

The perception of nanotechnology in public

An experimental study on the attitudes towards nanotechnology

Bachelor Thesis

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Abstract

Purpose: To examine the influence of perception towards nanotechnology on several attitudinal variables.

Methods: The study was performed using a randomized experimental design with an experimental and control group. Using a Making of an IBM short movie, further called video, of nanotechnology, participants in the experimental group first saw the video and then were administered several attitudinal variables. Participants in the control group were administered the attitudinal variables and afterwards saw the same video. The study was conducted via an online platform.

Results: A significant positive effect was found regarding perceived usefulness, risk perception and benefit perception. No effects were found on positive affect and creative thinking.

Conclusion: The results of this study indicate a positive effect of the video about nanotechnology and the perception of participants towards nanotechnology. Participants in the experimental group seem to find nanotechnology more useful, less risky and more beneficial in comparison to participants in the control group. Further research should further investigate these positive effects.

1 Introduction

Nanotechnology and nanoscience is becoming more and more important in multiple scientific areas, such as biology, medicine, chemistry and physics (Kuzma & VerHage, 2008; Roco, 2003; Whitesides, 2005). The National Nanotechnology Initiative (2015) defines nanotechnology as the understanding and control of matter at dimensions between 1 and 100nm where unique phenomena enable novel applications. Drexler (1992) defines it as the manipulation of matter on a molecular or even atomic level. It has the potential to contribute to develop and solve problems concerning urgent public topics such as the need to provide clean energy, clean water, clean air and healthcare (Cacciatore, Scheufele & Corley, 2011; Mangematin & Walsh, 2012). However, the potential of nanotechnology to impact on so many different areas and topics makes a prediction about public reaction uncertain and even difficult to validate scientifically (Roco & Bainbridge, 2005).

Roco and Bainbridge (2005) identified several areas in which nanotechnology can have a great societal impact, such as productivity and equity (e.g. improving work efficiency), economics (e.g. creating entirely new industries), quality of life (e.g. production of a sufficient amount of food), converging technologies (e.g. biotechnology, information technology, cognitive sciences) and national security (e.g. advanced materials for armor). Also, science, technology and society are highly interlinked and show a strong interdependency (Bürge & Pradeep, 2006). Thus, nanotechnology cannot be looked at in isolation but rather in a multidimensional way considering societal developments and perspectives.

Although these accomplishments open great opportunities, several authors are uncertain about the reaction of the public and prefer to delay the public presentation of their achievements. For example, Parisi, Vigani and Rodriguez-Cerezo (2015) pointed out that industrial organizations are concerned about regulations such as labelling nano products, because of the potential negative connotation, which could be created around a new technology and also could lead to rejection of the products.

Furthermore, Renn (2004) stated that it is important to understand in advance potential public reactions by relevant social groups given the strong public oppositions after the euphoric introduction of new technologies in the past like nuclear technology, bioengineering or genetic modification.

However, Parisi, Vigani and Rodriguez-Cerezo (2015) have shown that the overall public opinion is not negative towards nanotechnology and that it is particularly influenced by perceived benefits and usefulness of the technology. Regarding the target group, i.e. the German population, of the current study, the German Federal Institute for risk evaluation stated in 2011 that nanotechnology becomes more popular. In 2004, 15% of the German population knew about nanotechnology. In 2007, the percentage increased up to 52%. Also, 66% of the population state they have a positive opinion on nanotechnology and estimate that the possibilities outweigh the risks by the field. Perceptions and knowledge are necessary to the public understanding of every new technology and science (Cobb & Macoubrie, 2004). It is important to involve the public and media from the beginning, because news and advertisements concerning nanotechnology will form the public perception and will determine the consumer's knowledge, attitude and behavior towards the technology (Bürge & Pradeep, 2006).

Introducing/Presenting nanotechnology to public. Previous studies have shown effects regarding the public perception of nanotechnology and its acceptance, taking academic grade, ethnic, gender, age, grade of literacy into account.

According to Renn (2004), public perception of risks and benefits of new technology depends on two aspects. One aspect is based on psychological factors such as perceived threat, familiarity, personal control options and positive risk-benefit ratio. The second aspect is based on political and cultural factors such as perceived equity and justice, visions about future developments and effects on one's interests and values.

Another strategy to present nanotechnology to the public is to present nano products with clear benefits and low risks for the consumers such as medical and environmental applications to make nanotechnology more acceptable in general (Gupta, Fischer, Gearoge and Frewer, 2013). Commercials with presentation of clear benefits are also more likely to get a positive resonance (George, Kaptan, Lee and Frewer, 2014).

Overall, there is a need for concrete illustration or presentation of products and processes which contain nanotechnological aspects, irrespective of the social, political or cultural embedding. As it becomes an inevitable part of everyday life, it has to become part of general knowledge, whether people work for any nano-field or not.

A Boy and His Atom. IBM has shown that it is possible to present the capabilities of nanotechnology in an entertaining way. IBM made a movie called "A Boy and His Atom"

created by just 12 atoms. This “World’s Smallest Movie” as it is presented by IBM, shows how far current scientific achievements are. It is published for the broad public and has a playful way of demonstrating future possibilities.

In the current study, the author wants to examine the influence of the movie on the public. To be more specific, the Making of the movie, further called video, is used.

Theoretical framework

As nanotechnology is an interdisciplinary field, multiple theories and models are being considered to determine variables for the current study. In order to transfer the insights on perception about nanotechnology we used the Technology Acceptance Model, the Affect Heuristic Model and the Broaden-and-Build Theory. Thus, creating a theoretical framework for the study.

Technology Acceptance Model. As it is stated above, there have been studies on consumer preferences demonstrating that overall public opinion on nanotechnology is particularly influenced by perceived benefits and usefulness of the technology. The Technology Acceptance Model (TAM) (Davis, 1989), which is based on the Theory of Reasoned Action (TRA) by Ajzen and Fishbein (1980), states that the acceptance and usage of technology depends on mostly two factors. *Perceived Usefulness* (PU), which is the degree of believing that using a particular technology can increase effectiveness in one’s own performance. *Perceived ease-of-use* (PEOU), which is the degree of assuming that a particular system goes along with less effort, i.e. is simple in usage. Because no practical influence of nanotechnology is shown in the video, the factor Perceived Usefulness will be used on a general perspective to determine if the video evokes thoughts that nanotechnology could be useful for diverse fields.

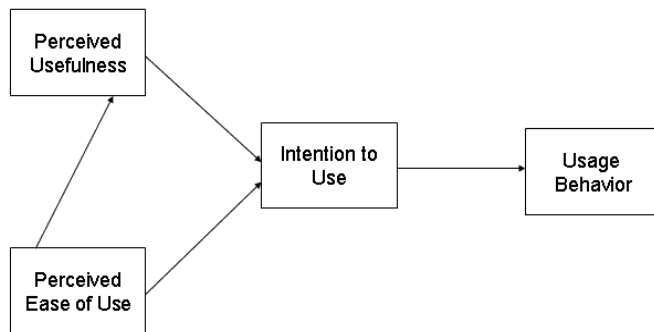


Figure 1. The Technology Acceptance Model, based on Davis (1989)

Affect Heuristic Model. In this study, the author wants to find out if the video leads to positive affection, so the viewer value the risks of nanotechnology lower and its benefits higher. The affect heuristic model (e.g. Slovic, Finucane, Peters & MacGregor, 2007) can also be used to examine the effect regarding people's perception of nanotechnology. The model states that people tend to use an affect heuristic for judgement by deriving risk and benefit evaluations, i.e. affective reactions towards events and objects. Many behavioral theories consider affect as secondary factor to cognition, however, the affective heuristic model further acknowledges affect as an important component of human judgement and decision making. According to this model, representations of objects and events in people's minds are associated with varying degrees of affect. People consult or refer to an affective pool in the decision making process for quick evaluations, i.e. judgements of risks and benefits are guided and linked by affect. More specifically, if an object or event is positively associated with affect, people tend to judge its risks lower and its benefits higher. Accordingly, if an object or event is negatively associated with affect people tend to judge its risks higher and its benefits lower. Reliance on affect probably increases and decreases according to various contextual factors, including the extent to which stimuli evoke images that are associated clearly with positive and negative affect. In addition, Finucane, Alhakami, Slovic and Johnson (2000) found that risks and benefits are negatively correlated in people's minds. The authors found that the inverse relationship between perceived risk and benefit of an object or an event is linked to the strength of positive or negative affect. Finucane, Alhakami, Slovic and Johnson (2000) measured this activity using bipolar scales (e.g. "good" vs. "bad"). Consequently, this implies that people base their judgements of an activity or a technology not only on what they think about it (cognition), but also on how they feel about it (affect).

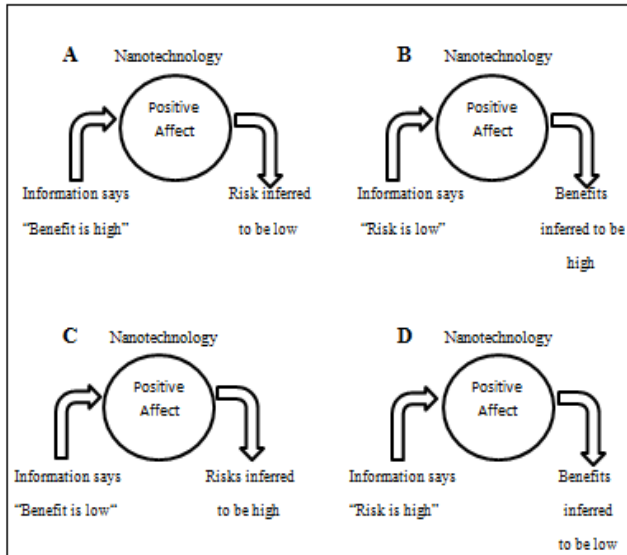


Figure 2. Affect Heuristic Model in relation to the nanotechnology, based on Slovic (2007)

Broaden-and-Build Theory. In the video, the emotion of joy is converged. So according to Fredrickson's theory people who watch that video should be able to think more broadened about the capabilities of the field of nanotechnology. Therefore, watching the video could have a positive effect on the viewer's perception. The broaden-and-build theory (Fredrickson, 2001) describes the form of positive emotions. This theoretical framework states that positive emotions broaden individual's way of thinking. Fredrickson (2001) calls this phenomenon broaden thought-action repertoire. The framework also describes the function of positive emotions. They build individual's enduring personal resources like physical, intellectual, social and psychological resources. Relative to negative emotions, positive emotions have an influence on one's way of thinking over long term. There are no automatic responses, but creative, flexible, unpredictable ways of thoughts and actions. Whereas negative emotions mostly have direct influence on one's behavior, e.g. the emotion of fear has the automatic response of flight. The theory supports the idea that positive emotions like joy, interest, contentment and love create flexible thinking and that most of those positive emotions initiate a cycle of more positive emotions. Personal skills can grow through broadening thoughts and actions. For example, interest sparks the urge to explore.

According to this theoretical framework a number of research questions can be derived regarding the influence of people's perception about nanotechnology.

Regarding this study, it will be interesting to see if the video evokes positive emotions, which will be analyzed by using variables of "flexible thinking" and "admiration" with respect to nanotechnology.

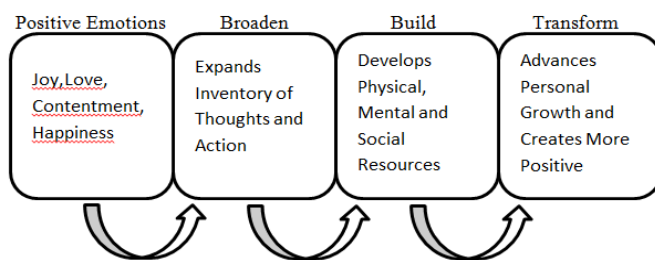


Figure 3. Broaden-and-Build Theory, based on Fredrickson (2001)

Research questions and hypotheses

1. *Are there differences in the perceived usefulness concerning nanotechnology between people who saw the video and people who did not?*

We hypothesized that participants in the experimental group will perceive nanotechnology as more useful in comparison to participants in the control group.

2. *Are there differences in the risk and benefit perception concerning nanotechnology between people who saw the video and people who did not?*

2.1 We hypothesized that participants in the experimental group will perceive less risk in nanotechnology in comparison to the control group.

2.2 We hypothesized that participants in the experimental group will perceive greater benefits in nanotechnology in comparison to the control group.

3. *Are there differences in the positive affect concerning nanotechnology between people who saw the video and people who did not?*

3.1 We hypothesized that participants in the experimental group will have a greater admiration for nanotechnology in comparison to participants in the control group.

3.2 We hypothesized that participants in the experimental group show a greater output in creative thinking towards nanotechnology in comparison to participants in the control group.

2 Methods

2.1 Design

We employed a randomized controlled experimental design with an experimental and a control group. Participants were randomly assigned either to the experimental group or the control group. The experimental group saw “*The Making Of*”-IBM movie, further called video, about nanotechnology from IBM and immediately rated the dependent variables, whereas the control group first rated the dependent variables and afterwards saw the same video. Both groups were administered further control variables in the end.

2.2 Participants

Because the author wanted to estimate the impact on general public in Germany, no specific group has been targeted. Participants were drawn using snowball sampling, starting requests from a circle of acquaintances. Data stem from a sample of 77 adults aged between 19-64 years (37.3% female; Mean age=34.75; $SD=12.27$) who took part in the study conducted in Germany. In total, 82% had German as nationality and 15% had Turkish as nationality, 1% were Kurds and 1% were Bulgarian.

The sample showed significant differences in the age between the both groups ($F(1,69)=4.45$, $p<.038$). Participants in the control group were significantly older ($M=38.46$, $SD=14.42$) in comparison to participants in the experimental group ($M=32.33$, $SD=10.11$).

No differences were found between both groups regarding gender ($F(1,73)=2.45$, $p<.122$) and education ($\chi^2(8)=4.16$, $p=.842$).

2.3 Measures

Variables. All measures were self-reported. There is a lack of valid instruments on attitudinal perceptions about nanotechnology (Schönborn, Höst & Lundin Palmerius, 2015). Therefore, we created new measures or adapted existing scales in terms of appropriateness for study content.

Dependent variables.

Perceived Usefulness. Participants rated the perceived usefulness of nanotechnology on 4 items (e.g. “*Nanotechnology will enable the industry to develop more efficient products and*”).

processes" on a five-point likert-scale ranging from "Totally agree" to "Do not agree at all"; Cronbachs alpha $\alpha=.79$).

Risk perception. Participants rated the risk perception of nanotechnology on 8 items (e.g. "Nanotechnology constitutes a threat"; five-point likert-scale ranging from "Totally agree" to "Do not agree at all"; Cronbachs alpha $\alpha=.80$).

Benefit perception. Participants rated the benefit perception of nanotechnology on 9 items (e.g. "Nanotechnology constitutes a benefit"; five-point likert-scale ranging from "Totally agree" to "Do not agree at all"; Cronbachs alpha $\alpha=.83$).

Admiration. Participants rated the admiration for nanotechnology on 9 items (e.g. "I find that nanotechnology is a remarkable field"; five-point likert-scale ranging from "Totally agree" to "Do not agree at all"; Cronbachs alpha $\alpha=.82$).

Creative thinking. Participants were asked to think about possible achievements of nanotechnology and list as many sentences as they could starting with the phrase "I would like to..." disregarding whether the idea concerning nanotechnology is realistic or not. The amount of ideas was summed up in a total score for each participant.

Control variables.

Comprehension, pre-interest and attitude were determined as control variables. These variables are not designed to be affected by the experimental design.

Comprehension. Participants rated their comprehension of nanotechnology on 7 items (e.g. "The Making Of Videos makes nanotechnology understandable"; five-point likert-scale ranging from "Totally agree" to "Do not agree at all"; Cronbachs alpha $\alpha=.66$).

Pre-interest. Participants rated their interest in nanotechnology on 4 items (e.g. "The Making Of evokes interest in nanotechnology"; five-point likert-scale ranging from "Totally agree" to "Do not agree at all"; Cronbachs alpha $\alpha=.81$).

Attitude. Participants rated their attitude towards the video and nanotechnology on 7 items (e.g. "I like The Making Of video"; five-point likert-scale ranging from "Totally agree" to "Do not agree at all"; Cronbachs alpha $\alpha=.91$).

2.4 Procedure

Participants were administered an online survey conducted with Qualtrics. The randomization of the participants was also organized automatically by Qualtrics. All instruments remained identical for both groups. Data acquisition took place at the local computers of the participants and took about 15 minutes.

“The Making Of”-IBM movie was the stimulus of the experiment. It shows the making of a video to advertise nanotechnology and is described by a narrator. The video takes about 5 minutes and was shown to the participants on their computer.

2.5 Data analyses

A Kolmogorov-Smirnov test was performed to find out whether the scales had a normal distribution. Independent sample t-tests were performed to control for differences between the two experimental groups.

3 Results

3.1 Preliminary analyses

Participants` opinions on the video regarding comprehension. Overall, comprehension refers to the impact of the video regarding understanding nanotechnology, understanding the method used in production of the movie, possibilities of nanotechnology and risk perception of nanotechnology. Using five-point likert-scales ranging from “Totally agree” to “Do not agree at all”, whereas lower ratings indicate higher agreement, participants stated that they did understand the method used in production of the movie ($M=2.12$, $SD=1.03$). Participants also agreed to items stating that the video made nanotechnology understandable ($M=2.53$, $SD=1.04$) and that they gained more knowledge about nanotechnology ($M=2.6$, $SD=1.16$) and its possibilities ($M=2.38$, $SD=1.02$). Furthermore, participants agreed to the statement that the video shows the usefulness of nanotechnology ($M=2.52$, $SD=1.27$). However, participants were neutral to the statement that the video makes one think about the risks of nanotechnology ($M=3.31$, $SD=1.23$).

Overall, participants in the experimental group showed no significant differences in comprehension of nanotechnology ($M=2.48$, $SD=0.61$) in comparison to participants in the control group ($M=2.46$, $SD=0.73$). Lower ratings indicate that participants show a good comprehension of nanotechnology. Thus, there were no significant differences between the groups regarding comprehension ($t(74)=0.09$; $p<.462$).

*Participants` opinions on the video regarding pre-interest.* Pre-interest refers to participants` interest in nanotechnology before and after the video and general impression of the video. Using five-point likert-scales ranging from “Totally agree” to “Do not agree at all”, whereas lower ratings indicate higher agreement, participants agreed that the video is interesting ($M=2.22$, $SD=1.19$). Participants also agreed that the video arouses interest in nanotechnology ($M=2.62$, $SD=1.14$) and makes one want to learn more about nanotechnology ($M=2.66$, $SD=1.17$). However, participants were neutral to the statement that they had interest in nanotechnology before seeing the video ($M=3.09$, $SD=1.39$).

Participants in the experimental group showed no significant differences in pre-interest towards nanotechnology ($M=2.56$, $SD=0.70$) in comparison the participants in the control group ($M=2.72$, $SD=0.81$). Lower ratings indicate that participants have a higher pre-interest towards nanotechnology. Thus, there were no significant differences between the groups regarding pre-interest ($t(74)=0.89$; $p<.188$).

Participants` opinion on the video regarding attitude. Attitude refers to pleasure and excitement regarding the video itself, attitude towards the work of the scientist seen in the video, the impact of the video regarding positive feelings and worries towards nanotechnology. Using five-point likert-scales ranging from “Totally agree” to “Do not agree at all”, whereas lower ratings indicate higher agreement, participants confirmed that they liked the video ($M=2.33$, $SD=1.08$) and that they want to see the movie ($M=2.46$, $SD=1.25$). Participants also agreed that the scientist seen in the video did a remarkable work ($M=2.67$, $SD=1.18$). Furthermore, participants agreed that the video did lead to a positive feeling about nanotechnology ($M=2.03$, $SD=0.95$) and were neutral to the statement that the video evokes worries ($M=3.19$, $SD=1.18$).

Participants in the experimental group showed no significant differences in attitude towards nanotechnology ($M=2.52$, $SD=0.98$) in comparison the participants in the control group ($M=2.55$, $SD=0.89$). Lower ratings indicate that participants have a higher attitude towards nanotechnology. Thus, there were no significant differences between the groups regarding attitude ($t(74)=0.13$; $p<.447$).

To sum up, both groups scored equally for all control variables.

3.2 Testing for normality of the distribution

The Kolmogorov-Smirnov test checked all scales for normal distribution. A normal distribution was found for all scales (*Perceived Usefulness*, *Risk Perception*, *Benefit Perception*, *Admiration*, *Creative Thinking*, *Comprehension*, *Pre-Interest* and *Attitude*), $p>.05$.

3.3 Hypotheses testing

The results of the main effects are shown in Table 1. Note that although total participation was $N=77$, absence of answers to items led to reduced numbers in df .

Table 1

Main effects of dependent variables

	Experimental (N=47)	Control (N=30)		
	M (SD)		df	t
Perceived Usefulness	2.67 (0.60)	3.12 (0.63)	74	3.20**
Risk Perception	3.36 (0.79)	3.07 (0.59)	74	1.77*
Benefit Perception	2.43 (0.66)	2.78 (0.60)	73	2.29*
Admiration	2.20 (0.88)	2.31 (0.92)	74	0.55
Creative Thinking	1.54 (1.93)	2.10 (2.54)	74	1.10

**=significant at the 0,01 level (1- tailed); *=significant at the 0.05 level (1-tailed)

Note: Lower scores indicate higher agreement with variables.

Hypotheses 1 - Perceived usefulness. Significant differences between the groups were found regarding perceived usefulness ($t(74)=3.20$; $p<.001$). Participants in the experimental group showed lower ratings in perceived usefulness ($M=2.67$, $SD=0.60$) in comparison to the participants in the control group ($M=3.12$, $SD=0.63$). Lower ratings indicate that participants perceive nanotechnology as more useful, which means that the first hypothesis is confirmed.

Hypotheses 2 – Risk and benefit perception. Significant differences between the groups were found regarding risk perception ($t(74)=1.77$; $p<.041$). Participants in the experimental group showed higher ratings in risk perception ($M=3.36$, $SD=0.79$) in comparison to the participants in the control group ($M=3.07$, $SD=0.59$). Higher ratings indicate that participants perceive nanotechnology as less risky.

Significant differences between the groups were also found regarding benefit perception ($t(73)=2.29$; $p<.013$). Participants in the experimental group showed lower ratings in benefit perception ($M=2.43$, $SD=0.66$) in comparison to the participants in the control group ($M=2.78$, $SD=0.60$). Lower ratings indicate that participants perceive nanotechnology as more beneficial.

Thus, hypotheses 2.1 and 2.2 can also be confirmed.

Hypotheses 3 – positive affect. No significant differences between the groups were found regarding admiration ($t(74)=0.55$; $p<.293$). Participants in the experimental group showed no significant differences in admiration of nanotechnology ($M=2.20$, $SD=0.88$) in

comparison to the participants in the control group ($M=2.31$, $SD=0.92$). Lower ratings indicate that participants perceive nanotechnology as admirable.

No significant differences between the groups were also found regarding creative thinking ($t(74)=1.10$; $p<.137$). Participants in the experimental group showed no significant differences in creative thinking towards nanotechnology ($M=1.54$, $SD=1.93$) in comparison to the participants in the control group ($M=2.10$, $SD=2.54$). Lower ratings indicate that participants have less creative ideas toward nanotechnology.

Thus, hypotheses 3.1 and 3.2 cannot be confirmed.

4 Discussion

The main purpose of the study was to investigate the perception of nanotechnology concerning attitudes and affection using a video about nanotechnology. Due to the fact that nanotechnology is an interdisciplinary topic and is becoming a major influence in various areas this study can show further insight into the public perception. The results indicated a positive effect towards perceived usefulness and risk and benefit perception. However, admiration and creative thinking were not significantly affected by the intervention.

The first hypothesis was confirmed, indicating that participants in the experimental group perceived nanotechnology as more useful. One example given in the video for possible usefulness of nanotechnology was higher memory capacities in electronic devices such as mobile phones. According to the Technology Acceptance Model, these outcomes suggest that presenting media of nanotechnology (e.g. a video) to the public can lead to a higher acceptance rate of the upcoming technological developments.

The second hypothesis was also confirmed, indicating that participants in the experimental group had lower risk perceptions and greater benefit perception about nanotechnology. With regard to the Affect Heuristic Model this means that the video had a positive impact on the affection towards nanotechnology. One possible reason for that outcome could be that the motivation and enthusiasms of the scientists were shown in the video. This could have led to coping of the positive affections. Interestingly, no practical influence of nanotechnology is shown in the video, but new possibilities are just mentioned or concluded by the scientists. It seems that scientist's credibility has a major influence on people's acceptance and perception of usefulness. To test this assumption future research could investigate with a further condition group in which participants get a pure presentation of nanotechnology without scientist's enthusiasm projected in the content. For instance, using just the IBM movie "A Boy and His Atom". Apparently, there is no need to explicitly trivialize possible risks to reduce risk perception. To test differences in effective presentation future research could investigate with an additional group. Participants could get a presentation of nanotechnology in which possible risks are explicitly qualified. Although, possible risks are just mentioned and trivialized, people could tend to start thinking about risks, which could lead to higher risk perception.

The third hypothesis was not confirmed, indicating that participants in the experimental group did not show higher admiration for nanotechnology compared to the control group. Further, participants in the experimental group also did not show a higher creative output than participants in the control group. One possible explanation for that could be that the instruments used for this purpose did not fit the concept of the study. Maybe, participants did not figure out how to do a creative task during the experiment, because only likert scales were used for previous variables. The similar results for the variable admiration in both conditions confirms previous studies and researches indicating that there is already a high enthusiasm about nanotechnology in the public (Burri & Bellucci, 2008). However, the broaden-and-build theory states also that positive emotions have an influence on one's way of thinking on a long term. This could indicate that the positive effects of the video are short termed. This could be an explanation why the second hypothesis is confirmed and the third hypothesis is not. Follow up studies could investigate this conclusion.

Regarding control variables, the video had similar effects in both groups with respect to comprehension, pre-interest and attitude.

An interesting aspect of the current study is that hypotheses were investigated using a video, which is accessible to public. This makes results considerably more significant for practical implementations regarding perception of nanotechnology in the future. Another positive point is that for this study, new instruments have been generated, which exhibit a good validity. These tools can be useful for future studies on the perception of nanotechnology. Results show that chosen theories and variables deliver good basis for current study. To be specific, results show that videos, presenting new possibilities and scientific enthusiasm, have a positive effect on people's perception and expectations towards nanotechnology.

Possible limitations of the study. Although two of the three hypotheses have been confirmed and thus might indicate a positive effect of the "IBM Making of" video regarding the perception of nanotechnology, the results should be interpreted with caution, because of possible limitations to the study. First, the sample of the study cannot be regarded as representative. Using the snowball sampling, the author asked for participation in this study drawing a final sample that included a wide range of age (from 19 to 64 years). Further, there were more male participants in the final sample, thus the results are not significantly representative for public regarding age and by gender variation. However, distribution of gender was similar between conditions, i.e. that there was no significant difference between

both groups. That means, although groups did not represent the broad public, comparing differences of both conditions still gives a significant insight. Also, the sample size was small, which may have limited the power of some statistical analyses. Second, all measurements were self-reported, which means they might be prone to social desirability and do not necessarily reflect the true opinion of the participants. On the other side, possible influence of social desirability is reduced due to the fact that a psychological study is about nanotechnology, i.e. participants could not conclude possible purposes of the study. Another point is that participation was anonymous and not accompanied by the administrator which also reduces a possible influence of social desirability. Third, data acquisition has been conducted via an online tool; therefore, test performances could not be monitored. It may be possible, that participants were not fully concentrated during the administration of the online survey or that they did several others tasks while filling out the survey. However, these are general limitations to online surveys and concerns both experimental conditions with respect to randomization of participants. Fourth, this study only shows short-time effects. Right now, no results can be given about the long-term effects. As it is stated above, it might be possible that the effects disappear in a follow-up measurement. Fifth, instruments were created for the purpose of the study and were not derived from established and empirically validated instruments, although the instruments in this study showed acceptable psychometric.

Future research should investigate the long term effects of the video usage, use a larger sample size, and validate the created instruments. For practical purposes, this study did not investigate all the various factors implemented in the theoretical frameworks. Furthermore, Schönborn, Höst and Lundin Palmerius (2015) have delivered effective items to measure the general knowledge of the participants about nanotechnology. This instrument could be included for further measurements or follow up studies to determine if pre-knowledge has an impact on impression of the video.

In sum, these results indicate that the video did have a positive effect on people's perception of nanotechnology. This confirms previous studies which stated that commercials with presentations of clear benefits and enthusiasm towards nanotechnology are more likely to get positive responses (e.g. George et al., 2014). Also, it illustrates that the media can be a communication channel to reach and enlighten the broad public. In order to shape the public opinion and perception about nanotechnology the use of media is recommended. However, further studies should investigate efficiency of other possibilities and methods to inform the public and also compare efficiency of diverse methods. The effects in the present study are

promising and demonstrate the great impact even a short video about nanotechnology can have on people's perception. Because of the strong interdependency between introduction of new technology and public acceptance or public well-being, this study also demonstrates the importance of consideration multiple aspect and variables based on divers theories and models in order to alter attitudes about technology.

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6 Appendix

Variables and items

Variables	Items
Usefulness	Die Nanotechnologie wird der Industrie ermöglichen effizientere Produkte und Verfahren zu entwickeln Die Nanotechnologie wird es der Lebensmittelindustrie ermöglichen effizientere Produkte und Verfahren für die Lebensmittelversorgung zu entwickeln Die Nanotechnologie ermöglicht es dem medizinischen Bereich effizientere Produkte und Verfahren für die Gesundheitsversorgung zu entwickeln Nanotechnologie ebnet den Weg für neue Felder
Risk Perception	Nanotechnologie stellt eine Bedrohung dar Nanotechnologie stellt eine Bedrohung für die Lebensgrundlage vieler Menschen dar Die Nanotechnologie stellt eine Bedrohung für die Lebensgrundlage von wenigen Menschen dar Nanotechnologie führt oft zu negativen Auswirkungen für Menschen Die Nanotechnologie wird in den nächsten 10 Jahren wahrscheinlich zu negativen Konsequenzen führen Negative Auswirkungen auf Basis der Nanotechnologie werden häufiger auftreten Wenn ich über Bedrohung durch Nanotechnologie denke, wird mir unbehaglich Ich werde die Möglichkeit haben Risiken der Nanotechnologie zu reduzieren
Benefit Perception	Nanotechnologie stellt einen Vorteil dar Nanotechnologie stellt einen Vorteil für die Lebensgrundlage vieler Menschen dar Die Nanotechnologie stellt einen Vorteil für die Lebensgrundlage von wenigen Menschen dar Nanotechnologie führt oft zu positiven Auswirkungen für Menschen Nanotechnologie führt selten zu positiven Auswirkungen für Menschen Die Nanotechnologie wird in den nächsten 10 Jahren wahrscheinlich zu positiven Konsequenzen führen

	Positive Auswirkungen auf Basis der Nanotechnologie werden häufiger auftreten Wenn ich über Vorteile durch Nanotechnologie denke, fühle ich mich zuversichtlich Ich habe die Möglichkeit Vorteile der Nanotechnologie zu erhöhen
Admiration	Ich möchte mehr über Nanotechnologie lernen Ich interessiere mich für nanotechnologische Entwicklungen Ich finde, dass die Nanotechnologie ein bemerkenswertes Feld ist
Comprehension	Das Making Of macht Nanotechnologie verständlich Ich habe verstanden wie der Film gemacht wurde Ich habe eine Vorstellung über das, was mit Nanotechnologie möglich ist Ich weiß mehr über Nanotechnologie, nachdem ich das Making Of gesehen habe Das Making Of zeigt, dass Nanotechnologie nützlich ist Das Making Of lässt mich über die Risiken der Nanotechnologie nachdenken Ich glaube nicht mehr über Nanotechnologie zu wissen, nachdem ich das Making Of gesehen habe
Pre-Interest	Ich hatte bereits Interesse an Nanotechnologie bevor ich das Making Of gesehen habe Das Making Of weckt Interesse für Nanotechnologie Ich finde das Making Of interessant Das Making Of regt mich dazu an, mehr über Nanotechnologie erfahren zu wollen
Attitude	Das Making Of gefällt mir Ich möchte den Film gerne sehen Durch das Making Of bin ich gespannt auf die Errungenschaften der Nanotechnologie Das Making Of weckt mein Interesse an der weiteren Entwicklung in der Nanotechnologie Die Wissenschaftler haben eine bemerkenswerte Arbeit bei diesem Projekt geleistet Das Making Of gibt mir ein positives Gefühl über Nanotechnologie Durch das Making Of bin ich weniger besorgt über die Entwicklung der Nanotechnologie

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Questionnaire

Questionnaire Control Group

Sehr geehrte Teilnehmerinnen und Teilnehmer, herzlichen Dank für Ihr Interesse an meiner Befragung. Schön, dass Sie sich die Zeit nehmen, diesen Fragebogen auszufüllen! Dieser Fragebogen ist Teil meiner Bachelor Arbeit im Fachbereich Psychologie an der Universität Twente in Enschede. Durch das Ausfüllen des Fragebogens leisten Sie einen wertvollen Beitrag zum wissenschaftlichen Vorankommen. Die einzigen Teilnahmebedingungen sind ein Bezug zu Deutschland und Volljährigkeit. Die Befragung wird circa 10-15 Minuten in Anspruch nehmen. Die Daten werden anonym erfasst, so dass keine Rückschlüsse auf einzelne Personen möglich sind. Sie können die Umfrage jederzeit stoppen oder abbrechen. In diesem Fall werden Ihre Daten nicht weiter verarbeitet. Bitte beantworten Sie alle Antworten stets entsprechend Ihrer ehrlichen Meinung und ohne viel nachzudenken - es gibt keine "richtigen" oder "falschen" Antworten. Sie kriegen zuerst einige Fragen über Ihre Meinung zur Nanotechnologie. Danach sehen Sie ein Making Of des Kurzfilms "A Boy and His Atom" von IBM. Anschließend kriegen Sie einige Fragen über Ihre Meinung zum Making Of. Vielen Dank im Voraus und viel Spaß beim Ausfüllen! Bei Fragen oder Anmerkungen könne Sie sich gerne melden unter: h.dogangun@student.utwente.nl.

Ich habe den obenstehenden Text gelesen und bin einverstanden mit der Teilnahme an dieser Studie.

☐ Einverstanden (1)

Die folgenden Fragen beziehen sich auf Ihre Vorstellung vom Nutzen der Nanotechnologie in diversen Sektoren. Wie bereits gesagt gibt es keine "richtige" oder "falsche" Antworten.

	Stimme völlig zu (2)	Stimme eher zu (3)	Vielleicht (4)	Stimme weniger zu (5)	Stimme nicht zu (6)
Die Nanotechnologie wird der Industrie ermöglichen effizientere Produkte und Verfahren zu entwickeln (1)	☐	☐	☐	☐	☐
Die Nanotechnologie wird es der Lebensmittelindustrie ermöglichen effizientere Produkte und Verfahren für die Lebensmittelversorgung zu entwickeln (2)	☐	☐	☐	☐	☐
Die Nanotechnologie ermöglicht es dem medizinischen Bereich effizientere Produkte und Verfahren für die Gesundheitsversorgung zu entwickeln (3)	☐	☐	☐	☐	☐
Nanotechnologie ebnet den Weg für neue Felder (4)	☐	☐	☐	☐	☐

Die folgenden Fragen beziehen sich auf Ihre Vorstellungen von Risiken der Nanotechnologie.

	Stimme völlig zu (1)	Stimme eher zu (2)	vielleicht (3)	Stimme weniger zu (4)	Stimme nicht zu (5)
Nanotechnologie stellt eine Bedrohung dar (1)	☐	☐	☐	☐	☐
Nanotechnologie stellt eine Bedrohung für die Lebensgrundlage vieler Menschen dar (2)	☐	☐	☐	☐	☐
Die Nanotechnologie stellt eine Bedrohung für die Lebensgrundlage von wenigen Menschen dar (3)	☐	☐	☐	☐	☐
Nanotechnologie führt oft zu negativen Auswirkungen für Menschen (4)	☐	☐	☐	☐	☐
Die Nanotechnologie	☐	☐	☐	☐	☐

wird in den nächsten 10 Jahren wahrscheinlich zu negativen Konsequenzen führen (5)					
Negative Auswirkungen auf Basis der Nanotechnologie werden häufiger auftreten (6)	☐	☐	☐	☐	☐
Wenn ich über Bedrohung durch Nanotechnologie denke, wird mir unbehaglich (7)	☐	☐	☐	☐	☐
Ich werde die Möglichkeit haben Risiken der Nanotechnologie zu reduzieren (8)	☐	☐	☐	☐	☐

Die folgenden Fragen beziehen sich auf Ihre Vorstellungen von Vorteilen der Nanotechnologie.

	Stimme völlig zu (1)	Stimme eher zu (2)	vielleicht (3)	Stimme weniger zu (4)	Stimme nicht zu (5)
Nanotechnologie stellt einen Vorteil dar (1)	☐	☐	☐	☐	☐
Nanotechnologie stellt einen Vorteil für die Lebensgrundlage vieler Menschen dar (2)	☐	☐	☐	☐	☐
Die Nanotechnologie stellt einen Vorteil für die Lebensgrundlage von wenigen Menschen dar (3)	☐	☐	☐	☐	☐
Nanotechnologie führt oft zu positiven Auswirkungen für Menschen (4)	☐	☐	☐	☐	☐
Nanotechnologie führt selten zu positiven Auswirkungen	☐	☐	☐	☐	☐

für Menschen (5)					
Die Nanotechnologie wird in den nächsten 10 Jahren wahrscheinlich zu positiven Konsequenzen führen (7)	☐	☐	☐	☐	☐
Positive Auswirkungen auf Basis der Nanotechnologie werden häufiger auftreten (8)	☐	☐	☐	☐	☐
Wenn ich über Vorteile durch Nanotechnologie denke, fühle ich mich zuversichtlich (9)	☐	☐	☐	☐	☐
Ich habe die Möglichkeit Vorteile der Nanotechnologie zu erhöhen (10)	☐	☐	☐	☐	☐

Welche Errungenschaften würden Sie sich durch die Nanotechnologie wünschen bzw. können Sie sich vorstellen? Sie können in jedes Feld unbegrenzt viel schreiben. Zählen Sie so viele Beispiele auf wie Sie können. Bedenken Sie, dass es keine "unlogischen" oder "falschen" Beispiele gibt.

Ich würde mir wünschen, dass (1)

Ich würde mir wünschen, dass (2)

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Ich würde mir wünschen, dass (4)

Ich würde mir wünschen, dass (5)

Ich würde mir wünschen, dass (6)

Ich würde mir wünschen, dass (7)

Ich würde mir wünschen, dass (8)

Ich würde mir wünschen, dass (9)

Ich würde mir wünschen, dass (10)

Die folgenden Fragen beziehen sich auf Ihre Einstellung gegenüber der Nanotechnologie.

	Stimme völlig zu (1)	Stimme eher zu (2)	vielleicht (3)	Stimme weniger zu (4)	Stimme nicht zu (5)
Ich möchte mehr über Nanotechnologie lernen (1)	☐	☐	☐	☐	☐
Ich interessiere mich für nanotechnologische Entwicklungen (2)	☐	☐	☐	☐	☐
Ich finde, dass die Nanotechnologie ein bemerkenswertes Feld ist (3)	☐	☐	☐	☐	☐

Nun kriegen Sie ein Video zu sehen. Das Video ist ein Making Of zum Kurzfilm "A Boy and His Atom". Dieser Film wurde mit Hilfe von aktuellen nanotechnologischen Mitteln produziert. Viel Spaß!

Bitte fahren Sie nun mit dem Fragebogen fort. Danke

Die folgenden Fragen beziehen sich auf den Inhalt des Making Of's.

	Stimme völlig zu (1)	Stimme eher zu (2)	vielleicht (3)	Stimme weniger zu (4)	Stimme nicht zu (5)
Das Making Of macht Nanotechnologie verständlich (1)	☐	☐	☐	☐	☐
Ich habe verstanden wie der Film gemacht wurde (2)	☐	☐	☐	☐	☐
Ich habe eine Vorstellung über das, was mit Nanotechnologie möglich ist (3)	☐	☐	☐	☐	☐
Ich weiß mehr über Nanotechnologie, nachdem ich das Making Of gesehen habe (4)	☐	☐	☐	☐	☐
Das Making Of zeigt, dass Nanotechnologie nützlich ist (5)	☐	☐	☐	☐	☐
Das Making Of lässt mich über die Risiken der Nanotechnologie	☐	☐	☐	☐	☐

nachdenken (7)					
Ich glaube nicht mehr über Nanotechnologie zu wissen, nachdem ich das Making Of gesehen habe (6)	☐	☐	☐	☐	☐

Die folgenden Fragen beziehen sich auf den Eindruck der durch das Making Of entsteht.

	Stimme völlig zu (1)	Stimme eher zu (2)	vielleicht (3)	Stimme weniger zu (4)	Stimme nicht zu (5)
Ich hatte bereits Interesse an Nanotechnologie bevor ich das Making Of gesehen habe (1)	☐	☐	☐	☐	☐
Das Making Of weckt Interesse für Nanotechnologie (2)	☐	☐	☐	☐	☐
Ich finde das Making Of interessant (3)	☐	☐	☐	☐	☐
Das Making Of regt mich dazu an, mehr über Nanotechnologie erfahren zu wollen (4)	☐	☐	☐	☐	☐

Die folgenden Fragen beziehen sich auf Ihre persönliche Beurteilung des Making Of.

	Stimme völlig zu (1)	Stimme eher zu (2)	vielleicht (3)	Stimme weniger zu (4)	Stimme nicht zu (5)
Das Making Of gefällt mir (1)	☐	☐	☐	☐	☐
Ich möchte den Film gerne sehen (2)	☐	☐	☐	☐	☐
Durch das Making Of bin ich gespannt auf die Errungenschaften der Nanotechnologie (3)	☐	☐	☐	☐	☐
Das Making Of weckt mein Interesse an der weiteren Entwicklung in der Nanotechnologie (4)	☐	☐	☐	☐	☐
Die Wissenschaftler haben eine bemerkenswerte Arbeit bei diesem Projekt geleistet (6)	☐	☐	☐	☐	☐

Das Making Of gibt mir ein positives Gefühl über Nanotechnologie (5)	☐	☐	☐	☐	☐
Durch das Making Of bin ich weniger besorgt über die Entwicklung der Nanotechnologie (7)	☐	☐	☐	☐	☐

Wie alt sind Sie?

Geschlecht

- ☐ weiblich (1)
- ☐ männlich (2)

Abschluss

- ☐ keinen Abschluss (1)
- ☐ Hauptschulabschluss (2)
- ☐ Realschulabschluss (3)
- ☐ Fachabitur (4)
- ☐ Abitur (5)
- ☐ Berufsausbildung (6)
- ☐ Bachelor (7)
- ☐ Master (8)
- ☐ Andere (9)

Answer If Abschluss Bachelor Is Selected Or Abschluss Master Is Selected

Fachbereich

- ☐ Geisteswissenschaft (1)
- ☐ Gesellschaftswissenschaft (2)
- ☐ Technisch (3)
- ☐ Naturwissenschaft (4)

Nationalität

Beschreiben Sie kurz in eigenen Worten worum es in dieser Studie geht.

Haben Sie noch Anmerkungen zur Studie?

Dankeschön! Zuallererst möchte ich mich herzlich für Ihre Mitarbeit an meiner Studie bedanken. Wenn Sie an den Ergebnissen dieser Studie interessiert sind, können Sie mir eine E-Mail an h.dogangun@student.utwente.nl schreiben. Ich wünsche Ihnen alles Gute!

Questionnaire for Experimental Group

Sehr geehrte Teilnehmerinnen und Teilnehmer, herzlichen Dank für Ihr Interesse an meiner Befragung. Schön, dass Sie sich die Zeit nehmen, diesen Fragebogen auszufüllen! Dieser Fragebogen ist Teil meiner Bachelor Arbeit im Fachbereich Psychologie an der Universität Twente in Enschede. Durch das Ausfüllen des Fragebogens leisten Sie einen wertvollen Beitrag zum wissenschaftlichen Vorankommen. Die einzigen Teilnahmebedingungen sind ein Bezug zu Deutschland und Volljährigkeit. Die Befragung wird circa 10-15 Minuten in Anspruch nehmen. Die Daten werden anonym erfasst, so dass keine Rückschlüsse

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Die Nanotechnologie ermöglicht es dem medizinischen Bereich effizientere Produkte und Verfahren für die Gesundheitsversorgung zu entwickeln (3)	☐	☐	☐	☐	☐
Nanotechnologie ebnet den Weg für neue Felder (4)	☐	☐	☐	☐	☐

Die folgenden Fragen beziehen sich auf Ihre Vorstellungen von Risiken der Nanotechnologie.

	Stimme völlig zu (1)	Stimme eher zu (2)	vielleicht (3)	Stimme weniger zu (4)	Stimme nicht zu (5)
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Die Nanotechnologie	☐	☐	☐	☐	☐

wird in den nächsten 10 Jahren wahrscheinlich zu negativen Konsequenzen führen (5)					
Negative Auswirkungen auf Basis der Nanotechnologie werden häufiger auftreten (6)	☐	☐	☐	☐	☐
Wenn ich über Bedrohung durch Nanotechnologie denke, wird mir unbehaglich (7)	☐	☐	☐	☐	☐
Ich werde die Möglichkeit haben Risiken der Nanotechnologie zu reduzieren (8)	☐	☐	☐	☐	☐

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Wenn ich über Vorteile durch Nanotechnologie denke, fühle ich mich zuversichtlich (9)	☐	☐	☐	☐	☐
Ich habe die Möglichkeit Vorteile der Nanotechnologie zu erhöhen (10)	☐	☐	☐	☐	☐

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Die folgenden Fragen beziehen sich auf Ihre Einstellung gegenüber der Nanotechnologie.

	Stimme völlig zu (1)	Stimme eher zu (2)	vielleicht (3)	Stimme weniger zu (4)	Stimme nicht zu (5)
Ich möchte mehr über Nanotechnologie lernen (1)	☐	☐	☐	☐	☐
Ich interessiere mich für nanotechnologische Entwicklungen (2)	☐	☐	☐	☐	☐
Ich finde, dass die Nanotechnologie ein bemerkenswertes Feld ist (3)	☐	☐	☐	☐	☐

Die folgenden Fragen beziehen sich auf den Inhalt des Making Of's.

	Stimme völlig zu (1)	Stimme eher zu (2)	vielleicht (3)	Stimme weniger zu (4)	Stimme nicht zu (5)
Das Making Of macht Nanotechnologie verständlich (1)	☐	☐	☐	☐	☐
Ich habe verstanden wie der Film gemacht wurde (2)	☐	☐	☐	☐	☐
Ich habe eine Vorstellung über das, was mit Nanotechnologie möglich ist (3)	☐	☐	☐	☐	☐
Ich weiß mehr über Nanotechnologie, nachdem ich das Making Of gesehen habe (4)	☐	☐	☐	☐	☐
Das Making Of zeigt, dass Nanotechnologie nützlich ist (5)	☐	☐	☐	☐	☐
Das Making Of lässt mich über die Risiken der Nanotechnologie	☐	☐	☐	☐	☐

nachdenken (7)					
Ich glaube nicht mehr über Nanotechnologie zu wissen, nachdem ich das Making Of gesehen habe (6)	☐	☐	☐	☐	☐

Die folgenden Fragen beziehen sich auf den Eindruck der durch das Making Of entsteht.

	Stimme völlig zu (1)	Stimme eher zu (2)	vielleicht (3)	Stimme weniger zu (4)	Stimme nicht zu (5)
Ich hatte bereits Interesse an Nanotechnologie bevor ich das Making Of gesehen habe (1)	☐	☐	☐	☐	☐
Das Making Of weckt Interesse für Nanotechnologie (2)	☐	☐	☐	☐	☐
Ich finde das Making Of interessant (3)	☐	☐	☐	☐	☐
Das Making Of regt mich dazu an, mehr über Nanotechnologie erfahren zu wollen (4)	☐	☐	☐	☐	☐

Die folgenden Fragen beziehen sich auf Ihre persönliche Beurteilung des Making Of.

	Stimme völlig zu (1)	Stimme eher zu (2)	vielleicht (3)	Stimme weniger zu (4)	Stimme nicht zu (5)
Das Making Of gefällt mir (1)	☐	☐	☐	☐	☐
Ich möchte den Film gerne sehen (2)	☐	☐	☐	☐	☐
Durch das Making Of bin ich gespannt auf die Errungenschaften der Nanotechnologie (3)	☐	☐	☐	☐	☐
Das Making Of weckt mein Interesse an der weiteren Entwicklung in der Nanotechnologie (4)	☐	☐	☐	☐	☐
Die Wissenschaftler haben eine bemerkenswerte Arbeit bei diesem Projekt geleistet (6)	☐	☐	☐	☐	☐

Das Making Of gibt mir ein positives Gefühl über Nanotechnologie (5)	☐	☐	☐	☐	☐
Durch das Making Of bin ich weniger besorgt über die Entwicklung der Nanotechnologie (7)	☐	☐	☐	☐	☐

Wie alt sind Sie?

Geschlecht

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- ☐ männlich (2)

Abschluss

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- ☐ Hauptschulabschluss (2)
- ☐ Realschulabschluss (3)
- ☐ Fachabitur (4)
- ☐ Abitur (5)
- ☐ Berufsausbildung (6)
- ☐ Bachelor (7)
- ☐ Master (8)
- ☐ Andere (9)

Answer If Abschluss Bachelor Is Selected Or Abschluss Master Is Selected

Fachbereich

- ☐ Geisteswissenschaft (1)
- ☐ Gesellschaftswissenschaft (2)
- ☐ Technisch (3)
- ☐ Naturwissenschaft (4)

Nationalität

Beschreiben Sie kurz in eigenen Worten worum es in dieser Studie geht.

Haben Sie noch Anmerkungen zur Studie?

Dankeschön! Zuallererst möchte ich mich herzlich für Ihre Mitarbeit an meiner Studie bedanken. Wenn Sie an den Ergebnissen dieser Studie interessiert sind, können Sie mir eine E-Mail an h.dogangun@student.utwente.nl schreiben. Ich wünsche Ihnen alles Gute!