken, 1999).

Applicability is clearly relevant to understanding how the heuristic mode operates, in that the likelihood of heuristic processing is in part determined by the nature and strength of associations between particular heuristics and particular judgmental tasks (Chen & Chaiken, 1999).

1.3 Metaphors

Over the past two decades, the cognitive perspective on metaphors has undergone a radical shift (Bowdle & Gentner, 2005). First, metaphors were treated as being restricted to poetic uses. For example a wine-dark sea by Homer in ancient Greece. However, current research is suggesting the opposite. Rather than being restricted to poetic uses, metaphors are common in everyday communication. By for example analysing television programmes, speakers used approximately one unique metaphor for every twenty-five words. There is also evidence that suggests that metaphors are important for communicating about abstract concepts such as time and emotion, and in this case nanotechnology. They are even used to invent, organize, and illuminate theoretical constructs (Bowdle & Gentner, 2005). The first paragraph will explain how one thought that metaphors were processed in the past and how they are processed nowadays. The second paragraph will explain in which different ways metaphors can be comprehended.

1.3.1 Metaphor processing

The traditional view on metaphor understanding assumed that metaphors were difficult to process because they were deviating from standard, literal expressions. One of these traditional views is the *'standard pragmatic view'*. Later in time another view became more popular called the *'direct access view'*. Both views will be discussed in the paragraphs below.

Standard pragmatic view

The *'standard pragmatic view'* assumes that people process metaphors in three steps. In the first step the person analyses the literal meaning of the entire expression. In the following step the person assesses whether this literal interpretation is appropriate for the specific context. Finally, when the literal meaning seems to be contextually inappropriate, the person must derive the intended metaphorical meaning through the cooperative principle or the rules of speech acts. This traditional view suggests that metaphors are more difficult to comprehend than corresponding literal expressions, since they require an additional processing step in which the literal meanings are rejected and the intended figurative meanings are subsequently inferred (Gibbs, 2006). However, there is also a large number of experiments in psycholinguistics that have examined the predictions of the *'standard pragmatic view'*, and found that many kinds of figurative languages, also including metaphors, can be understood as quickly as literal expressions when they are encountered in rich linguistic contexts. Sometimes people can even read figurative utterances more quickly than the literal use of the same expressions (Gibbs, 2002; Gibbs, 2006).

Direct access view

The *'direct access view'* which assumes that people can process the intended meanings of many non-literal utterances directly. This view suggests that a person does not automatically needs to analyse the complete literal meaning of an expression before accessing pragmatic knowledge to figure out what the message is intended to communicate. Nonetheless, this view does not imply that listeners never access stored information about what the individual words literally mean during processing of what the message implies. Moreover, this view does not claim that people never take longer to process a figurative meaning than to understand a literal one. Sometimes people need a little bit more time to process a metaphor (Gibbs, 2001).

Familiarity

An important factor in metaphor processing is familiarity. Familiar metaphors have at least two salient interpretations which are a literal one and a metaphoric one. Less familiar, or unfamiliar, metaphors have only one salient meaning which is the literal one (Giora & Fein, 1999).

It was believed that processing familiar metaphors should involve an activation of both a metaphoric and a literal meaning regardless of contextual bias. For example, processing a familiar metaphor such as *“step on somebody’s toes”* should activate both its literal (e.g. *foot*) and figurative (e.g. *offend*) meaning in the context in which it is intended metaphorically, and in the context in which it is intended to be literally. Processing less familiar, or unfamiliar, metaphors (e.g. *Their bone density is not like ours*) should activate the literal meaning in both the metaphoric context as the literal context (Giora & Fein, 1999). However, results show that the literal meaning of metaphors is always processed. This is for both familiar and less familiar (or unfamiliar) metaphors (Giora & Fein, 1999).

1.3.2 Metaphor comprehension

The interpretation of a metaphor arises from the interaction of its base and target concepts. To explain this a little bit better the well-known metaphor *‘The mind is a computer’* is used. The target, which is the first term, of this metaphor refers to an abstract entity (e.g. *the mind*), and the base, which is the second term refers to a complex electronic device (e.g. *the computer*). This distinguishes metaphors from literal comparison statements and literal categorization statements in which the target and base representations typically belong to the same semantic domain (Bowdle & Gentner, 2005). This base and target can interact in one of the following three ways: pure-matching, abstraction-first, and alignment-first. The *pure-matching* models involve a search for common properties between the base and the target. *Abstraction-first* models entail a projection of properties from the base to the target, and *alignment-first* models evoke both kinds of processing which starts with a search for common properties and a later projection of further properties from the base (Gentner & Wolff, 1997). The alignment-first models will not be further discussed since they are outside the scope of this research.

Pure-matching models

In pure-matching models metaphors are interpreted by matching identical features of the target and the base and are heavily drawn on matching processes. According to Tversky (1977) metaphors are understood by an assessment of the similarity between the base and target and that this involved a search for features that optimized the quality of this resemblance. This involves summation of the features between the two terms (base and target), with the shared features giving greater weight. The metaphor can then be comprehended in terms of shared features (Ortony, 1979, Genter and Wolff, 1997). Studies by Johnson and Malgady (1976, 1979) showed that participants who rated metaphors with many shared features also tended to rate these as easier to interpret. Figure 1 on the left shows how a pure-matching

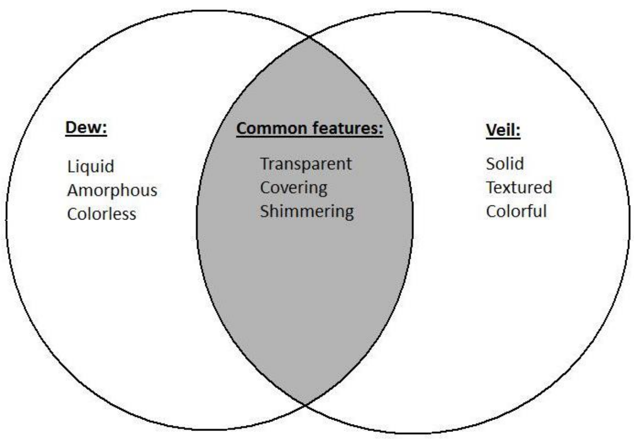


Figure 2: Feature-matching interpretation of *"Dew is a veil"* (Gentner and Bowdle, 2005)

model looks like in the case of the metaphor *"Dew is a veil"*. The metaphor can be interpreted by the overlapping features of the target and base. In this case this would imply that people are most likely to interpret *"Dew"* as something that is transparent, covering, and shimmering.

However, pure matching models do not capture the full metaphoric phenomenon (Glucksberg & Keysar, 1990). According to pure matching models, the features that enter the interpretation of a metaphor are those that are shared by both the base and the target. Nonetheless, not every shared feature is included in an interpretation. For example let us take a look at the metaphor *"A surgeon is a butcher"*. Surgeons and butchers share a number of features: both wear white coats, breathe air, and belong to service professions. Nonetheless, none of these is relevant to the meaning of the metaphor (Tourangeau & Rips, 1991; Glucksberg & Keysar, 1990). Another problem with pure matching models is the matching of similar but non-identical features. An example of this is the phrase *'Men are like wolves'*. A similar feature of the base and the target could be *'predators'*. However, the way in which wolves are predators is different from the way in which men are predators. Therefore it is better to assume that metaphors involve similar rather than identical features (Ortony et al, 1985). Since these models treat non-identical features as distinctive rather than common, they do not predict the inclusion of such matches in the interpretation of a metaphor (Bowdle & Gentner, 2005). Besides the matching similar but non-identical features, the lack of explaining the phenomenon of asymmetry is posed a problem. This implies that metaphors often have different interpretations when they are reversed. An example is the metaphor *"Most surgeons are butchers"* which refers to surgeons are clumsy whereas *"Most butchers are surgeons"* refers to that butchers are precise in their work. Pure matching models are unable to explain why metaphors are more asymmetric than are literal comparisons (Glucksberg et al, 1997). Perhaps the biggest problem with pure matching models is failing to predict feature importation which means that features present in only one of the terms can enter into an interpretation. For example, from the metaphor *"Richard is a tiger"* we can derive the interpretation *"Richard is ferocious and energetic"* without knowing anything about Richard in advance (Glucksberg and Keysar, 1990).

Abstraction-first models

Abstraction-first models assume processing begins with the base. An interpretation is constructed by first finding or deriving an abstraction associated with the base, followed by projecting this abstraction from the base to the target and then verifying the information in the target by matching the selected abstraction with the target representation. A theory of metaphor proposed by Glucksberg and Keysar (1990) fits into the framework of abstraction-first. Their theory of metaphor proposes that metaphors are comprehended by assigning the target to an abstract category associated with the base, which permits the inheritance of features by the target. The abstract category is either stored with the base or derived from the base as an ad hoc category. To illustrate this we use the following example. In the metaphor *"My job is a jail"* the base (*"jail"*) is used to identify the category of which it is a prototypical member (e.g. an institution that confines one against one's will, is unpleasant and so on). The properties of the base are then conveyed to the target (*"my job"*) by assigning the target as a member of the category defined by the base (Gentner & Wolff, 1997; Glucksberg and Keysar, 1990). Figure 2 shows the metaphor *"My surgeon is a butcher"*. With this metaphor meaning is not created through the overlapping features, but through the individual features of the base to the target.

Processing metaphors by abstraction-first processes can be divided in two cases. In the first case there is a pre-existing abstraction associated with the base. Taking the example of the metaphor *"My surgeon is a butcher"* there may already be a stored association between the base term *"butcher"* and the category "*individuals who are clumsy and incompetent in tasks that require finesse"*. When such abstract category pre-exists it allows processing proceeding via access to a conventionalized meaning. In the second case there is no pre-existing category association. The abstraction of the base term must be derived on the spot. Taking the same example of *"My surgeon is a butcher"* the implied category (*"individuals who are clumsy and incompetent in tasks that require finesse"*) may need to be created during processing of the metaphor. Once the category is either accessed or created, in either case it is used to attribute information from the base to the target and therefore providing an interpretation of the metaphor (Gentner & Wolff, 1997).

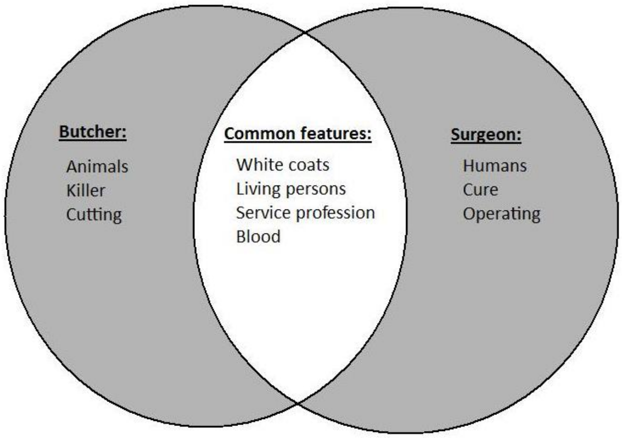


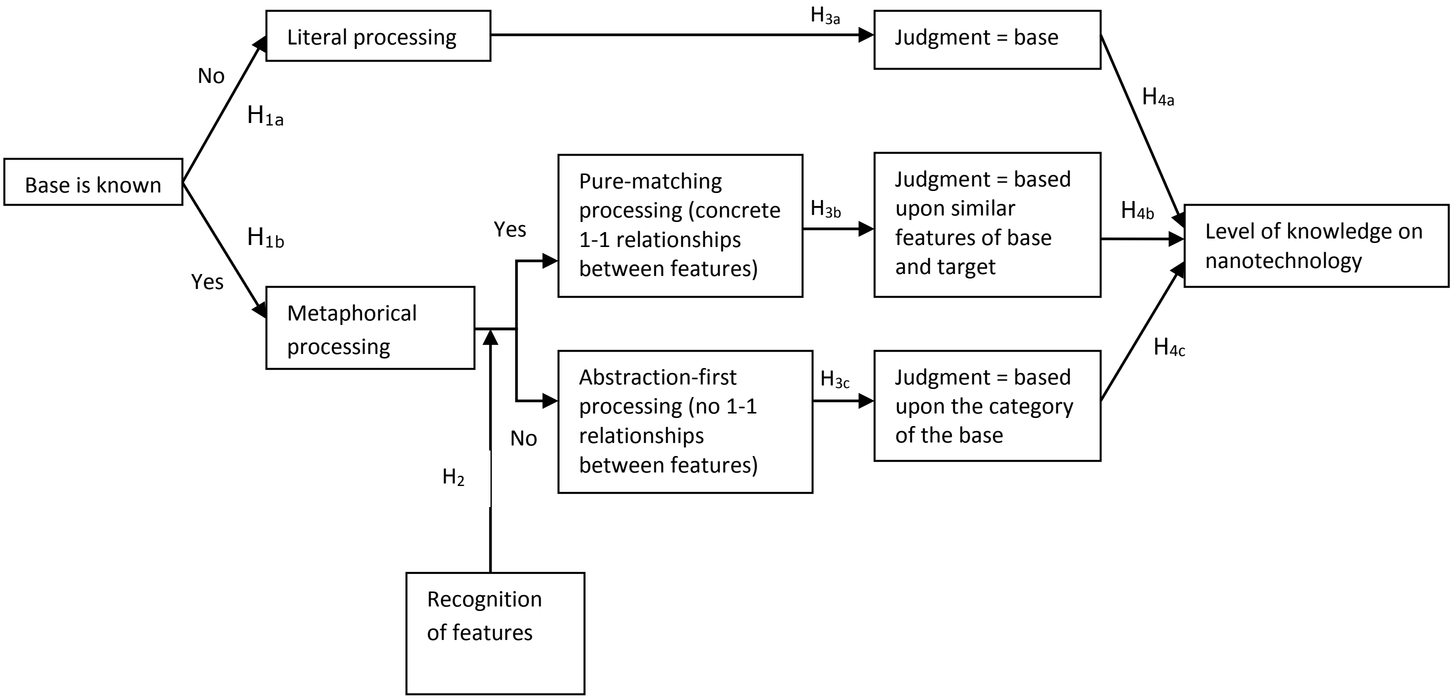
Figure 2: Abstraction-first interpretation of *"My surgeon is a butcher"*

1.4 Concluding remarks

Metaphors are best understood when they are *accessible* and *available* in people's mind, and processed with little cognitive effort. Moreover, they have to be *applicable* to the situation at hand. When using metaphors in explaining nanotechnology, the consumer has to have enough *sufficient* judgmental confidence in the information presented by the metaphor. It should not be necessary for the consumer to engage in high cognitive processing. Another factor that is important in considering the use of metaphors is *familiarity*. Consumers are likely to switch to the literal interpretation of a metaphor when they are unfamiliar with the metaphor at hand. Literal interpretations can lead to misinterpretations of the information provided through the metaphor.

3. Conceptual framework

The following conceptual framework is developed to illustrate the expected outcomes. There are three routes that can be taken depending on the type of metaphor provided. When the base is unknown it is more likely that a person engages in literal processing. His judgment is most likely based upon the base of the metaphor and knowledge barely increases because of this metaphor. When the base is known a person is likely to engage in metaphorical processing which is either based on pure-matching or abstraction-first processing depending on the type of metaphor provided. Judgment is then either based upon the similar features of the base and the target or based upon the category of the base. In both situations the knowledge level is supposed to increase because of the provided metaphor.



It all depends on the type of metaphor that determines which kind of processing is likely to occur. The hypotheses that follow from this framework are:

H_{1a}: If the base is unknown a person is most likely to engage in literal processing.

H_{1b}: If the base is known a person is most likely to engage in metaphorical processing.

H_2: The more similarities are recognized, the more a person is likely to engage in pure-matching processing.

H_{3a}: Literal processing leads to a judgment based upon the base of the metaphor.

H_{3b}: Pure-matching processing leads to a judgment based upon similar features of the base and the target.

H_{3c}: Abstraction-first metaphor processing leads to a judgment based upon an abstraction of the base to the target.

H_{4a}: Judgment based upon the base does not lead to an increased knowledge level.

H_{4b}: Judgment based upon similarities between the base and target leads to an increased knowledge level.

H_{4c}: Judgment based upon an abstraction of the base to the target leads to an increased knowledge level

4. Methodology

This chapter discusses the sample, the design, manipulations, measures and procedure of this study.

4.1 Sample

The sample of this study consisted of Dutch students from the Wageningen University. This group was chosen because they were consistently similar in educational level and age.

In total 101 respondents participated in the experiment (Scenario 1 had 24 respondents; condition 2 had 23 respondents; condition 3 had 33 respondents; and condition 4 had 21 respondents). This sample consisted of 30 males and 71 females. Respondents were between 18 and 32 years old.

From these 101 participants 67 were unfamiliar with nanofiltration, 30 were a little familiar, and only 4 were familiar with nanofiltration.

4.2 Design

The design of this study consisted of a four-group experiment which is presented in Table 1.

Table 2: Experimental design

	Base (b):	Target (t):	bs - t	bc - t	Something else*** - t
Control	ø	ø	0	0	1
Literal-based	ø	t	1	1	1
Similarity-based	bs*	t	1	0	0
Categorical-based	bc**	t	0	1	0

* bs = base pure-matching-based, ** bc = base abstraction-first-based, *** something else = outcome not based upon the base

This experiment existed of one control condition and three experimental conditions. The experimental conditions were literal-based, pure-matching-based, and abstraction-first-based. The literal-based condition had an unknown base, the pure-matching-based condition had a known base which is directly applicable, and the abstraction-first-based condition had a known base which is indirectly applicable.
When there was a metaphor with an unknown base, it was expected that participants would follow literal processing and use information stored in memory to make sense of the target. In the two conditions in which there was a metaphor with a known base, it was expected that participants would follow metaphorical processing and were either presented with a pure-matching-based base or an abstraction-first-based base. In both conditions they were expected to use the presented base to make sense of the target. All conditions were expected to lead to a certain judgment on the target. The following figures show the different routes that participants were expected to take in the different conditions.

<u>Experimental condition 1:</u>

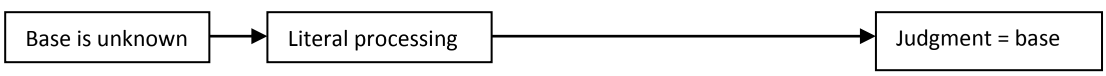


Figure 1: Literal-based condition

Experimental condition 2:

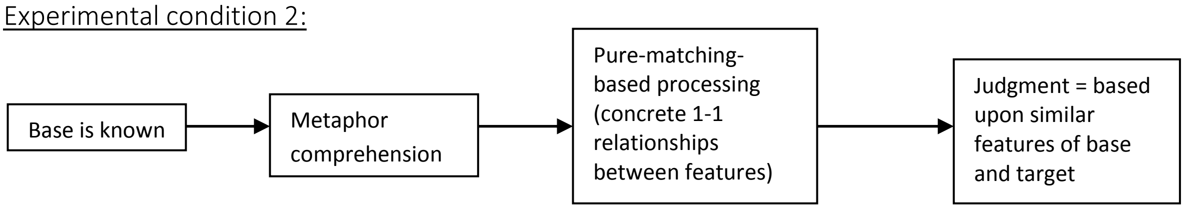


Figure 2: Pure-matching-based condition

Experimental condition 3:

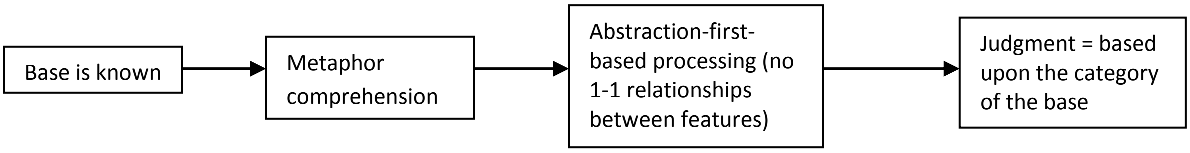


Figure 3: Abstraction-first-based condition

The experiment was executed using Qualtrics, a software that allows one to make online experimental questionnaires.

4.3 Manipulations

The manipulations in this study consisted of four scenario's from which each of them was related to one of the four conditions. To be consistent throughout all scenario's, the subject for each scenario was the same. The subject chosen was *"Nanofiltration of milk"*. Each of the scenario's was mainly the same with small differences in accordance with the different experimental conditions discussed in the previous paragraph. Construction of the metaphors depended on the variables familiar/unfamiliar, accessible/inaccessible, available/unavailable, and applicable/inapplicable. All scenarios were translated to Dutch.

4.3.1 Scenario 1 – Control

The control condition did not contain a metaphor. Participants had to read a passage from the chapter *"Potential Benefits and Market Drivers for Nanotechnology Applications in the Food Sector"* by Kampers (2010) from the book *"Nanotechnologies in Food"*. This passage was the scenario in which the metaphor was integrated. This scenario can be found in Appendix A.

4.3.2 Scenario 2 – Literal processing

This scenario contained a metaphor which was unfamiliar, inaccessible, and unavailable. Applicability is not included since it is about an unknown base. The metaphor used in this condition was *"Nanofiltration is as percolating coffee"*. Percolation is a filtration method that was popular decades ago for making coffee. *"Percolating coffee"* was expected to be unknown to most participants, and was therefore chosen as the base in this metaphor. The scenario accompanying this metaphor can be found in Appendix A.

4.3.3 Scenario 3 – Pure-matching processing

This scenario contained a metaphor which was familiar, accessible, available, and *directly* applicable (e.g. base is known) to the situation at hand. The metaphor used in this condition was *"A nanofilter is as a paper coffee filter"*. *"Paper coffee filter"* was expected to be known to all participants, and was therefore chosen as the base in this metaphor. Moreover, it was expected that participants would recognize the similar features between a nanofilter and a paper coffee filter. The scenario accompanying this metaphor can be found in Appendix A.

4.3.4 Scenario 4 – Abstraction-first processing

This scenario contained a metaphor which was familiar, accessible, available, and *indirectly* applicable to the situation at hand. The metaphor used in this condition was: *"Nanofiltration is as heat based pasteurisation of milk"*. *"Pasteurisation"* was expected to be known to all participants and contained features that were similar to *"nanofiltration"* on a more abstract level. The scenario can be found in Appendix A.

4.4 Measures

The measures of this study included base understanding, judgement, and knowledge. An extra measure included in this study was attitude. All questions can be found in Appendix A. Each of these different measures is discussed separately.

4.4.1 Base understanding

Base understanding is about the base used in the metaphors. In total three metaphors were developed. These were *"Nanofiltration is as percolating coffee"*, *"Nanofiltration is as making coffee with a paper coffee filter"*, and *"Nanofiltration is as pasteurisation of milk"*. To test whether properties of the metaphors were mapped onto nanofiltration, several line-scale questions were developed based on characteristics of the bases used in the metaphors. Regarding percolating coffee one characteristic was included: *"It works with pressure"*. Regarding making coffee with a paper coffee filter two characteristics were included: *"It keeps bacteria from entering"* and *"It has holes"*. Regarding pasteurisation of milk two characteristics were included: *"It kills bacteria"* and *"Works with heating"*. These five characteristics were measured on a 5-point scale with (e.g. 1=Not at all applicable to 5=Totally applicable). It was expected that participants would consider characteristics of the provided metaphor more than other characteristics.

4.4.2 Judgement

Judgement is the outcome of the route the participants were guided through and was measured with one question. Answers had to show whether their judgement was also most similar to the route they had taken according to the conceptual framework. Judgment was measured on a 7-point scale (e.g. 1= Not at all to 7=Totally yes).

4.4.3 Knowledge

This study considered two types of knowledge: prior knowledge and post knowledge. The prior knowledge questions were only objective, whereas the post knowledge questions were both objective and subjective. Both measures included closed and 7-point line-scale questions (e.g. 1=Strongly disagree to 7=Totally agree).

4.4.4 Attitude

Although attitude was not part of the conceptual framework, it was still interesting whether the different scenarios had an influence on people's attitude. Therefore, an attitude question was asked before and after the scenario. Both questions were measured on a 7-point line-scale (e.g. 1 = Totally disagree to 7 = Totally agree).

4.5 Pilot study

A pilot study was done to validate the manipulations before using them in the final study. An online questionnaire was set up using Qualtrics. No specific target group was needed and therefore the questionnaire was spread through social media. In total 29 respondents participated in the pilot study. The entire questionnaire can be found in Appendix A. Results of this pilot study are presented below.

4.5.1 Results of pilot study

Table 3 shows the mean scores of the characteristics of the provided metaphors. One can notice that it has holes is scored significantly lower by participants provided with the metaphor *coffee filter* than participants provided with either *no metaphor* or *pasteurization*. At the same time it is interesting that participants provided with the metaphor *pasteurization* scored it has holes as highest compared to all other scenarios (M=4.33). Moreover, participants provided with the metaphor *pasteurization* scored works with heating as least applicable to nanofiltration (M=1.33). With this in mind both the coffee filter and pasteurization metaphor were altered. Instead of emphasizing the process of making coffee with a coffee filter, the purpose of the coffee filter was emphasized. In the case of the pasteurization metaphor a direct comparison between nanofiltration and pasteurization was emphasized. Instead of a direct comparison the *effect* of pasteurization was emphasized for the final study.

Table 3: Mean scores (SD) on applicability of different properties on nanofiltration[1]

	Scenario	Mean/SD	F-value (d,f)	p-value
It has holes	Control (n=6)	4.33ᵃ (1.63)	(3,25)=2.21	0.11
	Percolation (n=10)	3.90ᵃᵇ (0.74)		
	Coffee filter (n=7)	3.00ᵇ (1.16)		
	Pasteurization (n=6)	4.33ᵃ (0.82)		
Keeps bacteria from entering	Control (n=6)	5.00ᵃ (0.00)	(3,25)=4.62	0.01
	Percolation (n=10)	4.40ᵇ (0.52)		
	Coffee filter (n=7)	4.00ᵇ (0.58)		
	Pasteurization (n=6)	4.50ᵃᵇ (0.55)		
Works with heating	Control (n=6)	1.50ᵇ (0.55)	(3,25)=4.53	0.01
	Percolation (n=10)	1.80ᵇ (0.79)		
	Coffee filter (n=7)	2.86ᵃ (1.07)		
	Pasteurization (n=6)	1.33ᵇ (0.82)		
Works with pressure	Control (n=6)	2.50 (1.38)	(3,25)=1.37	0.28
	Percolation (n=10)	3.50 (0.97)		
	Coffee filter (n=7)	3.14 (1.07)		
	Pasteurization (n=6)	2.50 (1.38)		
It kills bacteria	Control (n=6)	2.50 (1.98)	(3,25)=1.52	0.23
	Percolation (n=10)	1.40 (0.52)		
	Coffee filter (n=7)	2.00 (0.82)		
	Pasteurization (n=6)	1.50 (0.84)		

[1]Values in a column that share a superscript character are not significantly different from each other (LSD).

An ANOVA showed that there were significant differences among participants considering coffee filter as being more similar to nanofiltration (F(3,25)=3.46; p=0.03), and marginally differences among participants considering percolation as being more similar to nanofiltration (F(3,25)=0.08; p=0.08). More specifically, participants provided with the metaphor percolation considered percolation significantly more similar to nanofiltration than those provided with either a coffee filter or a pasteurization metaphor (see Table 4). Participants provided with no metaphor considered coffee significantly more similar to nanofiltration than those provided with either a percolation or a coffee filter metaphor (see Table 4). It is interesting to see that participants provided the metaphor pasteurization considered coffee filter as being more similar to nanofiltration than the pasteurization that was provided to them (M=6.17).

Table 4: Mean scores (SD) of judgment with different provided metaphors[1]

	Metaphor	Mean/SD	F (d,f)	p-value
Percolation	Control (n=6)	4.33^{abc} (1.63)	(3,25)=2.50	0.08
	Percolation (n=10)	5.60^{a} (1.71)		
	Coffee filter (n=7)	4.14^{bc} (0.38)		
	Pasteurization (n=6)	3.83^{bc} (1.47)		
Coffee filter	Control (n=6)	6.33^{ab} (0.52)	(3,25)=3.46	0.03
	Percolation (n=10)	5.30^{c} (0.68)		
	Coffee filter (n=7)	5.29^{cd} (1.11)		
	Pasteurization (n=6)	6.17^{ad} (0.75)		
Pasteurization	Control (n=6)	2.67 (1.97)	(3,25)=0.91	0.45
	Percolation (n=10)	3.00 (1.56)		
	Coffee filter (n=7)	3.29 (0.95)		
	Pasteurization (n=6)	2.00 (1.27)		

[1]Values in a column that share a superscript character are not significantly different from each other (LSD).

To check the manipulations, participants were asked to score whether the text was understandable, easy to read, and its credibility. An ANOVA showed that there was no influence of the provided metaphor on these aspects (see Table 5).

Table 5: Mean scores (SD) of the intelligibility, readability, and credibility of the scenarios

	Metaphor	Mean/SD	F (d,f)	p-value
Intelligibility	Control (n=6)	5.83 (0.41)	(3,25)=1.02	0.40
	Percolation (n=10)	5.00 (1.63)		
	Coffee filter (n=7)	4.43 (1.62)		
	Pasteurization (n=6)	5.00 (1.55)		
Readability	Control (n=6)	4.83 (1.33)	(3,25)=1.44	0.25
	Percolation (n=10)	4.70 (1.57)		
	Coffee filter (n=7)	3.43 (1.27)		
	Pasteurization (n=6)	4.50 (1.38)		
Credibility	Control (n=6)	6.00 (0.00)	(3,25)=1.56	0.23
	Percolation (n=10)	4.70 (1.34)		
	Coffee filter (n=7)	4.86 (1.07)		
	Pasteurization (n=6)	5.00 (1.67)		

[1]Values in a column that share a superscript character are not significantly different from each other (LSD).

4.5.2 Implications for final study

It became clear that the metaphor pasteurization was not processed by participants as expected. This was probably due to the formulation of the metaphor in the scenario. Instead of emphasizing the direct comparison between pasteurization and nanofiltration, the effect of pasteurization was emphasized. The altered scenario can be found in Appendix A.

All scenarios were scored as understandable, readable and credible. This implies that the scenarios fitted the target group.

4.6 Procedure

This study consisted of a pilot study and a final study. The procedure of the final study will be discussed below.

- Step 1: Test room was set up. Six separate cubicles were built to ensure the privacy of the participant. Posters with silent symbols were placed at the entrance. In front of each cubicle a chair was placed where participants could leave their possessions. In each of the cubicles a table, chair and laptop were present.

- Step 2: Recruiting of participants with help of flyers and posters. During the small breaks and lunch breaks there was flyered at the doors and throughout the whole building.
- Step 3: Participants were guided to one of the cubicles and had to take place in front of a laptop. The experiment leader started the experiment.
- Step 4: When the experiment was ended, participants had to report themselves to the experiment leader. They had to fill out their name, address, and signature on a list in order to make sure that they had received the reward.
- Step 5: Participants were rewarded with coupons of the canteen restaurant.
- Step 6: Experiment leader checked the cubicles after participants left in order to make sure that everything was set for the next participant.

In total there were seven testing days and walk in sessions started at 10 am until 5 pm. The final questionnaire can be found in Appendix A.

5. Results

Participants (n=101) were Wageningen students (30 males, 71 females). From the 101 students there were 66 bachelor students, 29 master students, and six students doing their minor at the Wageningen University. Two students also participated in the pilot study on nanofiltration. From the 101 students there were 67 students unfamiliar with nanofiltration, 30 students were a little familiar with nanofiltration and only four students were familiar with nanofiltration.

Manipulation checks showed that participants were somewhat familiar with percolation of coffee, and familiar with a coffee filter and pasteurization. Results of the whole study are discussed in the paragraphs below.

5.1 Metaphor comprehension

An ANOVA showed that the extent to which participants considered that nanofiltration worked with pressure, marginally depended on the provided metaphor (scenario) (F(3,97)=2.173; p=0.096). More specifically pairwise comparisons showed significant differences between the metaphors *coffee filter* and *percolation* (p=0.02; see Table 6); where participants provided with the metaphor *percolation* (M=3.87) considered pressure more often involved than those provided with the metaphor *coffee filter* (M=3.00). This implies that some kind of literal processing had occurred between percolation and pressure in nanofiltration. This implies that marginal support was found for H_{1a}.

An ANOVA confirmed that the extent to which nanofiltration worked because *"It has holes"* (F(3,97)=1.917; p=0.13) or *"Keeps bacteria from entering"* (F(3,97)=1.886; p=0.14) does not depend on the provided metaphor. So no evidence was found that providing the metaphor *"Nanofiltration is as making coffee with a paper coffee filter"* lead people to see filtration more as a *coffee filter*. It should however be noticed that regardless of the provided metaphor (or control) the interpretation that nanofilters have *holes* and *keep bacteria from entering* were scored as most likely (see Table 6), this suggests that people in all situation map *coffee filter* properties on nanofilters.

Moreover, unique characteristics of pasteurization (*"It kills bacteria"* and *"Works with heating"*) were not mapped onto nanofiltration by participants. This was tested with an ANOVA which showed no significant differences among the provided metaphors (or control)(*"It kills bacteria"* F(3,97)=0.666; p=0.58; *"Works with heating"* F(3,97)=0.531; p=0.66). This implies that no support was found for H_{1b}.

Table 6: Mean scores (SD) on applicability of comparison between different characteristics and nanofiltration[1]

	Metaphor	Mean/SD	F-value (d,f)	p-value
It has holes	Control (n=24)	4.04^{ab} (1.23)	(3,97)=1.91	0.13
	Percolation (n=23)	4.30^{ab} (0.93)		
	Coffee filter (n=33)	3.82^{a} (1.21)		
	Pasteurization (n=21)	4.52^{b} (1.08)		
It kills bacteria	Control (n=24)	2.25 (1.42)	(3,97)=0.67	0.58
	Percolation (n=23)	1.74 (1.10)		
	Coffee filter (n=33)	1.91 (1.21)		
	Pasteurization (n=21)	2.00 (1.38)		
Works with heating	Control (n=24)	1.67 (0.70)	(3,97)=0.53	0.66
	Percolation (n=23)	1.43 (0.59)		
	Coffee filter (n=33)	1.70 (0.88)		
	Pasteurization (n=21)	1.62 (0.97)		
Works with pressure	Control (n=24)	3.21^{ab} (1.35)	(3,97)=2.17	0.10
	Percolation (n=23)	3.87^{a} (1.29)		

	Coffee filter (n=33)	3.00^{b} (1.15)		
	Pasteurization (n=21)	3.14^{ab} (1.49)		
Keeps bacteria from entering	Control (n=24)	4.04^{a} (1.20)	(3,97)=1.89	0.14
	Percolation (n=23)	4.22^{ab} (1.13)		
	Coffee filter (n=33)	4.58^{b} (0.79)		
	Pasteurization (n=21)	4.57^{ab} (0.75)		

[1]*Values in a column that share a superscript character are not significantly different from each other (LSD).*

5.2 Metaphor processing

In condition 3 (*"Nanofiltration is as making coffee with a paper coffee filter"*) the base (e.g. paper coffee filter) and the target (e.g. nanofiltration) were based upon direct similarities between features of both the base and the target. In condition 4 (*"Nanofiltration is as pasteurization of milk"*) the base (e.g. pasteurization) and the target (e.g. nanofiltration) were based upon abstract indirect similarities between features.

Some unique characteristics were directly applicable to nanofiltration (*"It has holes"* and *"It keeps bacteria from entering"*). A MANOVA confirmed that there was an effect of the type of metaphor across all outcome measures (Roy's largest root F (5,95)=2.37; p=0.05). Subsequent ANOVA's showed no effect of type of metaphor on *"It has holes"* and *"It keeps bacteria from entering"* in all conditions. More specially pairwise comparisons (LSD) showed significant differences between the metaphors *coffee filter* and *pasteurization* (p=0.03; see Table 6) regarding *"It has holes"*; where participants provided with the metaphor pasteurization (M=4.52) considered *it has holes* more often involved than those provided with the metaphor *coffee filter* (M=3.82). This implies that the metaphor *pasteurization* caused an opposite effect and therefore no support was found for H_2.

5.3 Judgment

It was expected that participants based their judgment on the provided type of metaphor. A MANOVA confirmed that there was an effect of the type of metaphor across all outcome measures (Roy's largest root F(3,97)=24.21; p=0.00). Subsequent ANOVA's showed a significant effect of the metaphor *percolation* on judgment (F(3,97)=22.00; p=0.00), a marginally significant effect of the metaphor *coffee filter* on judgment (F(3,97)=2.23; p=0.09), and no significant effect of the metaphor *pasteurization* on judgment (F(3,97)=1.67; p=0.18).

More specifically pairwise comparisons (LSD) showed that participants' judgment depended in almost all scenarios on the type of metaphor provided. Participants provided with the metaphor *percolation* considered percolation significantly more similar to nanofiltration than those in all other scenarios (see Table 7). Participants provided with the metaphor *coffee filter* considered coffee filter significantly more similar to nanofiltration than those provided with the metaphor *percolation* (p=0.01; see Table 7). Participants provided with the metaphor *pasteurization* considered pasteurization marginally significant more similar to nanofiltration than those who were provided with the metaphor *coffee filter* (p=0.07; see Table 7). This implies thatl support was found for H_{3a}, and partial support was found for H_{3b} and H_{3c}.

Table 7: Mean scores (SD) of judgment with different provided metaphors[1]

Judgement	Metaphor	Mean/SD	F-value (d,f)	p-value
Percolation	Control (n=24)	3.92^{a} (0.24)	(3,97)=22.00	0.00
	Percolation (n=23)	5.74^{b} (0.25)		
	Coffee filter (n=33)	3.52^{c} (0.20)		
	Pasteurization (n=21)	3.19^{d} (0.26)		
Coffee filter	Control (n=24)	5.96^{ab} (0.18)	(3,97)=2.23	0.09
	Percolation (n=23)	5.48^{b} (0.18)		
	Coffee filter (n=33)	6.06^{a} (0.15)		
	Pasteurization (n=21)	5.81^{ab} (0.19)		
Pasteurization	Control (n=24)	2.42^{a} (0.32)	(3,97)=1.67	0.18
	Percolation (n=23)	2.70^{b} (0.32)		
	Coffee filter (n=33)	2.58^{b} (0.27)		
	Pasteurization (n=21)	3.38^{b} (0.34)		

[1]Values in a column that share a superscript character are not significantly different (LSD).

5.4 Knowledge

Both subjective and objective knowledge were evaluated in this study. Results of both types of knowledge are discussed below.

5.4.1 Subjective knowledge

It was expected that the level of subjective knowledge depended on the type of judgment formed by participants derived from the provided metaphor. Subjective knowledge was determined by the *general subjective understanding* of nanotechnology and nanofiltration and the subjective *influence of the type of metaphor* in understanding nanofiltration. An ANOVA confirmed that there was no effect of the type of metaphor across all outcome measures (F(3,97)=1,018; p=0.39 ; F(3,97)=0.187; p=0.91; see Table 8) regarding the *general subjective understanding* of nanotechnology and nanofiltration.

An ANOVA confirmed that there was an effect of type of metaphor on the subjective influence of the type of metaphor in understanding nanofiltration across all outcome measures (F(2,74)=12.89; p=0.00; see Table 8). More specially pairwise comparisons (LSD) showed that participants provided with the metaphor *coffee filter* considered their metaphor significantly more helpful in understanding nanofiltration than participants provided with either the metaphor *percolation* or the metaphor *pasteurization* (p=0.00; p=0.00; see Table 8). This shows partial support for H_4

Table 8: Mean scores (SD) of subjective knowledge with different provided metaphors[1]

Subjective knowledge	Metaphor	Mean/SD	F (d,f)	p-value
Understanding nanofiltration	Control (n=24)	6.04^{a} (0.16)	(3,97)=1.02	0.39
	Percolation (n=23)	5.70^{a} (0.17)		
	Coffee filter (n=33)	6.03^{a} (0.14)		
	Pasteurization (n=21)	5.91^{a} (0.17)		
Understanding an application of nanotechnology	Control (n=24)	5.71^{a} (0.19)	(3,97)=0.19	0.91
	Percolation (n=23)	5.57^{a} (0.20)		
	Coffee filter (n=33)	5.64^{a} (0.16)		
	Pasteurization (n=21)	5.76^{a} (0.21)		
Metaphor helped in understanding nanofiltration	Control (n=24)	No metaphor	(2,74)=12.89	0.00
	Percolation (n=23)	4.48^{a} (0.33)		
	Coffee filter (n=33)	6.21^{b} (0.27)		
	Pasteurization (n=21)	4.29^{a} (0.34)		

[1]Values in a column that share a superscript character are not significantly different (LSD).

5.4.2 Objective knowledge

Two participants did not knew what happened to the bacteria during nanofiltration and twelve participants did not knew that the holes in the micro sieve have to be uniform to remove all bacteria Due to the limited amount of wrong answers no further analyses were done. Cross-tabulations can be found in Appendix B (Table 1 and 2).

It was expected that each scenario caused an increase of objective knowledge of participants since they were all provided with the same objective information. A repeated-measures ANVOA confirmed that there was an significant increase of objective knowledge across all outcome measures (Roy's largest root F(3,50)=51.31; p=0.00). This implies that objective knowledge increased despite of the type of metaphor used (or control) and support was found for H_5.

5.5 Attitude

Attitude of participants was measured before and after reading the scenario. A repeated measures ANOVA confirmed a main effect of positive change in attitude (pre – post) (F(1,97)=4.11; p=0.05; see Table 9). Attitudes on nanotechnology were in general not significantly different across scenarios, neither in pre-attitude (p=0.74) nor in post-attitude (p=0.65; see Table 9). The interaction between pre- and post-attitude was not significant (F(3,97)=0.90; p=0.44).

An ANOVA showed that participants' attitude towards nanofiltration did not depend on the type of metaphor provided and was similar for all participants (F(3,97)=0.10; p=0.96; see Table 9). Only the post-attitude of nanofiltration was measured.

Table 9: Mean scores (SD) of pre and post-attitude of nanotechnology and attitude towards nanofiltration.

	Metaphor	Mean/SD	F (d,f)	p-value	Overall mean	F(d,f)	p-value
Pre-attitude nanotechnology	Control (n=24)	5.04 (1.20)	(3,97)=0.42	0.74	4.86	(1,97)=4.11	0.05
	Percolation (n=23)	4.74 (1.29)					
	Coffee filter (n=33)	4.76 (1.03)					
	Pasteurization (n=21)	4.95 (1.12)					
Post-attitude nanotechnology	Control (n=24)	5.00 (1.41)	(3,97)=0.55	0.65	5.07		
	Percolation (n=23)	5.17 (0.94)					
	Coffee filter (n=33)	4.91 (1.13)					
	Pasteurization (n=21)	5.29 (1.06)					
Attitude nanofiltration	Control (n=24)	5.63 (1.35)	(3,97)=0.10	0.96	5.51	-	-
	Percolation (n=23)	5.48 (0.85)					
	Coffee filter (n=33)	5.48 (1.09)					
	Pasteurization (n=21)	5.48 (1.33)					

6. Discussion and conclusion

This chapter discusses the main results, both positive and negative findings and their theoretical and practical implications.

6.1 Main results

The study was guided by four hypotheses divided in different sub-hypotheses. Only the main hypotheses are discussed below.

Participants provided with the metaphor *percolation* (unknown base) considered *pressure* more often involved in nanofiltration than those provided with the metaphor *coffee filter* indicating literal processing occurred. However, participants provided with this metaphor considered specific characteristics as *it has holes* and *keeps bacteria from entering* equally applicable to nanofiltration as the characteristic *works with pressure*. This implies that when the base is unknown a person not necessarily engages in literal processing. Providing participants with the metaphor coffee filter did not influence the choice for scoring characteristics *it has holes* and *keeps bacteria from entering* since these characteristics were scored highest by all participants. This implies that all people map *coffee filter* properties on nanofilters. Unique characteristics of pasteurization were not mapped onto nanofiltration. Therefore no support was found for H_1 implying that *engaging in metaphorical processing does not necessarily depends on the provided base of the metaphor*. What could have happened here is reasoning by analogy where nanofilter properties were always compared to coffee filter properties. A process that often occurs naturally by pre-learned analogies (Gick and Holyoak, 1983). Properties of coffee filter probably came to mind when specific properties of a nanofilter were provided and the process of reasoning by analogy was put in motion.

When providing participants with a more abstract metaphor (*pasteurization*) seemed to have an opposite effect. Coffee filter characteristics were considered more often by participants provided with the metaphor *pasteurization* than participants provided with the metaphor *coffee filter*. Therefore no support was found for H_2 implying that *engaging in pure-matching processing does not necessarily depend on the recognition of similarities between base and target of the metaphor*. The provided metaphor does not necessarily influence the reasoning of participants, because the metaphor was irrelevant since the coffee filter analogy already explained everything.

Participants provided with the metaphor *percolation* judged percolation significantly more similar to nanofiltration than those in all other scenarios. Participants provided with the metaphor *coffee filter* judged coffee filter significantly more similar to nanofiltration than those provided with the metaphor *percolation*. Participants provided with the metaphor *pasteurization* judged pasteurization marginally significant more similar to nanofiltration than those who were provided with the metaphor *coffee filter*. Therefore partial support was found for H_3 implying that *the provided metaphor partially influences participants' judgment on nanofiltration*.

Participants provided with the metaphor *coffee filter* considered coffee filter more helpful in understanding nanofiltration than participants provided with either the metaphor *percolation* or the metaphor *pasteurization.* Subjective knowledge increased most with the use of the metaphor *coffee filter*. Objective knowledge did not depend on the type of metaphor provided, and increased for

participants across all scenarios. Therefore support was found for H_4 implying that *especially subjective knowledge depended on the provided type of metaphor.*
Two multiple choice questions served as a check to see whether participants had read the scenario properly. There were some false answers in questions on what happens to the bacteria and the type of micro sieve used. This indicates that some participants perhaps had not read the scenario properly. However, since there were only a few participants in every condition this would have not changed the results.

6.2 Positive findings

Although only mixed support was found for the hypotheses there were some positive findings in this study. Overall, it was quite obvious that the metaphor coffee filter worked best. Although participants were provided with a different metaphor, coffee filter properties were considered more applicable than the other properties. However, the provided metaphors did guide participants in understanding nanofiltration with the metaphor *percolation*. Percolation is characterized by working with pressure. Participants provided with this metaphor found this characteristic more applicable than participants provided with another metaphor. A better example of this is participants' judgment. Participants scored the provided metaphor as most similar to nanofiltration. However, it should be noted that the metaphor *coffee filter* scored highest on average.

Pure-matching seemed to be the process that was dominating throughout all scenarios. This type of metaphor created the highest understanding of nanofiltration and was most similar to nanofiltration according to participants' answers.

This study investigated the possible routes of metaphorical processing. By using different metaphors participants were guided to one of the three possible routes (e.g. literal processing of the metaphor, pure-matching processing of the metaphor, and abstraction-first processing of the metaphor). Not all participants took the desired route. It was remarkable to see that participants' judgment was influenced by the provided metaphor in the scenario. This implies that the metaphor did have an influence on how nanofiltration was perceived despite of the fact that coffee filter properties were already activated in their minds. This study showed that metaphors in fact can provide information and influence the understanding of new, modern technologies like nanotechnology. However, it is recommended to do multiple studies with different technologies for validation.

6.3 Negative findings

Providing participants with the metaphor pasteurization increased the identification of coffee filter properties on nanofiltration. It seemed that the metaphor pasteurization was deviating much from nanofiltration and the higher, abstract comparison of pasteurization was not mapped onto nanofiltration. It is possible that the target (nanofiltration) was not assigned to an abstract category which was associated with the base (pasteurization) which caused that properties of pasteurization were in the participants' minds not applicable to nanofiltration. Coffee filter properties were probably already in the mind of participants provided with the metaphor *pasteurization*, since the metaphor *coffee filter* was only presented later on in the experimental questionnaire after asking for specific characteristics of nanofiltration.

In the pilot study pasteurization was directly compared to nanofiltration instead of the indirect relationship. Results of this pilot study showed that this direct comparison caused participants to choose the pasteurization properties as least applicable. To overcome this problem in the final study the *direct* comparison was removed and the *effect* of pasteurization was emphasized which should lead to abstraction-first processing. Unfortunately, this did not change the way the metaphor was processed.

6.4 Theoretical implications

The results of this study indicated that metaphors can be valuable in understanding difficult concepts like nanofiltration. This study suggests that pure-matching metaphors provide most useful information. However, it is important that the path of abstraction-first metaphors is further studied. Using pasteurization as a metaphor to explain nanofiltration did not have the desired effect, but this does not immediately imply that abstraction-first metaphors do not work. Pasteurization could just have been an unfortunate choice. Moreover, it should be taken into account that people also form their own metaphors in their mind while reading a text. This became clear in this study due to the fact that participants found coffee filter properties more applicable to nanofiltration even when they were not provided with this metaphor in the text.

By studying the different paths of metaphor processing it became clear that pure-matching metaphors work best for new technologies, preferably a metaphor that is very close to the technology at hand (e.g. coffee filter and nanofilter). Using an abstraction-first metaphor can cause difficulties in extracting properties from the base and applying these on the target, since the target is unknown (e.g. nanotechnology). This may have happened with the metaphor pasteurization.

6.5 Practical implications

A first step in developing an opinion on nanotechnology is by understanding what it is and becoming familiar with it. This study showed that it is possible to give people a first hand-on information on a new technology. As already stated in the introduction, metaphors are restricting the complexity of issues and can open up different interpretations each time (Hellsten, 2003). It is important that when one wants to promote a new technology to the public that a metaphor opens just the right interpretation that you want people to believe. Metaphors can take away the fear and uncertainty for the unknown and take down the power of the metaphors used for expressing ones opinion (e.g. the use of the *'Frankenfood'* metaphor for describing genetic modified foods). This study showed that participants found the metaphor coffee filter especially helpful in understanding nanofiltration implying that metaphors indeed help in getting a first impression of nanotechnology. Metaphors are often used for targeting the emotional involvement of one. By using metaphors as a way of providing information you are doing an appeal on people's rationality, such as most companies want (Scheufele & Lewenstein, 2005; Crisp & Turner, 2007). In the past metaphors have been used to illustrate negative aspects of new technologies by activist groups and NGO's, while companies have been stuck to fact sheets. Positive metaphors (especially pure-matching metaphors) can also help to create support and understanding for new technologies.

Appendices

Appendix A

Pilot study

Introduction	Beste meneer/mevrouw, Hartelijk dank voor het deelnemen aan deze vragenlijst. Deze vragenlijst gaat over nanotechnologie en zal ongeveer 5-10 minuten duren. De antwoorden zullen vertrouwelijk behandelt worden. Ik wil u erop wijzen dat er geen goede of slechte antwoorden mogelijk zijn.
Scenarios (Randomized)	Scenario 1 – Control Lees onderstaande tekst goed door: Nanotechnologieën, in het bijzonder microtechnologieën, kunnen worden gebruikt om bepaalde voedingspathogenen uit specifieke producten te verwijderen. Een voorbeeld van deze microtechnologieën is nanofiltratie. Door middel van nanofiltratie kan bijvoorbeeld de zuivelindustrie bacteriën uit rauwe melk filtreren. Dit gebeurt met behulp van microzeven. De melk wordt voorzichtig door de filtermembranen geleid waar bacteriën achterblijven. De melk die overblijft is vrij van bacteriën. Nanofiltratie is niet alleen een zeer eenvoudige manier om bacteriën uit melk te verwijderen, maar het is ook zeer duurzaam omdat dit proces weinig tot geen energie nodig heeft om de bacteriën te verwijderen. Dit systeem met microzeven werkt alleen als de gaten in de microzeef extreem uniform sinds dat ervoor zorgt dat alle bacteriën eruit gefilterd kunnen worden.” Scenario 2 – Literal Lees onderstaande tekst goed door: Nanotechnologieën, in het bijzonder microtechnologieën, kunnen worden gebruikt om bepaalde voedingspathogenen uit specifieke producten te verwijderen. Een voorbeeld van deze microtechnologieën is nanofiltratie. Nanofiltratie lijkt veel op het percoleren van koffie. Door middel van nanofiltratie kan bijvoorbeeld de zuivelindustrie bacteriën uit rauwe melk halen. Dit gebeurt met behulp van microzeven. De melk wordt voorzichtig door de filtermembranen geleid waar bacteriën achterblijven. De melk die overblijft is vrij van bacteriën. Dit lijkt veel op het percolatie-proces van koffie waarbij heet water door de koffie gedrukt wordt.

<table>
<tr><td></td><td>Nanofiltratie niet alleen een zeer eenvoudige manier om bacteriën uit melk te verwijderen, maar het is ook zeer duurzaam omdat dit proces weinig tot geen energie nodig heeft om de bacteriën te verwijderen.
Dit systeem met microzeven werkt alleen als de gaten in de microzeef extreem uniform sinds dat ervoor zorgt dat alle bacteriën eruit gefilterd kunnen worden.

Scenario 3 – Pure-matching

Lees onderstaande tekst <u>goed</u> door:

Nanotechnologieën, in het bijzonder microtechnologieën, kunnen worden gebruikt om bepaalde voedingspathogenen uit specifieke producten te verwijderen. Een voorbeeld van deze microtechnologieën is nanofiltratie.

Nanofiltratie lijkt veel op koffiezetten met een papieren koffiefilter. Door middel van nanofiltratie kan bijvoorbeeld de zuivelindustrie bacteriën uit rauwe melk halen. Dit gebeurt met behulp van microzeven. De melk wordt voorzichtig door de filtermembranen geleid waar bacteriën achterblijven. De melk die dan overblijft is vrij van bacteriën. Dit lijkt veel op koffiezetten met een papieren koffiefilter waarbij warm water door het filter geleid wordt.

Nanofiltratie is niet alleen een zeer eenvoudige manier om bacteriën uit melk te verwijderen, maar het is ook zeer duurzaam omdat dit proces weinig tot geen energie nodig heeft om de bacteriën te verwijderen.
Dit systeem met microzeven werkt alleen als de gaten in de microzeef extreem uniform zijn sinds dat ervoor zorgt dat alle bacteriën eruit gefilterd kunnen worden.

Scenario 4 – Abstraction-first

Lees onderstaande tekst <u>goed</u> door:

Nanotechnologieën, in het bijzonder microtechnologieën, kunnen worden gebruikt om bepaalde voedingspathogenen uit specifieke producten te verwijderen. Een voorbeeld van deze microtechnologieën is nanofiltratie.

Nanofiltratie lijkt veel op het pasteuriseren van melk. Door middel van nanofiltratie kan bijvoorbeeld de zuivelindustrie bacteriën uit rauwe melk halen. Dit gebeurt met behulp van microzeven. De melk wordt voorzichtig door de filtermembranen geleid waar bacteriën achterblijven. De melk die overblijft is vrij van bacteriën. Dit lijkt veel op pasteurisatie waarbij de melk lang genoeg verhit wordt om alle bacteriën te doden.

Nanofiltratie is niet alleen een zeer eenvoudige manier om bacteriën uit melk te verwijderen, maar het is ook zeer duurzaam omdat dit proces weinig tot geen energie nodig heeft om de bacteriën te verwijderen.
Dit systeem met microzeven werkt alleen als de gaten in de microzeef extreem uniform zijn sinds dat ervoor zorgt dat alle bacteriën eruit gefilterd kunnen worden.</td></tr>
<tr><td>Questions</td><td>1) Na het lezen van voorgaand scenario, in hoeverre denkt u dat de</td></tr>
</table>

	volgende eigenschappen van een nanofilter bij nanofiltratie van toepassing zijn? (5-puntsschaal met 1 = Helemaal niet van toepassing en 5 = Volledig van toepassing)(De goede antwoorden zijn onderstreept). a. Het heeft gaatjes. b. Het houdt bacteriën tegen. c. Het werkt met verhitting. d. Het werkt met druk. e. Het doodt bacteriën. 2) Wat gebeurt er met de bacteriën bij nanofiltratie? (Één antwoord mogelijk) a. Bacteriën gaan dood. b. Bacteriën blijven achter in het filter. c. Bacteriën worden onschadelijk gemaakt. d. Geen van bovenstaande antwoorden. 3) Hoeveel energie word er tijdens nanofiltratie verbruikt? (Één antwoord mogelijk) a. Weinig tot geen b. Gemiddeld c. Veel d. Zeer veel 4) Is dit proces duurzaam? a. Ja b. Nee 5) De gaten in de microzeef moeten ... zijn om te zorgen dat alle bacteriën verwijderd kunnen worden. a. Verschillend b. Uniform 6) In hoeverre vind u de volgende processen lijken op nanofiltratie? (7-puntsschaal met 1 = Helemaal niet en 7 = Heel veel). a. Koffiezetten met een papieren koffiefilter. b. Pasteurisatie. c. Het percoleren van koffie.
Questions on the built up of the scenario	1) Was de tekst over nanofiltratie begrijpelijk? (7-puntsschaal met 1 = Heel erg onbegrijpelijk en 7 = Heel erg begrijpelijk). 2) Was de tekst over nanofiltratie moeilijk te lezen? (7-puntsschaal met 1 = Heel erg moeilijk en 7 = Heel erg makkelijk). 3) Was de tekst over nanofiltratie geloofwaardig? (7-puntsschaal met 1 = Heel erg ongeloofwaardig en 7 = Heel erg geloofwaardig).
Background questions	1) Wat is uw geslacht? a. Man b. Vrouw 2) Hoe oud bent u? 3) Welke studie volgt u momenteel?
Word of thank	Hartelijk dank voor het deelnemen aan deze vragenlijst. Het scenario dat u gelezen heeft is gebaseerd op een passage uit het hoofdstuk "*Potential Benefits and Market Drivers for Nanotechnology Applications in the Food Sector*"geschreven door F.W.H. Kampers in het boek *"Nanotechnologies in Food"* (2010). Deze passage is vervolgens door mij vertaald naar het Nederlands.

	Mocht u interesse hebben in dit onderwerp, dan wil ik u doorverwijzen naar dit boek. Nogmaals hartelijk dank voor het deelnemen aan deze vragenlijst.

Final study

Introduction	Je krijgt nu een vragenlijst over nanotechnologie. Dit zal ongeveer 10 minuten duren. Er zijn geen foute of slechte antwoorden, het is jouw mening die telt en van belang is voor het onderzoek.
Prior questions	1) Heb je ooit gehoord van nanotechnologie? ○ Ja ○ Nee 2) In hoeverre ben je het eens met de volgende stelling: *Over het algemeen steun ik het gebruik van nanotechnologie* (7-puntsschaal met 1 = Helemaal niet en 7 = Helemaal mee eens
	Nu volgen enkele vragen over nanofiltratie. Nanofiltratie is een toepassing van nanotechnologie die kan worden gebruikt om bacteriën uit melk te filtreren.
	3) Hoeveel energie denk je dat er verbruikt word tijdens nanofiltratie? (Één antwoord mogelijk) (7-puntsschaal met 1 = Weinig tot geen en 7 = Heel veel tot extreem veel) 4) Is dit proces duurzaam? (7-puntsschaal met 1 = Helemaal niet en 7 = Helemaal wel)
Scenarios (randomized)	Scenario 1 – Control Lees onderstaande tekst <u>goed</u> door: Nanotechnologieën, in het bijzonder microtechnologieën, kunnen worden gebruikt om bepaalde voedingspathogenen uit specifieke producten te verwijderen. Een voorbeeld van deze microtechnologieën is nanofiltratie. Door middel van nanofiltratie kan bijvoorbeeld de zuivelindustrie bacteriën uit rauwe melk filtreren. Dit gebeurt met behulp van microzeven. De melk wordt voorzichtig door de filtermembranen geleid waar bacteriën achterblijven. De melk die overblijft is vrij van bacteriën. Nanofiltratie is niet alleen een zeer eenvoudige manier om bacteriën uit melk te verwijderen, maar het is ook zeer duurzaam omdat dit proces weinig tot geen energie nodig heeft om de bacteriën te verwijderen. Dit systeem met microzeven werkt alleen als de gaten in de microzeef extreem uniform zijn, omdat dat ervoor zorgt dat alle bacteriën eruit gefilterd kunnen worden.
	Scenario 2 – Literal Lees onderstaande tekst <u>goed</u> door: Nanotechnologieën, in het bijzonder microtechnologieën, kunnen worden gebruikt om bepaalde voedingspathogenen uit specifieke producten te verwijderen. Een voorbeeld van deze microtechnologieën is nanofiltratie. Nanofiltratie lijkt veel op het percoleren van koffie. Door middel van nanofiltratie kan bijvoorbeeld de zuivelindustrie bacteriën uit rauwe melk halen. Dit gebeurt met behulp van microzeven. De melk wordt voorzichtig door de filtermembranen geleid waar bacteriën achterblijven. Dit lijkt veel op het percolatie-proces van

	koffie waarbij water door de koffie gedrukt wordt. De melk die overblijft is vrij van bacteriën. Nanofiltratie niet alleen een zeer eenvoudige manier om bacteriën uit melk te verwijderen, maar het is ook zeer duurzaam omdat dit proces weinig tot geen energie nodig heeft om de bacteriën te verwijderen. Dit systeem met microzeven werkt alleen als de gaten in de microzeef extreem uniform zijn, omdat dat ervoor zorgt dat alle bacteriën eruit gefilterd kunnen worden.
	Scenario 3 – Pure-matching Lees onderstaande tekst goed door: Nanotechnologieën, in het bijzonder microtechnologieën, kunnen worden gebruikt om bepaalde voedingspathogenen uit specifieke producten te verwijderen. Een voorbeeld van deze microtechnologieën is nanofiltratie. Nanofiltratie lijkt veel op koffiezetten met een papieren koffiefilter. Door middel van nanofiltratie kan bijvoorbeeld de zuivelindustrie bacteriën uit rauwe melk halen. Dit gebeurt met behulp van microzeven. De melk wordt voorzichtig door de filtermembranen geleid waar bacteriën achterblijven. Dit lijkt veel op het zetten van koffie waarbij de gemalen koffie in het filter achterblijft. De melk die dan overblijft is vrij van bacteriën. Nanofiltratie is niet alleen een zeer eenvoudige manier om bacteriën uit melk te verwijderen, maar het is ook zeer duurzaam omdat dit proces weinig tot geen energie nodig heeft om de bacteriën te verwijderen. Dit systeem met microzeven werkt alleen als de gaten in de microzeef extreem uniform zijn, omdat dat ervoor zorgt dat alle bacteriën eruit gefilterd kunnen worden.
	Scenario 4 – Abstraciton-first Lees onderstaande tekst goed door: Nanotechnologieën, in het bijzonder microtechnologieën, kunnen worden gebruikt om bepaalde voedingspathogenen uit specifieke producten te verwijderen. Een voorbeeld van deze microtechnologieën is nanofiltratie. Nanofiltratie lijkt veel op het pasteuriseren van melk. Door middel van nanofiltratie kan bijvoorbeeld de zuivelindustrie bacteriën uit rauwe melk halen. Dit gebeurt met behulp van microzeven. De melk wordt voorzichtig door de filtermembranen geleid waar bacteriën achterblijven. Het effect hiervan lijkt op pasteurisatie waarbij de melk genoeg verhit wordt om de meeste bacteriën te doden. De melk die overblijft is vrij van bacteriën. Nanofiltratie is niet alleen een zeer eenvoudige manier om bacteriën uit melk te verwijderen, maar het is ook zeer duurzaam omdat dit proces weinig tot geen energie nodig heeft om de bacteriën te verwijderen. Dit systeem met microzeven werkt alleen als de gaten in de microzeef extreem uniform zijn, omdat dat ervoor zorgt dat alle bacteriën eruit gefilterd kunnen worden.
Questions afterwards	5) Na het lezen van voorgaand scenario, in hoeverre denk je dat de volgende eigenschappen van toepassing zijn? (5-puntsschaal met 1 = Helemaal niet van toepassing en 5 = Volledig van toepassing) a. Het heeft gaatjes. b. Het doodt bacteriën. c. Het werkt met verhitting.

	d. Het werkt met druk. e. Het houdt bacteriën tegen.
	6) In hoeverre vindt je de volgende processen lijken op nanofiltratie? (7-puntsschaal met 1 = Helemaal niet en 7 = Heel veel). a. Koffiezetten met een papieren koffiefilter. b. Pasteurisatie. c. Het percoleren van koffie.
	Nu volgen enkele vragen over nanofiltratie.
	7) Wat gebeurt er met de bacteriën bij nanofiltratie? (Één antwoord mogelijk) a. Bacteriën gaan dood. b. Bacteriën blijven achter in het filter. c. Bacteriën worden onschadelijk gemaakt. d. Geen van bovenstaande antwoorden. 8) Hoeveel energie word er tijdens nanofiltratie verbruikt? (Één antwoord mogelijk) (7-puntsschaal met 1 = Weinig tot geen en 7 = Heel veel tot extreem veel) 9) Is dit proces duurzaam? (7-puntsschaal met 1 = Helemaal niet en 7 = Helemaal wel) 10) De gaten in de microzeef moeten ... zijn om te zorgen dat alle bacteriën verwijderd kunnen worden. a. Verschillend b. Uniform
	Nu volgen enkele stellingen over de tekst die je gelezen hebt en het gebruik van nanotechnologie.
	11) Ik begrijp nanofiltratie (beter) door voorgaand scenario (7-puntschaal met 1 = Helemaal niet mee eens en 7 = Helemaal mee eens) 12) Ik heb een (beter) idee van wat een toepassing van nanotechnologie kan inhouden. (7-puntschaal met 1 = Helemaal niet mee eens en 7 = Helemaal mee eens) 13) De metafoor (scenario 2,3,4) heeft mij geholpen om nanofiltratie (beter) te begrijpen (7-puntschaal met 1 = Helemaal niet mee eens en 7 = Helemaal mee eens) • Indien scenario 2 → De metafoor *"Nanofiltratie is hetzelfde als het percoleren van koffie"* heeft mij geholpen om nanofiltratie (beter) te begrijpen. • Indien scenario 3 → De metafoor *"Nanofiltratie is hetzelfde als koffiezetten met een papieren koffiefilter"* heeft mij geholpen om nanofiltratie (beter) te begrijpen. • Indien scenario 4 → De metafoor *"Nanofiltratie is als het pasteuriseren van melk"* heeft mij geholpen om nanofiltratie (beter) te begrijpen.
	14) Ik steun deze toepassing van nanotechnologie. (7-puntschaal met 1 = Helemaal niet mee eens en 7 = Helemaal mee eens) 15) Over het algemeen steun ik het gebruik van nanotechnologie. (7-puntschaal met 1 = Helemaal niet mee eens en 7 = Helemaal mee eens)
Original scenario	Het scenario dat u gelezen heeft is gebaseerd op een passage uit het hoofdstuk

<table>
<tr><td></td><td>“Potential Benefits and Market Drivers for Nanotechnology Applications in the Food Sector” geschreven door F.W.H. Kampers in het boek “Nanotechnologies in Food” (2010). Deze passage is vervolgens door mij vertaald naar het Nederlands. Mocht u interesse hebben in dit onderwerp, dan verwijs ik graag door naar dit boek.</td></tr>
<tr><td rowspan="3">Background questions</td><td>Je bent nu klaar met het onderzoek. Je gaat nu verder met een aantal algemene vragen. Dit duurt nog enkele minuten.</td></tr>
<tr><td>16) In hoeverre was u voor dit onderzoek bekend met nano-filtratie?
a. Onbekend
b. Een beetje bekend
c. Bekend
17) Heeft u recent een vragenlijst over nano-filtratie ingevuld?
a. Ja
b. Nee</td></tr>
<tr><td>18) Wat is je leeftijd in jaren? <tekstbox>
19) Wat is je geslacht?
a. Man
b. Vrouw
20) Hoe sta je ingeschreven bij de WUR?
a. Bachelor student
b. Master student
c. PhD student
d. Medewerker
e. Anders, nl <tekstbox></td></tr>
<tr><td>Word of thank</td><td>Bedankt voor je deelname aan dit onderzoek.</td></tr>
</table>

Appendix B

Table 1: Cross-tabulation on the given answers what happens to the bacteria during nanofiltration

		Provided metaphor				**Total:**
		Control	Percolation	Coffee filter	Pasteurization	
What happens to the bacteria by using nanofiltration?	Bacteria stay behind in the filter.	23	22	33	21	99
	Bacteria are disarmed.	1	1	0	0	2
Total:		24	23	33	21	101

Table 2: Cross-tabulation on the given answers about the micro sieve removing the bacteria

		Provided metaphor				**Total:**
		Control	Percolation	Coffee filter	Pasteurization	
The holes in the micro sieve have to be … to remove all bacteria.	Distinct	4	1	3	4	12
	Uniform	20	22	30	17	89
Total:		24	23	33	21	101

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