New hypotheses about Attitude formation towards nanotechnology

A new grounded conception of the role of affect and cognition in laypeoples' attitudes towards nanotechnology

University of Twente.
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Author: Vanessa Starke

Jan M. Gutteling, Dr.
Sabine Roeser, Prof. Dr.

The purpose of this study was to explore and explain the attitudes of laypeople towards nanotechnology. Previous studies showed that affect and cognitions play an important role in the risk perception of nanotechnology. The methodology of Grounded theory served as the guideline for this research. Attitudes towards nanotechnology were explored via unstructured in-depth interviews (n=5) with a focus on nano-technology. A dynamic relationship has been identified between the sub-categories: perceived level of knowledge and referencing internal and external sources. Three strategies have been found that laypeople use to generate attitudes. Cognitive and affective dimensional aspects in attitudes towards nanotechnology formed the core category. Three hypotheses concerning the interplay of affect, cognitionsand strategies in attitudes were developed and explained.

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1. Introduction

1.1 Purpose of the study

The purpose of this study is twofold: exploring and explaining the attitudes of laypeople towards nanotechnology. The first step is to discover the factors underlying their attitudes, while the second step is to sketch an explanation for these factors. A focal point of this study is the influence of affect and cognition as necessary, and contributing factors of attitudes (Edwards, 1990; Scherer, 2005) towards this new emerging, not well-known technology (Kahan, Slovic, Braman, Gastil, & Cohen, 2007; Lee, Scheufele, & Lewenstein, 2005; Swierstra & Rip, 2007). In the following paragraphs, the term 'affect' will be associated with a state of feeling (Finucane, Alhakami, Slovic, & Johnson, 2000). Affective phenomena can be found in emotions and moods (Forgas, 2000, p. 110; Scherer, 2005) but also in preferences, affect dispositions, interpersonal stances and attitudes (Scherer, 2005). Cognition will refer loosely to some sort of information processing (Scherer, 2005). Previous studies assumed a dichotomy between emotions and rationality in these judgments based on the theoretical background of the *dual process theory*[1] (Finucane et al., 2000; Kahan et al., 2007; Roeser, 2009). A-priori formulated theoretical assumptions based on a *dual process theory* make researchers assume a too simplistic categorization of system 1, which is associated with affective phenomena and prone to biases and, therefore, normatively less correct, and system 2 – the normatively more correct rational one – of laypeople's risk judgments (Roeser, 2009). Take for example the conjunction fallacy introduced by Kahneman (2012, pp. 157-160). The Linda experiment[2] revealed that a conjunction of two events (A & B) has been rated as being more likely than one event

[1]System 1 operates automatically requiring little or no effort and no sense of voluntary control. Furthermore, it generates impressions and feelings, which form the basis of the belief of attitudes and beliefs generated by System 2 (Kahneman, 2012, p. 105). System 2 is active in deliberate memory search, planning comparisons and choice, which requires continuous attention. System 2 analyzes ideas and thoughts generated by System 1 (Kahneman, 2012, p. 21; 103).

[2] Kahneman (2012, p. 156): "*Linda a thirty-one years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations"*. Respondents chose out of two possibilities(Kahneman, 2012, p. 157): *Linda is a bank teller* or *Linda is a bank teller and is active in the feminist movement*. 85% chose the second option.

alone (A), even though the logical probability of a conjunction A & B is in any case lower than the logical probability of a single event A resp. B. Respondents chose the conjunction of event A and B because it seemed more plausible, but they failed to make a logical decision (Kahneman, 2012, p. 159). In this way intuitions, associated with system 1, were seen as the cause to not respond logically (Kahneman, 2012, p. 158;160). However, Gigerenzer (2007, p. 104) argues that such logic norms (cf. Kahneman, 2012, p. 158) are '*content- blind'* because they ignore that humans have to operate in an uncertain environment which asks for more than artificial logical rules.

Besides the normative aspect, it is disputable to assume that perceptions of reality can be grouped into two systems. A close collaboration of the factors affect and cognition is highly likely, although these relationships have not yet been fully discovered (Mellers et al., 2002, p. 269). It is necessary to reveal the relationships and the interplay between the affective and cognitive aspects of attitudes (Edwards, 1990), and the conditions that give rise to them. Therefore, this study is aimed to explore and discover theoretical explanations of the factors determining laypeople's attitudes towards nanotechnology, with a specific focus on the relationships between cognitive and affective aspects.

Research questions about the cause, the mechanisms behind and the relationships between phenomena are of an explanatory nature and can therefore best be answered by a case study (Yin, 2009, p. 9). To this end, *Grounded Theory* (Glaser & Strauss, 1967), a qualitative methodology, is implemented in order to construct theoretical explanations for emerging phenomena. This study first identifies underlying factors of laypeoples' attitudes towards nanotechnology. Possible underlying factors are affect and cognition. The analysis continues to compare all occurring phenomena within each case and with all other cases until a conceptual density has been achieved to allow formulating an explaining theory. Therefore, this study aims for the theoretical relevance of just a few cases, instead of statistical representativeness of occurring factors identified by quantitative studies (Kahan et al., 2007; Strauss & Corbin, 1990; Swierstra, van de Wijngaert, Hilbrink, & Koppeschaar, 2011).

In the first step, attitudes towards nanotechnology were explored via unstructured in-depth interviews with five respondents. Two conditions, namely time pressure (Finucane et al., 2000) and vignettes (Swierstra et

al., 2011), were used to elicit different responses of respondents. In a second step, the data material was coded and relevant data was used to build up the core category and subcategories. The relationships between the categories developed lead to the formulation of hypotheses about the attitudes towards nanotechnology; these will be explained and discussed in the following text.

1.2 Background: nanotechnology and risk perception

Bawa, Bawa, Maebius, Flynn, and Wei (2005) describe nanotechnology as: *"The design, characterization, production, and application of structures, devices, and systems by controlled manipulation of size and shape at the nanometer scale (atomic, molecular, and macromolecular scale) that produces structures, devices, and systems with at least one novel/superior characteristic or property."* The term is generally used when referring to small particles with at least one particle of nanometer size, i.e. one billionth of a meter (10^{-9} m). Nanotechnology is a research field with a wide range of applications (Swierstra & Rip, 2007) as in medicines and new sustainable technologies. Nanotechnology may lead to a new industrial revolution so it is important to understand public concerns (Macoubrie, 2006). The perceived benefits of nanotechnology may decrease when people's perception of the risks increases. It was shown that if one affective attribute is manipulated another affective attribute is influenced as well (Finucane et al., 2000). Nanotechnology may experience a backlash of public concerns as has already happened with genetically modified food (Macoubrie, 2006). Public perception about risks and possible benefits will determine the future of nanotechnology to a great extent (Kahan et al., 2007).

The referenced papers show that there is a need to investigate further how risk perceptions about nanotechnology are formed in lay people. Recent papers identify the contributing factors in the attitude formation as cognition, affect, trust and demographical characteristics.

A large-scale online survey in the U.S. (N=1500) about the risk perception of nanotechnology suggested that the majority, namely 81% of people, have little or no knowledge about this emerging technology (Kahan et al., 2007). However, it was also found that 89% nonetheless reported an attitude about nanotechnology (Kahan et al., 2007). It seems that people can form an attitude without knowing about

nanotechnology. A weak majority (53%) of respondents in this US study posed that the benefits of nanotechnology outweigh the risks (Kahan et al., 2007). In contrast a large scale study in the Netherlands (N= 4854) observed the opposite, i.e. respondents were mostly skeptical and observant concerning this emerging technology (Swierstra & Rip, 2007; Swierstra et al., 2011). It maybe that affective reactions towards nanotechnology are the most predicting factors of these attitudes(Kahan, 2008b; Kahan et al., 2007). Furthermore, even when people gain more knowledge about nanotechnology their attitudes remain consistent (Kahan et al., 2007). Subjects were more likely to accept nanotechnology if they hold favorable attitudes towards new technologies in general. The perception about nanotechnology may be shaped through associations with familiar risks such as global warming and nuclear power (Kahan et al., 2007). Kahan (2008a) explains this relationship by means of the Cultural Cognition Theory. The Cultural Cognition Theory states that individuals' attitudes adapt themselves to fit the cultural norm, which become in return the individuals' values and define their identities (Kahan, 2008b) The differences found between the study performed in the US (Kahan et al., 2007) and the study performed in the Netherlands (Swierstra et al., 2011) might be therefore attributed to these cultural differences. However both studies are not easily compared as the respondents of the study in the Netherlands received information about the 'soft impacts' of nanotechnology which are related to quality of life and relationships and the US sample did not. The different method of either providing information or none might have influenced their perceptions and might have cancelled out or amplified the differences in perceptions due to cultural differences.

Macoubrie (2006) conducted a quasi-experimental study (N=152) in the U.S. to research the concerns of the public towards nanotechnology. Following the view of Kahan (2008a), this study assumed that values play an important role in risk perception and that respondents would form an attitude based on their existing values and knowledge, combined with the new information. However, participants' agreed in a discussion that their concerns about nanotechnology were not based on affect, but to a vast extent on past experiences and knowledge (Macoubrie, 2006). The difference found in the contribution of affective reactions to the risk perception might be attributed to a difference in the methods that were used, i.e. self-report (Macoubrie, 2006) versus a single bipolar scale item (Kahan et al., 2007). Lee et al. (2005)

conducted a national telephone survey in the U.S. (N=706) to study the main effects of cognition and affect and their interaction with public perceptions of nanotechnology. Cognitive variables were defined as knowledge of science in general, knowledge about nanotechnology. Affective variables were defined as trust in scientists, negative emotion towards science in general, and negative emotions towards nanotechnology. Strikingly, Lee et al. (2005) characterized trust itself as an affective variable, whereas Macoubrie (2006) argued that trust in the government is based on previous experiences and knowledge rather than on affective reactions. Furthermore, Lee et al. (2005) found that emotional heuristics moderate the effect that knowledge of nanotechnology has on people's overall attitudes towards nanotechnology (cf. Finucane, 2013; Finucane et al., 2000). If cognitive processing is constrained, for instance by means of time pressure, people make use of affective processes to make quick judgments (Finucane et al., 2000).

The role of trust in government was crucial for laypeople to judge the acceptability of this new emerging technology (Macoubrie, 2006; Swierstra et al., 2011). Macoubrie (2006) found that indeed 62% (N=152) of the respondents in the U.S. had little trust in the government's capability to manage the risks; their trust decreased along with a higher level of education. Swierstra et al. (2011) showed that most participants in the Netherlands (69%; N=4854) would like to see the government assume a more active role in regulating nanotechnology.

Demographic factors in general were not related to the trust of respondents (Macoubrie, 2006). Gender of respondents (Kahan et al., 2007; Swierstra et al., 2011) significantly influenced the attitudes towards nanotechnology. Other demographic characteristics such as respondents age and political attitudes were only slightly connected to the attitudes (Swierstra et al., 2011).

2. Method: Grounded Theory

Even though quantitative research methods such as surveys are widespread in this research field (Kahan et al., 2007; Lee et al., 2005; Swierstra et al., 2011), case studies, histories and experiments are preferable research methods when it comes to establishing deeper explanations (Yin, 2009, p. 9). Case studies as experiments can explore the question as to why and how contemporary events occur, whereas history studies focus on past events (Yin, 2009, p. 8). Qualitative methods help to understand the background of nearly unknown phenomena, entering the world of participants(Corbin & Strauss, 2008, p. 13) to research the underlying factors of laypeople's attitudes towards nanotechnology. Glaser and Strauss (1967) developed *Grounded Theory*, a qualitative research method that makes use of systematic procedures to develop an inductively deduced object-related theory about phenomena (Strauss & Corbin, 1996, p. 8). Grounded Theory has its origins in sociological research, but is applied also in psychological studies searching for a methodology to gain a grounded insight in specific phenomena (Strauss & Corbin, 1996, p. 11). The methodology helps to fulfill the objective of this study and applied thusly (cf. Corbin & Strauss, 2008, p. 324). Conceptualization and categorizations are crucial parts of data description in qualitative research (Strauss & Corbin, 1996, pp. 6-7). Grounded Theory continues along this descriptive analysis, but continues to relate the different categories to each other to form one theory by means of interpretation (Strauss & Corbin, 1996, p. 7). Therefore Grounded Theory helps to discover the underlying factors of the attitudes towards nanotechnology and form a coherent theoretical framework. In the following it will be described how the *Grounded Theory* was applied to each methodological section in this study.

2.1 Sampling

In contrast to quantitative studies, a random sampling in qualitative research would lead to a distortion of the results, because a random sampling restricts the choice of cases that are relevant for the research problem (Kelle & Kluge, 2010, p. 42;43). This study is not aimed at generalizing results per se, so representativeness of persons was not aimed for. Strauss and Corbin (1990) state: *"In grounded theory, representativeness of concepts, not of persons, is crucial. The aim is ultimately to build a theoretical*

explanation by specifying phenomena in terms of conditions that give rise to them, how they are expressed through action/interaction, the consequences that result from them, and variations of these qualifiers."

For this endeavor, *Theoretical sampling* (Corbin & Strauss, 2008, p. 144), a method of collecting data based on concepts has been implemented. These concepts are derived during the data collection (Thomas, 2011, p. 163). Typically the researcher has to gather the first amount of data, generate concepts from that data and adjust the data gathering process on the basis of these preliminary concepts. The concepts are grouped to categories and the data gathering is continued until a category is saturated with theoretical concepts (Corbin & Strauss, 2008, p. 146). In other words, the selection of cases is responsive to the collected data of the pilot-interviews rather than being selected prior to the interviews.

Furthermore, Grounded Theory asks for an integration of the data material into macroscopic conditions such as cultural values and social trends (Strauss & Corbin, 1996, p. 219). Therefore, demographic data serves as an indicator of the respondents' lifestyle and values. It was discussed that demographical characteristics might be correlated with the risk perception of laypeople (Lee et al., 2005; Macoubrie, 2006; Swierstra et al., 2011). Since quantitative correlations were weak, qualitative research might shed some light on the underlying mechanisms of how risk perception actually arises.

Participants (n=5) were selected from the researcher's circle of acquaintances in two different areas of Germany, namely Bavaria and Rhineland-Palatinate, according to the following criteria: The participants need not be experts nor professionally connected to nanotechnology. Minimizing of differences, as a comparable level of knowledge, enhances the chance to find similar data for one group and therefore to ensure the respective theoretical relevance (Kelle & Kluge, 2010, p. 48). However, one respondent with a more technical background, hence possessing more specific scientific knowledge, was selected to look for contrasting empirical evidences (cf. Kelle & Kluge, 2010, p. 43). Maximizing differences by means of varying demographic characteristics will enhance the probability to attain the aimed at variance in attitudes about this topic in this group (Kelle & Kluge, 2010, p. 48).

Participants were chosen so that they differed in age, gender, educational level and profession in order to gain a most varied impression of their risk perception despite the small sample size. Selective sampling

satisfies the criteria of heterogeneity as regards the perception of nanotechnology (Kelle & Kluge, 2010, p. 109).

Pseudo name	Gender	Age	Education	Profession
Adam	male	53	A-levels(Abitur) Study of Philosophy, Politics and Psychology PhD in Philosophy& Politics	Assistant professor
Berta	female	71	Certificate of Secondary Education (Hauptschulabschluss) Apprenticeship master tailor	Master tailor now: retirement
Carla	female	24	Vocational diploma (Fachabitur)	Financial advisor
Daniel	male	24	A-Levels(Abitur) BSc computer science student	In education
Eva	female	61	Certificate of Secondary Education (Realschulabschluss) Apprenticeship banker	Deputy chairwoman of the works council of a German bank

Table1. Respondents with pseudo names and their demographic characteristics

2.2 Manipulations

A challenge for this research has been to create a natural environment while, at the same time, altering the settings to identify various perceptions. On that account, situations enhancing the chance to elicit more diverse attitudes towards nanotechnology were created. "*Grounded theory, seeks not only to uncover relevant conditions, but also to determine how the actors respond to changing conditions and to the consequences of their actions*" (Strauss & Corbin, 1990). Even if the predetermined criteria have not been sufficient to fully guarantee the envisaged diversity of attitudes, these manipulations will aim at eliciting different reactions. Furthermore, the criterion of data source triangulation will be met using these

manipulations. Stake (1995) explains this criterion like this: *„Data source triangulation is an effort to see if what we are observing and reporting carries the same meaning when found under different circumstances."* In this study, two manipulations aimed at triggering participants' attitudes under different circumstances: time pressure (Finucane et al., 2000) and vignettes (Swierstra & Rip, 2007)[3].

In the manipulation of time pressure, participants were instructed before the interview to react quickly and directly state their opinions and views about the topic they were about to hear. The participants were then prompted with the word nanotechnology without any further information. Only in the case that the participant did not know anything about nanotechnology – this only occurred once – a short description of nanotechnology was given. The short description tried to give a balanced view of benefits and risks. The description included the small scale of nanotechnology and as an example the lotus effect was given.

After the participants had given their opinions and views and had nothing further to add, a natural atmosphere without pressure was created entering into a less structured dialogue by showing interest in their experiences, switching from informal to formal and focused talks, just like a common focused conversation. After a natural atmosphere had been re-established, either the dialogue continued or the second manipulation followed.

Without the time pressure manipulation, respondents were asked freely if and what they had to contribute to the topic of nanotechnology and no instructions of urgency were given.

The second manipulation addressed participants' imagination on how nanotechnology could possibly affect their future. For this purpose, the participants had to read two vignettes - short future scenarios concerning nanotechnology developed by Swierstra et al. (2011) (see Appendix B). Both vignettes were displayed in a consistent order, vignette 1 followed by vignette 2, offering enough time in between for respondents to reply.

[3] The author of this study would like to extend her gratitude towards Professor Dr Tsjalling Swierstra from the University of Maastricht for providing the vignettes.

Participant	Time pressure	Vignettes
Adam	☐	☐
Berta	☐	☑
Carla	☑	☐
Daniel	☑	☑
Eva	☐	☐

Table 2. Manipulation order for each respondent; ☐ = manipulation was not performed, ☑ = manipulation took place

2.3 Interviews

The interviews were unstructured in-depth-interviews with a focus on nanotechnology. Such interviews offer the most appropriate method to answer the research questions, because they provide the chance to ask respondents about their opinions and knowledge about this specific topic (Yin, 2009, p. 107).

Methodological weaknesses of interviews were defined as response biases that may be due to poorly articulated questions, reflexivity between the interviewer and the interviewee, and inaccuracies due to poor recall (Yin, 2009, p. 102). The standard demand is to use several relevant sources of evidence to prevent and minimize these weaknesses (Yin, 2009, p. 102). However when studying attitudes or opinions, corroborating established attitudes against other sources would not be relevant and therefore not necessary for this research (Yin, 2009, p. 109). Before conducting the interviews, two pilot interviews were performed. These pilot interviews served to get better acquainted with the interviewing techniques. The participants' feedback concerning the methodology and interviewing techniques was used to improve the researcher's interviewing techniques. Another advantage was that these pilot interviews helped to re-assess the theoretical relevance of the first planned cases (cf. Corbin & Strauss, 2008, pp. 144-146).

The interviews were structured as follows: First, interviewees were asked to read and sign the informed consent and have any concerns on their part about the interview answered. Then the video recording started and participants were asked to answer demographic questions concerning their age, profession and educational level. After the manipulations took place, the open and unstructured dialogue about nanotechnology was initiated. Crucial points included the opinions participants held about nanotechnology

itself, the kind of information they have received or wish to receive. All topics focused on nanotechnology, but within the choice of topics were determined by the interviewees. At the end of the interview, the participants were provided some time to ask further questions, and then a debriefing about the aim of this study was given. The length of the interviews was adjusted to the respondents' requirements. The shortest interview took 24 minutes, the longest 44 minutes.

2.4 Data analysis

Coding refers to a process of data analysis (Strauss & Corbin, 1996, p. 43). In order to simplify the coding process of the video recordings the interviews were coded with the qualitative computer program Atlas.ti. Mayring (2008, p. 112) advises this program especially for the coding process developed by Glaser and Strauss (1967).

In the first step, *Open Coding*, relevant material was noted and labeled on the basis of the underlying concept it refers to (Strauss & Corbin, 1996, pp. 44 -55). *Concepts* are conceptualizations for single events, incidents or for other examples of phenomena (Strauss & Corbin, 1996, p. 43). Concepts were created ad hoc during the data analysis. They were compared with each other to see whether they refer to a similar phenomenon. If this was the case, they were grouped under a superordinate, more abstract concept, the *category*. The first kinds of categories emerge from the concrete situation and data that must be explained by the researcher (Glaser & Strauss, 2010). The other kinds of categories are constructed by the researcher and may serve to explain these concrete situational categories (Glaser & Strauss, 2010). In this way, some ideas for these categories had already been developed ex ante.

In the second step, *Axial Coding*, relationships between the categories were generated that were evaluated in line with the data (Strauss & Corbin, 1996, pp. 76-93). Furthermore, the researcher has to confront each identified phenomenon with the questions as to why, how, what and where this phenomenon occurred. Hereby, recognizable characteristics, dimensions for each phenomenon or, better, for each category were developed and abstracted further. The development of categories proceeded during axial coding. The farther the process advanced the more data material was reduced to the essential parts. If new aspects

emerged, they were coded, if not, these aspects were ignored. During comparison some features of the categories contradicted each other. Then, *memos* about these ideas or generative questions were generated to make it possible to focus on these units later on during theory building (Glaser & Strauss, 2010, p. 121; Strauss & Corbin, 1990). On a more advanced level, the original data will answer possible questions and serve to illustrate these. *Memos* served as a basis for both hypotheses and theory.

In the last step of coding, *Selective Coding*, all categories were grouped around one central *core category*, which represented the main analytic idea of this research (Strauss & Corbin, 1996, pp. 94-117). The relationships between the identified categories were analyzed so that each generated subcategory could be interlinked with this core category. Coding was an iterative process, and it was necessary to jump from one coding level to another. In this *Comparative Analysis* process (Corbin & Strauss, 2008, p. 195), it was necessary to compare the relevance of each code and feature for each category. Besides the individual case analysis, all cases will be compared with each other. Hence, if an idea about a category and its characteristics was developed it was necessary to look for striking or underpinning evidences in the same case, but also in all other cases, until a conceptual density was achieved. This is the focal process of *Theoretical Sampling* in data analysis (Glaser & Strauss, 2010, p. 76). Units of analysis offering either relevant differences or big similarities will be compared with each other (Kelle & Kluge, 2010, p. 48). Finally, composing the theory and hypotheses of the identified relationships, the researchers made use of the coded material of their respective categories including their features and the self-constructed notes and memos.

2.5 Ethical consideration

Participants were asked at the beginning of the interview to read and sign an informed consent form providing information about the guaranteed anonymity of their data and ensuring that the interviews will not be used in any other context than this research. They were also told that these interviews will be video recorded. Respondents received a detailed debriefing afterwards about the actual goals of this study. They

unanimously found the atmosphere pleasing, even in time pressure condition, and expressed an interest in being informed about the further progress of the study.

3. Findings

In the following sections, reactions evoked by the manipulations, the generated subcategories and the core category will be displayed. Quotes translated into English (see Appendix A. Original Quotes) will serve to illustrate the occurring phenomena.

3.1 Manipulation check

Vignettes and time pressure aimed to enhance the diversity of reactions in this research. It was compared how respondents react to the word nanotechnology under time pressure to those not under time pressure. The reactions showed no clear difference due to the manipulation. There was a general consistency of respondents' perceived level of knowledge (see below p. 15). Vignettes evoked two powerful associations with the participants: robots and a potential societal change. The association of robots was evoked strongly by the first vignette:

> *Daniel: Imagining the human being as Arnold Schwarzenegger- half human/half engine, the doctor half human/half engine, who is able to do everything on his own. Basically, this is imaginable.*
>
> *Berta: Do they want there to be no more doctors?*

Technological risks themselves were seen as less important in these future scenarios. However, Daniel came up with this human hacking idea:

> *Daniel: Depending on how much technology there is involved, how it is connected with the internet, and whether it is relayed via satellites it is evident that a virus could be transmitted into a car of a president, or so; for criminals that might be a good opportunity.*

The perceived risks of nanotechnology were not related to technological issues, but to a societal change of human interaction. The association evoked was that of a clean, cold and sterile world without feelings.

> *Daniel: A way has been found to get rid of all the garbage, that is quite handy… They are still humans, but already somehow robots. This distance. The companionship is lost.*

3.2 Subcategories

Three subcategories have been generated in this research. The respective characteristics, dimensions and features for each subcategory will be described in more detail in the following.

Characteristics	Dimensions	Subcategory
Idea/Knowledge	○ None ○ Some Subjects: ○ Size ○ Applications(products)	**Perceived level of knowledge about nanotechnology**
Need for information	○ Yes ○ No	**Reference external source**
Reliable sources for information	Sources: ○ Government ○ Media ○ Experts ○ Internet ○ Products	
Strategies: **References to previous experiences,** **Personal references** **References towards other technologies**	○ Conscious ○ Unconscious	**Reference internal sources**

Table 3. Overview of the subcategories developed including respective characteristics and dimensions

3.2.1 Perceived level of knowledge about nanotechnology

At the beginning of the interviews respondents were asked about their opinion about nanotechnology. The common reaction was an expression of the *perceived level of knowledge*[4]. The perceived level of knowledge was either a perceived total lack of knowledge or the perception of having some knowledge about nanotechnology. No respondent perceived his or her knowledge as detailed. The subjects of the dimensions related to *some knowledge* concerned the *size of nanoparticles* and the *application of this technology*.

> *Adam: I don't feel well informed, but I know that it is a technology that is very small, which was not possible before. And now new applications develop.*

> *Carla: Wow! I know so much about it [said in a tone of irony]. As you mention the word nanotechnology, in the end, the first that comes to my mind is that this is a topic I have not yet thought about a lot.*

3.2.2 Reference sources: External source

References: external sources is the umbrella category for the two characteristics *need for information* and *source of information*. The respondents experienced a *need for information* for two reasons: to be informed about nanotechnology and to be able to form an opinion about this topic. The idea for this characteristic - *need for information* - was generated in the first interview with Adam for whom technological aspects themselves did not seem so important in comparison with the effects of the technology.

> *Adam: The technology as such never interested me, only its impacts on society, morals and law.*

The handling with nanotechnology concerned two issues; first, citizens need to be informed so that the gap between informed experts and uninformed citizens narrows. Secondly, the information about how the external sources handle the impact of this technology, for example how the government controls the

[4] This study was not aimed at controlling whether what respondents know is true or justified. The term *perceived level of knowledge* therefore represents the subjectivity of respondents as to possessing some knowledge or not.

technological risks of nanotechnology. These two aspects concerned, on the one hand, the internal need for information to be able to form attitudes about the technology and, on the other hand, the way in which responsible parties deal with the impact of this technology. These reactions were followed by questions concerning the wish to obtain some information. All respondents, except Daniel whose future career might be connected to nanotechnology, hardly expressed any desire to be informed about the specific technological aspects. Those who had not heard about nanotechnology before just wanted to receive some information about how this technology could possibly affect their lives. The *need for information* was closely connected to the *source* of the information. The choice of source was determined by the reliability of the source itself and the perceived reliability of the information provided. The preferences for the *source of information*, their respective channel and the positive and negative characteristics varied across the cases.

Source	Channel	Positive characteristics associated with source and medium	Negative characteristics associated with source and medium
Personal surroundings	○ Dialogue		
Industry	○ Advertisements ○ Product information	○ Generation of attention ○ Consumer knowledge	○ Own profit
School	○ Integrated in subject material	○ Information in general ○ Important for future generations	
Research facilities (universities…)	○ Experts judgments ○ Information about control	○ Trust	○ Expert monopoly
Media	○ Journalistic material	○ Evoke interest ○ Provide basic information	○ Unreliable ○ Own profit
Government	○ News media (*Tagesschau*)	○ Trust ○ Independent ○ Powerful	○ Own interests ○ Too occupied ○ Unable to judge nanotechnology ○ Have to trust experts, leading to an "expertocracy"

Table 4. Summary of sources of information, the respective channel and respective positive and negative characteristics

Government has been the most preferred source of information, but was associated with the most negative aspects as it is perceived as unknowing and preoccupied.

> *Berta: No, they would not do anything; they cannot tell if this is good or bad for you. They only make their policies and even badly so.*

The other sources and characteristics varied too much to display any consistency in their preferences. Besides, the need for information stems from the respondents' desire to be able to give a well-founded opinion about nanotechnology when asked.

> *Daniel: Clearly, I did not know what this is about and so I did not inform myself about the drawbacks; surely there are many disadvantages? But for me, it currently only offers advantages in computer science, that is why I did not yet think about the disadvantages.*
>
> *Carla: As I told you, if I had informed myself then I could give you a better opinion and more information.*

Conspicuously when confronted with the topic of this interview everybody claimed to have not explicitly informed themselves about nanotechnology. The *need for information* was present due to the fact that they had to report something about a topic they have no or only limited knowledge about. The participants perceived a lack of knowledge due to the ongoing inquiry of the researcher. The *perceived level of knowledge* seemed to trigger the *need for information*.

A third phenomenon concerned the process of how the need for information developed during the interviews. Although the participants were more reserved at the beginning of the interview their perceived need for information increased during the interviews:

> *Carla: If this is so important that even studies are conducted about it, then you should obtain some information.*

As shown here the interviews themselves might have stimulated the perceived importance of this topic and hence the need for information. Another possibility might be that the more they reflected on this topic the

more pressing the topic became. An increased perceived importance was noted and an increased perceived need for information was detected. The reason why and how this process occurred could not be conclusively traced back with these data.

3.2.3 Reference sources: Internal source

Internal sources served respondents to retrieve information, feelings and opinions. Respondents succeed by retrieving *previous experiences, personal references and references to other technologies.*

Previous knowledge is a dimension of the perceived level of knowledge, as it is a strategy. Respondents reacted to nanotechnology by remembering facts and referring to previous experiences.

> *Adam: I am not very well informed, but I know that it is a technology which enters in size ranges that were not manageable before and that new in return new technologies can be developed. I think I have already used a color that had a special lotus effect through nanotechnology, but that is the only thing I actually came in contact with it [it here refers to nanotechnology].*

Personal references describe how respondents deduce information and opinions about nanotechnology based on how they perceive other people to view the technology. Carla, with close to no knowledge about nanotechnology, actually succeeded via a personal reference in deducing its importance.

> *Carla: I know that this topic is important, because I can see that from the reactions of my father, when he talks about it, especially in our society.*

References to other technologies helped to substitute knowledge. The reference was further used to form attitudes about nanotechnology. It was noted that the attitudes about the referenced technology were subsequently similar to the formed attitudes about nanotechnology:

> *Adam: If I compare it to genetically-manipulated plants, these could immediately lead to undesirable reactions if they were released in nature, and as far as nanotechnology is concerned I lack imagination to assume a direct causality.*

The above mentioned strategies were all externally stimulated by the interview questions. This was particularly evident for respondents who actually had little or no knowledge about this technology. The external stimulation lead to the use of internal references. It could not be clearly stated whether these strategies were used consciously or unconsciously.

3.3 Core category: Cognitive and affective dimensional aspects in attitude formation towards nanotechnology

Each subcategory – *perceived level of knowledge, internal source* and *external source* - has been strongly related to two characteristics of another category: the *affective and cognitive dimensional aspects* of respondents' attitudes towards nanotechnology. This category was thusly coined the core category.

> *Daniel: Entering this small universe. [Said with an air of enthusiasm] More performance on a smaller level.*
>
> *Eva: I've picked it up somewhere that it might be dangerous.[…said in a reluctant, suspicious tone]*

Such frequently occurring first statements of respondents prove two things. On the one hand, respondents displayed some knowledge of nanotechnology and, on the other hand, they showed affective reactions towards nanotechnology. *"Small Universe"* refers to the size of the nanoparticles, proving some knowledge, while the "*higher performance*" also refers to Daniel's strong positive affect towards nanotechnology. The same pattern of affect and cognition was also recognizable in Eva's attitude towards nanotechnology. Eva stated that she had some information of unknown source and that she initially perceived it as dangerous, revealed the same pattern. In Eva's case, the retrieved information suggested a consistent dislike of nanotechnology. She was not able to precisely reproduce the content and why she actually had such a negative attitude towards nanotechnology. Eva later remembered nanoparticles as "*permanent foreign particles".* Conspicuously, on the one hand, Eva perceived a strong lack of knowledge about nanotechnology, while on the other hand, she held a strong negative attitude towards it. There

seemed to be a discrepancy between Eva's perceived level of knowledge, her first inclination being that she knows nothing, while she actually possessed some knowledge about nanotechnology after all.

Another interesting phenomenon was that cognitive underpinning of attitudes towards nanotechnology was preferable to affective underpinning. Since the beginning of the interview, Eva had been critical towards nanotechnology and justified her critical attitude saying that she had read it somewhere. Later, during the interview, the critical feeling reemerged and she was asked again how she felt about this topic. It was observed that Eva displayed affective reactions, visible by her facial expression, but was not able to verbalize them. Just having the feeling without knowing its origin did not seem to be the appropriate reaction so she remembered this:

> *Eva: I cannot tell exactly. For me this was like a foreign particle in the food, something foreign, which does not belong there, some sort of plastic, which I can remember now.*

Eva searched consciously for a justification of her feelings by remembering facts that she had read somewhere. Adam would not give an opinion about the technology because he perceived to have no concrete factual knowledge about the technology. Since Adam is professionally involved, as a researcher in philosophy about moral questions, he was able to apply his knowledge about the moral implications of new technologies. Berta stated that she knew nothing at all and was therefore unwilling to state an attitude. It seemed that an attitude was omitted when the *perceived level of knowledge* was low, accompanied by the fact that no *external source for information* was available. The resulting *need for information* displayed the need for cognitive aspects for attitude formation. Carla and Daniel both supported their feelings with arguments. *Previous experiences, personal references* and *references towards other technologies* were recognizably used to generate these arguments as was displayed in the subcategory *internal sources.* One might conclude that attitudes about nanotechnology have paradigmatically only been expressed in a unification of affect and cognition. Notwithstanding, it would be hasty to assume on these results that affect and cognition are at an equal measure involved in the attitude formation process towards nanotechnology. To explain the results, it could be imagined that cognition and affect are like the

dimensions of a Cartesian coordination system with an X- and a Y-axis. The attitude formed is the point of intersection between these dimensional aspects. Nevertheless, this is rather a lopsided comparison, as attitudes and cognitive aspects were both necessary and cannot therefore, be displayed separately. However, the conception of affect and cognition as necessary dimensional aspects helps to imagine that both necessary aspects can vary in their extent in the attitudes formed towards nanotechnology.

4. Discussion

The purpose of this *Grounded Theory* study was to explore and explain the concrete attitudes of laypeople towards nanotechnology. The first objective was accomplished by identifying the underlying factors grouped into three subcategories and one core category. *Perceived level of knowledge, internal sources* and *external sources* have been defined as subcategories of this research. The core category concerned the cognitive and affective dimensional aspects in the constructed attitudes towards nanotechnology. The second objective – explaining and relating the discovered factors with each other – shall be accomplished in the following sections. Findings in this study were connected with previous theoretical explanations to generate three hypotheses. A description then follows of the limitations of these findings and of the suggestions for further research.

4.1 Hypotheses and explanations

In this section, the relations between affect, cognition and strategy use will be explained and discussed. These relations formed the basis of and inspiration for three hypotheses, which will be explained and set into relation with the results and theoretical explanations of previous studies.

I. *References to previous experiences, personal references and references towards other technologies are recognizable strategies when being confronted with nanotechnology*

II. *Affective reactions to nanotechnology need cognitive underpinning as justification*

III. *Affect serves as stopping mechanism for cognitive processing*

4.1.1 Cognition and strategy use

This paragraph attempts to explain the relationship between cognitive processing and the three identified strategies. Respondents made use of three identified strategies to bridge the gap between their lack of information and their required opinions. The first hypothesis results from the subcategory *internal sources*.

I. References to previous experiences, personal references and references towards other technologies are recognizable strategies when being confronted with nanotechnology

Laypeople tend to reference previous experience to remember nanotechnology in its everyday form. Respondents possessing some knowledge about nanotechnology were able to deduce its significance for daily life by remembering their previous experiences with it such as in colors, cosmetics and computers. Respondents referred to scientists, and people are more informed about this topic irrespective of their perceived level of knowledge. Referencing other technologies helped laypeople to visualize the possible risks and benefits. Strategies helped to deduce information by remembering previous experiences and reflecting on them, which was useful to restore information and create some ideas about nanotechnology.

These strategies could be taken as *fast and frugal cognitive heuristics*, which use *recognitions* to make rapid inferences about unknown aspects of the world, since challenging particular environmental structures require that of organisms (Gigerenzer, Todd, & Group, 1999, p. 18) .The *recognition heuristic* is only applied when one of two objects is not recognized (Gigerenzer et al., 1999, p. 41).This is a strong criterion of recognition and one must distinguish between three types of *recognized objects*. The novel ones, the unrecognized objects, the merely recognized objects, and objects that are recognized, whereas further knowledge is available at the same time (Gigerenzer et al., 1999, p. 39). In this research, only one person did not recognize the term nanotechnology[5]; for her this was an unrecognized object. Another person had no knowledge about it, but was able to merely recognize that somebody had used the term. She was able to deduce some information about the importance of this topic via a *personal reference*[6]. Other

[5] *Berta* when told the word nanotechnology*: Is that something technological?*

[6] *Carla: I know that this topic is important, because I can see it from the reactions of my father, when he talks about*

respondents recognized the technology but also possessed further knowledge. However, it was recognizable that all respondents used strategies for the generation of their attitudes. Even if laypeople perceived to have some knowledge about nanotechnology, they used strategies to deduce even more information to generate attitudes. In the risk perception of nanotechnology, in which nanotechnology may represent the unknown aspect of the environment, people will make inferences by reflecting and generalizing the information they hold about a better known technology such as gene technology (cf. Gigerenzer et al., 1999, pp. 42, 92). This would explain in part why people referred to other technologies. Furthermore, these recognitions served - though not for every respondent - as an impetus for a conscious reflection about their previous experiences. Respondents were actually able to compare and deduce the possible risks and benefits of nanotechnology on the basis of their previous experiences with other technologies. Strategies therefore served not only as an efficient alternative to cognitive processing, but turned out to be the only feasible strategy given the lack of knowledge about nanotechnology.

4.1.2 Affect as primary reaction

It has already been attempted to explain the influence of cognitive processing and strategy use. But when and how does affect come into the play? It is advisable to start with the first reactions of the uninformed respondents. References to one's own *perceived level of knowledge*, defined as the first subcategory, has been recognized as a starting point for the respondents' answers with regard to nanotechnology. However, this finding does not imply that realizing one's own *perceived level of knowledge* has been the primary reaction of respondents as it was recognizable that affective reactions were not used to validate attitudes towards nanotechnology. Zajonc (1980) emphasized that affective reactions can be essential for cognitive responses, but sometimes it is impossible to verbalize them. Laypeople's first reactions to nanotechnology might be affective, but because these primary reactions are too vague respondents were unable to

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it, especially in our society.

verbalize them (Zajonc, 1980). This would explain in part the second hypothesis, which is why affective reactions were not used to validate ones attitudes.

II. Affective reactions to nanotechnology need cognitive underpinning as justification

Besides explaining the difficulty to verbalize affective reactions, it did not seem appropriate for respondents to use verbalized affective reactions as exclusive validation of their attitudes. Even when showing an affective reaction towards nanotechnology respondents seemed to be content with their justification if it only contained a cognitive argument. These cognitive arguments concerned scientific underpinnings of arguments, but foremost the possible impacts on society. A clear cut differentiation between affective and cognitive arguments was not possible since they were often interwoven. The conclusion that people support their affective reaction with cognitive underpinnings underlines the need for both dimensional aspects. Notwithstanding, it was clearly stated by respondents themselves that they cannot offer an opinion if they lack the necessary information on what this technology is about.

4.1.3 The role of affect in cognitive processing

It seems that cognitive processes were closely interlinked with the strategies and that affective reactions might have been crucial for cognitive processing. This latter point is just one attempt to explain the relationship between cognition and attitudes in attitudes towards nanotechnology.

Previous research suggested that affect plays an important role in risk perception towards nanotechnology, for example as a moderator or and as a heuristic (Finucane et al., 2000; Kahan et al., 2007; Lee et al., 2005). Interestingly, the time pressure condition did not create any noticeable difference as regards affective reactions, which was demonstrated by previous research (Finucane et al., 2000). A closer look at the type of affect might be necessary to understand this difference. Despite that, this difference might be attributable to the difference in methodology (see below p. 28). An interesting question is whether the affective reaction has been evoked by the actual lack of time, i.e. reduced cognitive sources for analytic deliberation (Finucane et al., 2000), or instead by the pressure introduced by the researcher. The latter might be analogous to what Finucane et al. (2000) mean when talking about an increased general arousal

level that induces affective changes. Affective reactions might be task-related (Gigerenzer & Selten, 2001, p. 267) and triggered by a stressful situation of pressure in which individuals have to make a decision, rather than by induced limited cognitive processing itself. Therefore, it would be interesting for future research to differentiate how the affective reactions have been actually evoked. Besides, this type of emotions must be distinguished from anticipated emotions (Gigerenzer & Selten, 2001, pp. 268-270) that help us to imagine how we would experience the outcomes of our decision, often involving cognitive processing, which would be systematically excluded by time pressure. The differentiation between task-related emotions -coming from the test situation- and anticipated emotions – accompanying the imagination about the impacts of nanotechnology-helps to understand where what type of affective reactions is actually coming from.

Lee et al. (2005) postulated that emotional reactions are influenced by perceptions of previous scientific experiences. Applied to this study, that conclusion (Lee et al., 2005) would implicate a strong relationship between the identified strategies - *referencing previous experiences and referencing to other technologies* - and the affective aspects of attitudes. Gigerenzer and Selten (2001, p. 363) emphasized that emotions may facilitate rapid decision-making by putting clear limits on the search for information or alternatives. Emotional heuristics, such as social imitation, help us to make decisions within a limited space of time and with little knowledge (Gigerenzer et al., 1999, p. 31). One explanation for this complicated relationship would be that affect works as an effective stopping rule to the search for information (Gigerenzer & Selten, 2001, p. 9). In other words, affect is a cue indicating when to stop using this cognitive information seeking strategies that consume a lot of energy. This brings us to the third hypothesis:

III. Affect serves as a stopping mechanism for cognitive processing

This interaction would explain why generated attitudes displayed both aspects. Zajonc (1980) emphasized that, even though there are two systems – one associated with the more affective aspects and the other one with the more cognitive ones – these act in part interdependently. Zajonc (1980) explains that affect accompanies all cognitions, which would explain the necessity of both aspects. Both aspects cognition and affect are necessary and dimensional, this is reflected in their varying extent on how they contribute to the

formation of attitudes (cf. Edwards, 1990). Furthermore, affect might be primary to cognition, as replicated in this study (Zajonc, 1980). If affect serves as a stopping mechanism (Gigerenzer & Selten, 2001, p. 363) this would supply clues on how affect, cognitive processing and the strategies discovered might be intertwined.

4.2 Evaluation methodology

The methodology of Grounded Theory was used to gain a grounded insight in the phenomena underlying laypeople's attitudes towards nanotechnology. One of the major strengths of Grounded Theory is that not simply classifications or descriptions of phenomena have been developed, but theoretical concepts for stronger explanations have been achieved (Strauss & Corbin, 1990). Theoretical sensitivity acquired by going through previously mentioned literature and theoretical sampling to look for striking events were necessary to analyze the relationships between the different categories. The identification of the relationships between the underlying factors formed the core of this study.

However, one must also see the theoretical representativeness of this study in the light of its limitations.

The redefinition of original evaluative criteria of quantitative and qualitative studies led Strauss and Corbin (1990) to define two sets of criteria for the empirical grounding of findings and to establish the research process. These criteria will serve as a guideline to describe the limitations of this study.

4.2.1 Limitations to the empirical grounding of findings

The pre-assumption that affect and cognition are contributing factors in attitudes towards nanotechnology have influenced the generation of the core category, i.e. cognitive and affective dimensional aspects in attitude formation towards nanotechnology. Emergent categories, i.e. categories built from data, are more preferable (Glaser & Strauss, 2010, p. 62). Notwithstanding, the dimensional aspects of affect and cognition were not forced upon the data from outside, but have been also recognized and grounded in the data (Kelle & Kluge, 2010, p. 71). Moreover, an exact *ex ante* formulated categorization of affect and cognition was not possible as only a preliminary and broad characterization has been used (Finucane et al.,

2000; Forgas, 2000; Scherer, 2005). Nonetheless, if these pre-assumptions might have influenced the findings in this way, the purpose of a qualitative analysis to gain an insight in the attitudes of respondents has not been limited (Kelle & Kluge, 2010, p. 70).

A weakness of this study is that the analysis has been too microscopic rather than focusing on macroscopic issues such as economic conditions or social movements (Strauss & Corbin, 1996, p. 219). It would be interesting for future qualitative research to establish how factors such as cultural values influence people's attitudes towards nanotechnology (Kahan, 2008a; Kahan et al., 2007).

4.2.2 Limitations to the research process

In this research only one researcher was in charge of the literature research, conducting the interviews and interpreting the interviews. Working together with other researchers, which was not possible in this study, might have been preferable. Having multiple researchers involved helps to gain new insights and to enhance one's theoretical sensitivity (cf. Strauss & Corbin, 1996). However, it was tried to plan the case studies by talking to other researchers from the field, receiving feedback from respondents during the process and, in the end, discussing the findings and possible implications with other researchers and peers. The objectivity that *intercoder-reliablity*, which means several persons analyzing the date and comparing their results, aims for, is seen as problematic by qualitative researchers like Mayring (2008, pp. 117-118). A wide agreement between different coders is only attainable with very simple analysis (Mayring, 2008, p. 117).

Respondents have been selected by means of theoretical sampling. However, the process of selecting respondents on the basis of previous theoretical concepts stagnated because there was not enough time in between some interviews to generate theoretical concepts (Corbin & Strauss, 2008, p. 146). Further, sampling effects may have occurred since the respondents have been chosen out of the researchers' circle of acquaintances. However the aim to evoke heterogeneity of attitudes towards nanotechnology was still accomplished by the differing pre-determined criteria and the two manipulations.

It was tried to use general, unbiased and unambiguous formulations in the interview questions about the impact of nanotechnology, like positive or negative aspects or general implications. However, interview questions sometimes contained ambiguous formulations after all, such as risk. Risk may refer to the quantitatively estimable risks or the moral aspects of these risks (Roeser, 2009). A formulation such as risk may be interpreted in a quantitative manner and not discover this ambiguity. Interestingly, respondents distinguished on their own between the actual risk of nanotechnology and its impact on society, morals and law. However, due to the personal nature of this qualitative research method, emerging questions concerning such formulations could be answered directly.

The manipulations used may also be improved. The time pressure condition did not evoke any noticeable difference in reactions, as was also demonstrated by other research (Finucane et al., 2000). The time pressure condition might be better applied in more standardized methods such as surveys involving exact timing. An interesting item for future research might be to observe whether the reactions are evoked by an actual lack of time, limited time for cognitive processing, or the pressure introduced by the researcher. The latter characteristic of the time pressure condition was applied in this research.

The second manipulation made use of the vignettes (Swierstra et al., 2011). These future scenarios should have helped respondents to imagine how a future with nanotechnology would look like. In this way, the vignettes really succeeded in helping respondents to imagine such a world. Still, it was problematic that respondents created too specific ideas such as a strong association with a callous robotic world void of feelings rather than general ideas about nanotechnology. A different choice and a greater quantity of vignettes might resolve this problem in future studies.

4.3 Suggestions for further research

Suggestions for future studies will be made upon what has been reviewed in this study. Qualitative research, especially if based on Grounded Theory should look for a stronger saturation of categories by selecting more data than what has been possible in this study. An interesting phenomenon was that the need for information increased during the interviews. Future studies should focus on this phenomenon as

it has not been possible explaining it with the data of this study. Besides it would be interesting to research the influence of interviews on the perceived importance of participants regarding this topic. Furthermore it has to be found out if the affective reactions evoked by time pressure are task related due to the pressuring situation itself, or due to limited cognitive processing (Finucane et al., 2000). It is important to discover in representative studies (Kahan et al., 2007; Macoubrie, 2006; Swierstra et al., 2011) what laypeople are actually concerned about when confronted with nanotechnology. Here a comparison between the data and theories generated from quantitative studies and the theories generated by qualitative studies can serve to complete the picture (Glaser & Strauss, 2010, p. 35).

Content-specific suggestions for further research include the need for a better understanding of the interplay between affect and cognition in attitudes towards nanotechnology and the question as to how macroscopic issues influence risk perception (cf. Kahan, 2008a). Another suggestion would be to investigate the issue of why and how laypeople do not validate their attitude with occurring affective reactions.

5. Conclusion

Several conclusions can be drawn concerning the empirical findings and their theoretical explanations. Respondents when confronted with nanotechnology, irrespective of their *perceived level of knowledge*, tried to deduce information by means of *internal sources*, making use of strategies such as references to previous experiences, personal references and references towards other technologies. This was partially evident as no *external source* for factual information was provided. The core category stating *affect and cognition as dimensional aspects*, varying in their extent, have been in a close interplay in forming attitudes towards nanotechnology.

The first developed hypothesis emphasized the role of the three recognized strategies as fast and frugal heuristics which help to make rapid inferences about this merely known technology (cf. Gigerenzer et al., 1999, p. 18; Kahan et al., 2007). The second hypothesis pointed out, that affective reactions need cognitive underpinnings as justification. Even though affective reactions might have been primary

(Zajonc, 1980, 1984), respondents experienced a strong need to justify their affective reactions by cognitive underpinnings. Firstly affective reactions can be difficult to verbalize (Zajonc, 1980) and secondly cognitive arguments are needed to content with these primary reactions. The third hypothesis partly explained the interplay of affect and cognition, that affect served as a stopping rule for the cognitive information seeking process (Gigerenzer & Selten, 2001, p. 9). This study shed light onto the interplay of the dimensional factors affect and cognition in attitude formation and lets one hope that affect can be regarded as different, but not inferior to cognition.

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7. Appendix

Appendix A. Original Quotes

Manipulation check

Daniel: Die Vorstellung des Menschen als Arnold Schwarzenegger, halb Mensch halb Maschine, der Doktor halb Mensch halb Maschine ist, der kann das ja dann auch alles selber. Grundsätzlich ist das schon vorstellbar.

Berta: Wollen die dass es keine Ärzte mehr gibt?

Daniel: Je nachdem wieviel Technik und das mit dem Internet verbunden ist und über Satelliten gesteuert wird, und das ist klar, könnte da auch ein Virus rein und ein Auto von einem Präsidenten; oder was auch immer, für Kriminelle ist das natürlich eine gute Möglichkeit.

Daniel: Es wurde ein Weg gefunden, um den ganzen Dreck loszuwerden, das ist ja ganz praktisch.

Daniel: Es sind dann zwar immer noch Menschen, aber auch schon immer eine Art Roboter. Die Distanz, das Miteinander geht flöten.

Perceived level of knowledge about Nanotechnology

Adam: Sehr detailliert informiert bin ich nicht, ich weiß dass es eine Technologie ist, die in Größenbereiche vordringt, die vorher nicht handhabbar waren und dass dadurch neue Techniken enstehen.

Carla: Wahnsinn! Da kenne ich mich so gut mit aus!(ironisch). Wenn du mir das Wort Nanotechnologie im Endeffekt sagst, also das Erste was in mir aufkommt, ist, dass ich denke, es ein Thema ist wo ich mich überhaupt noch nicht mit auseinander gesetzt habe.

Reference sources: External source

Adam: Die Technik als Technik interessiert mich nie, sondern immer nur in ihren Auswirkungen auf Gesellschaft, Moral und Recht.

Berta: Nee, die machen ja doch nichts, die können ja auch nicht sagen, das ist gut oder das ist nicht gut für sie. Die machen doch nur ihre Politik und das machen sie ja auch verkehrt.

Daniel: Ich wusste ja klar nicht worum es geht, und deswegen habe ich mich jetzt nicht auseinandergesetzt was es jetzt vielleicht für Nachteile gibt, mit Sicherheit hat es auch viele Nachteile (fragender Blick). Aber für mich hat es jetzt derzeit im Computerbereich nur Vorteile und deswegen habe ich mir über die Nachteile noch keine Gedanken gemacht.

Carla: Wie gesagt, wenn ich mich darüber auseinandergesetzt habe, könnte ich dir eine bessere Meinung und dir mehr Informationen geben.

Carla: Wenn das so wichtig ist, dass selbst Studien darüber geführt werden, sollte man sich mal darüber informieren.

Reference sources: Internal source

Adam: Sehr detailliert informiert bin ich nicht, ich weiß dass es eine Technologie ist, die in Größenbereiche vordringt, die vorher nicht handhabbar waren und dass dadurch neue Techniken entstehen. Was ich selbst, glaube ich, mal verwendet habe, war eine Farbe die durch Nanotechnologie einen besonderen Abperleffekt hatte, das Einzige wo ich sagen kann, da bin ich mal konkret mit in Berührung gekommen.

Carla: Ich weiß dass das Thema wichtig ist, weil ich an der Reaktion meines Vaters sehe, wenn er darüber redet, gerade in unserer Gesellschaft.

Adam: Wenn ich das vergleiche mit genmanipulierten Pflanzen, die könnten unmittelbar dadurch dass sie direkt in der Natur freigesetzt werden, es komme zu Reaktionen die unerwünscht ist, bei der Nanotechnologie fehlt mir die Fantasie um eine direkte Kausalität anzunehmen.

Core category

Daniel: In dieses kleine Universum einzutreten

Immer mehr Leistung auf einem kleineren Niveau

Eva: Ich habe das mal irgendwo gehört, dass es nicht ganz ungefährlich sein soll.

Eva: Für mich war das, als wäre es ein Fremdpartikel dann im Essen, irgendwas Fremdes, was da nicht hingehört, ein Kunststoff jetzt komme ich auf das Wort.

Appendix B. Vignettes

Original Vignette 1.(Swierstra et al., 2011)

Nanochirurgie

Op weg naar de ethische toetsingscommissie overdacht dokter Sanders alle feiten nog één keer. Het automatische terugkoppelingssysteem had hij uitgeschakeld, zoals gewoonlijk. De nanobots zouden niet ingrijpen tenzij hij toestemming gaf. Hij hield er niet van om het systeem alles te laten doen en hij gebruikte daarom NanoBot altijd op de halfautomatische stand. Het systeem waarschuwde daardoor wel als bepaalde waarden werden overschreden (de monitoring module werkte prima) maar hij bleef degene die de data moest interpreteren en die moest beslissen of de nanobots al dan niet zouden ingrijpen. Op de bewuste nacht (21 september) had hij het besluit genomen om de nanobots niet te laten opereren. In de uren ervoor waren al verschillende meldingen binnengekomen, maar die bleken vals alarm te zijn. Hij had visueel contact opgenomen met de patient en hij had de verpleegster een extra, 'ouderwetse' meting laten doen. De situatie leek hem echter niet ernstig genoeg om een nano-operatie uit te voeren. Toen de vierde melding binnenkwam, besloot hij dan ook om af te wachten. Hij draaide zich om en viel in slaap. Achteraf gezien had hij dat niet moeten doen. Maar het is makkelijk praten achteraf. Wat zal de commissie gaan zeggen? Heeft hij een fout gemaakt? Sommige leden van de commissie zijn voorstander van het automatische systeem, dat is algemeen bekend. Maar ook het systeem is niet waterdicht, want soms grijpt het in als dat niet moet. Dat wordt dan vaak een 'technische' fout genoemd. Tsja, wie op de halfautomatische stand werkt loopt het risico van persoonlijke blaam. Je draait je om, valt in slaap en enkele uren later blijkt de patient overleden. De schuld van de dokter, roepen ze dan. Had hij maar automatisch moeten werken. Waarvoor hebben we anders de technologie? De tijd van doktertje oude stijl is voorbij. Dat zullen ze zeggen, hij weet het. Waarom bleef hij in de oude manier van interpreteren en beoordelen geloven? Werd het niet stilaan tijd om het wat rustiger aan te doen, zeker op zijn leeftijd? Moest hij per se de held spelen? Blijven dwarsliggen op medische congressen, in commissies, in het ziekenhuisbestuur? Zijn auto draaide geruisloos de Wethouderstraat in. Volautomatisch.

Original Vignette 2.(Swierstra et al., 2011)

Antimicrobial nanoparticles imbedded in fabric

Nanotechnology enhances silver's natural antimicrobial and anti-odor properties. SmartSilver™ antimicrobial silver additives provide permanent bacteria and odor control across a broad range of products including health care, apparel and footwear, and coatings and plastics.

Silver is a natural antimicrobial. Microbes and fungus can't survive in the presence of silver ions. The smaller the ionic silver particles, the more silver ions they emit and the more unwanted microbes are eliminated. SmartSilver nanotechnology enables natural silver to produce more microbe fighting silver ions. SmartSilver nanoscale silver particles bind permanently so antimicrobial efficacy and odor elimination last for the product's expected life. SmartSilver protection doesn't wash out or wear off. It doesn't get diluted or neutralized. It keeps working as it was designed to work for as long as the product is used.

Nano-modified Textiles

Nanotechnology is able to enhance fabrics on a molecular level (Nano-Tex, BASF Mincor©,Nano-sphere©). For apparel, this results in fabric that resists spills, repels stains, wicks away moisture, and resists static without sacrificing comfort. This can also be applied to home fabrics, increasing the life of home textiles by keeping them clean and fresh for longer. The technology can be implemented for practically any fabric intended for any application, providing stain/water protection with improved ease of cleaning and relatively low environmental impact.

Normal surface Nano-modified surface (Lotus effect)	The end result

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Hygienic caresses

"Peter would you read your essay before your classmates?" (primary school)
"Yes, Madam:
Yesterday I watched a history documentary on TV. It was about people living 30 years ago, and their hygienic situation. It showed dirty streets, with garbage bins on the sidewalks and cigarette butts on the pavements. At that time, people considered it appropriate to walk from outside into any building with their streetclothes and shoes on. They would wash clothes with an old-fashioned liquid detergent that of course didn't kill the microbes as our silver sprays do. Their clothes had no silver nanoparticles in them. Of course, now we know that doesn't guarantee the protection of the user and of the people around him, and thus should not be worn in public places. And they smelled."
Robert and Chris looked at each other and started giggling. The teacher looked at them with disapproval. Peter went on:
"However, the most disconcerting thing for me was to see them gloves-and masks-free. Only surgeons in hospitals wore such, not people in the street (unless they were scared of the spread of some contagious disease). People used to go around unprotected. They even shook a stranger's hands without gloves. They whispered in each other's ears and kissed each other's cheeks, without masks on their mouths. Of course, infective diseases spread around. Some people would

die. Nowadays nobody dies from Influenza anymore because everyone responsibly wears antimicrobic gloves and masks. I am very happy I wasn't born 30 years ago."
Claudia was staring at Peter and tried to imagine being at school without her pink striped antibacterial gloves. She looked at Joy, who was touching the ribbon of her mask. Jane started to wonder whether Peter was making the story up just to impress Miss Vander.
Miss Vander graded Peter with a high score. Then, she stared out of the window, going back to her childhood, when her mom used to caress her with bare hands and kiss her cheek. She sighed.
"Start your laptops and finish your exercises!"

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This vignet aims to show how things that are considered normal nowadays can be seen differently when a new technology becomes embedded in our society and changes our behavior and concepts. In particular, it focuses on the idea of clean/dirty, hygienic/not-hygienic, that might be changed by the social embedment of antimicrobic fabrics. It shows how this change in collective behavior could be presented as a change in the responsibility of the individual.
It is a slippery slope argument. It shows how things that are normal nowadays can gradually be seen as wrong, not hygienic, irresponsible. Technology enables new habits, which can be adopted by the community and become a (unwritten) rule. If this process is successful, what are we going to miss? (the reader will relate to the positive aspect of his/her present gloves - and mask- free situation)

FL

Translated Vignette 1.

Text1.

Auf dem Weg zur ethischen Prüfungskommission überdachte Doktor Sandmann noch einmal alle Fakten. Das automatische Rückkopplungssystem hatte er wie gewöhnlich ausgeschaltet. Die Nanobots würden nicht eingreifen, solange er keine Zustimmung hierfür gab. Er mochte es nicht, das System eigenständig entscheiden zu lassen und deswegen ließ er den Nanobot immer nur halbautomatisch laufen. Das System warnte ihn, wenn bestimmte Werte überschritten wurden (das Monitormodul funktionierte prima).

Er allein blieb derjenige, der die Daten interpretierte und entschied, ob die Nanobots eingreifen.

In der besagten Nacht vom 21. September hatte er entschieden, die Nanobots nicht operieren zu lassen. In den Stunden zuvor waren verschiedene Meldungen eingegangen, die er als falschen Alarm interpretierte. Er hatte Sichtkontakt mit dem Patienten aufgenommen und der Krankenschwester eine zusätzliche 'altmodische' Messung angeordnet. Die Situation erschien ihm insgesamt nicht kritisch genug, um eine

Nano-Operation durchführen zu lassen.Als die vierte Meldung einging, entschied er sich, weiter zu warten. Er drehte sich um und fiel in Schlaf. Im Nachhinein war dies tragisch !

Wie wird die Kommission hierüber denken? Hat er einen Fehler begangen? Manche Mitglieder der Kommission sind Befürworter von automatischen Systemen, das ist allgemein bekannt.

Aber auch das System ist nicht wasserdicht, manchmal agiert es ohne Begründung. Dies wird dann „technischer Fehler“ genannt. Tja, wer mit dem halbautomatischen Zustand arbeitet, läuft Gefahr, hierfür persönlich haftbar gemacht zu werden. Du drehst dich um, schläfst ein und ein paar Stunden später ist der Patient tot.

Es wird dann gerufen „ärztliches Versagen“. Wofür haben wir denn die ganze Technik?

Die Zeit des alten Doktors ist vorbei. Das werden sie sagen, er weiß es. Warum glaubte er immer noch an die alten Interpretationen und Urteile? Wird es nicht allmählich Zeit, sich etwas anzupassen, auch in seinem Alter. Muss er denn per se den Helden spielen? Muss er immer wieder auf medizinischen Kongressen, Kommissionen und im Vorstand des Krankenhauses quer schießen?

Sein Auto bog in die Schloss-Straße ein, vollautomatisch.

Translated Vignette 2.

Text 2

„Peter würdest du deine Hausaufgabe vor deinen Mitschülern vorlesen?“

„Ja natürlich“

Gestern schaute ich eine Geschichtsdokumentation im Fernsehen an. Es handelte vom Leben der Menschen vor 30 Jahren und ihrer hygienischen Situation. Eine verschmutzte Straße mit Müllcontainern auf den Bürgersteigen und Zigarettenstummeln auf den Fußweg wurde gezeigt. Damals haben es die Leute als normal angehen mit ihren Straßenkleidung und Schuhen in ein Gebäude einzutreten. Sie haben ihre Wäsche mit altmodischen Flüssigwaschmitteln gewaschen, natürlich wurden dabei die Keime nicht wie mit unseren Silber Sprays getötet.

Ihre Kleidung hatte keine Silber-Nanopartikel. Selbstverständlich garantierte diese Kleidung nicht den Schutz für Leute im Umfeld, und sollte daher nicht an öffentlichen Plätzen getragen werden. Man konnte es auch riechen.

Robert und Chris schauten einander an und begonnen zu lachen. Der Lehrer schaute sie kopfschüttelnd an. Peter machte weiter:

Das Bestürzende für mich war aber, die Menschen ohne Handschuhe und Masken zu sehen. Nur Chirurgen in Krankenhäusern trugen solche, aber kein Mensch auf der Straße(es sei denn sie hatten Angst vor ansteckenden Krankheiten). Man war es gewöhnt ungeschützt herumzulaufen und sich sogar mit Fremden die Hände zu schütteln, ohne Handschuhe! Man flüsterte einander in die Ohren und küsste einander die Wangen, ohne Masken vor den Mündern!

Natürlich verbreiteten sich infektiöse Krankheiten. Nicht wenige Menschen starben daran.

In unserer heutigen Zeit stirbt niemand mehr an Influenza. Jeder trägt verantwortungsvoll antimikrobische Handschuhe und Masken. Ich bin sehr glücklich, nicht vor 30 Jahren geboren worden zu sein!

Claudia starrte Peter an und versuchte sich vorzustellen, wie es in der Schule wäre ohne ihre rosa gestreiften Handschuhe. Sie schaute Johanna an, die das Band ihrer Maske berührte. Jana fing an sich zu fragen, ob Peter diese Geschichte nur erfunden hatte, um Eindruck bei Frau Otto zu schinden.

Frau Otto gab Peter eine gute Note. Dann starrte Frau Otto aus dem Fenster, erinnerte sich an ihre Kindheit, wie ihre Mutter sie mit bloßen Händen umarmte und ihre Wangen küsste. Sie seufzte.

„Startet eure Laptops und beginnt mit den Übungen.“

Appendix C. Informed Consent

Vielen Dank, dass Sie im Rahmen meiner Bachelorarbeit an dieser Studie teilnehmen!

Bitte lesen Sie sich das Dokument genau durch und geben Sie unten mit Ihrer Unterschrift an, ob Sie mit der Teilnahme an dieser Studie einverstanden sind.

In dieser Studie werden Sie zu einem spezifischen Thema befragt und auf Video aufgenommen. Ihre Daten und die Videoaufnahmen werden ausschließlich für den Zweck dieser Studie verwendet und nicht an Dritte weitergegeben. Jede Information von Ihnen wird vertraulich behandelt und anonym verarbeitet. Ihr Name und Ihre Person wird in keinen Zusammenhang mit den Ergebnissen gebracht. Sie dürfen das Interview jederzeit abbrechen.

Dieses Interview wird ca. 60 Minuten dauern. Nach Beendigung des Interviews werden Sie über den Inhalt und das Ziel der Studie aufgeklärt. Bei weiteren Fragen dürfen Sie sich gerne an Vanessa Starke wenden via v.starke@student.utwente.nl .

Einverständniserklärung:

Ich erkläre hiermit mein Einverständnis, dass mein Interview auf Video aufgezeichnet und zu wissenschaftlichen Zwecken ausgewertet wird. Ich wurde darüber informiert, dass die erhobenen Daten vertraulich und verantwortungsvoll behandelt werden. Die Daten werden für keine mir unbekannten Zwecke gebraucht.