Edited by René Zimmer, Rolf Hertel, Gaby-Fleur Böl

Public Perceptions about Nanotechnology

Representative survey and basic morphological-psychological study

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Public perceptions about nanotechnology –
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1 Preface

The Federal Institute for Risk Assessment (BfR) has the statutory remit of identifying potential risks to consumers from foods, substances and products, of assessing them scientifically and of then involving all the stakeholders in an active communication and information process. By means of comprehensive, complete and transparent risk communication BfR makes science visible and usable for politicians, science, non-government organisations, associations and consumers. However, there are special challenges, particularly concerning new technologies like nanotechnology. All the stakeholders should have an opportunity to come to an informed opinion about the effect of new technologies in order to facilitate the responsible handling of these technologies. To achieve this, there is a need, amongst other things, to understand how consumers perceive certain risks.

However, research into public perceptions of nanotechnology is still in the early stages. The first representative surveys of public perceptions of nanotechnology are available from the USA, the United Kingdom, Australia and Germany. According to them, only a few people have any understanding whatsoever of nanotechnology. At the same time, in contrast to genetic engineering and nuclear energy, no major risks are expected from nanotechnology.

In order to determine how nanotechnology is currently seen by the German population, BfR conducted a research project on “Public perceptions of nanotechnology” in 2007. A representative population survey coupled with a qualitative-psychological basic study was to provide insight into the factors which influence public perceptions, what social dynamics are of importance in the area of nanotechnology and in which direction public opinion on nanotechnology could move. The goal was to identify risks or risk areas which are present in the public perception in a manifest, latent or potential manner, and to describe factors which impact risk communication in this new risk area.

This project is part of a whole series of dialogue and research activities initiated and conducted by BfR in recent years. Together with the Federal Office for Health and Safety and the Federal Environmental Agency, a research strategy to identify the potential risks of nanotechnology was published in 2007. Parallel to this, BfR conducted a consumer conference, an expert survey on the risks of nanotechnology and a media analysis of the subject. Furthermore, BfR is active in all the relevant scientific bodies which deal with regulating nanotechnology on the national or European level. All the above-mentioned activities share the common goal of guaranteeing the safe, responsible handling of nanotechnologies and its products.

Professor Dr. Dr. Andreas Hensel

President of the Federal Institute for Risk Assessment

2 Introduction

The rapid development of nanotechnology and the growing importance of this technology for everyday life have not really attracted any attention from the public at large. Initial representative surveys in various countries – for instance the survey by komm.passion in Germany in 2004 – show that only a small proportion of the population has any idea at all about the term “nanotechnology”.[1] The social and, for the vast majority of citizens, individual opinion-forming process on this subject has only just begun. So far there has been no broad discussion that also examines risks like there has been concerning the use of nuclear energy or genetic engineering.

By contrast, in many expert circles like for instance natural scientific-technological research, in various economic sectors and regions as well as on the political-ministerial level, the impression is spreading that, with nanotechnology, a future-centric, application-driven technology has at last been found that could provide technically intelligent and elegant solutions to problems of various kinds. In various federal states and regions research centres and innovation clusters have been set up which claim to have the edge in the field of nanotechnological research or production. These centres actively look for and develop informed audiences of the most varied kinds, for instance by means of fora, expert rounds, trade fairs and exhibitions.

Industrial companies have been engaged in nanotechnological developments for some time now. The hope is that nanotechnological applications will lead to major improvements to products and analytical methods and corresponding profit opportunities in areas like pharmaceutical production, surface treatment, sensor technology or the production of materials for aircraft construction. The fact that nanotechnologies are now deemed to have economic potential is obvious from the fact that large European banks recently have taken the initiative and set up “Global Nanotechnology Indexes”.[2]

However, the public opinion forming process on the subject of nanotechnology which is by no means complete and often largely unresearched makes it more difficult to estimate the impact of communication on the risks of this technology. There is uncertainty about how public opinion could move in the event of the possible occurrence of health or environmental damage caused by nanotechnologies. The comprehensive analysis of the public perception of the new subject nanotechnology can, however, help to make communication more appropriate and more suited to the target group - also from the risk angle.

To gain a better idea of the impact of communication, an examination is to be undertaken of the factors, thought patterns and images that shape public perceptions of nanotechnology. In this context the analysis will include both the individual and the public opinion forming processes.

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[1] Kahan *et al.* (2007); Rosenbladt *et al* (2007); Cobb, Macoubrie (2004), KommPassion (2004), Gaskel *et al* (2006); Elkins (2005)

[2] For instance Société Générale, which has offered a certificate on its "SGI Global Nanotechnology Index" since the autumn of 2007 (Drescher, 2007)

2.1 Objective

The aim of the analysis of public perceptions of nanotechnology was to describe the impact factors for risk communication in the new risk area of nanotechnology. A basic qualitative-psychological study in conjunction with a representative population survey of the perceptions of nanotechnology aimed to provide insight into the factors which influence consumer perceptions, the dynamics of importance in the field of nanotechnology and the direction in which public opinion on nanotechnology can move.
The study concentrated on questions and topics like:

- How widespread is knowledge about nanotechnology: How does knowledge about nanotechnology impact the assessment of this technology? Is nanotechnology perceived by the German population more from the risk or the benefit angle? When are risk aspects more to the fore in this perception, and when are the benefits more to the fore?
- Which psychological and cultural factors shape the public perception and assessment of “nanotechnology”? How should nanotechnology be seen on the basis of the classical determining factors of risk perception, particularly regarding the voluntary nature of risk exposure, familiarity with dealing with the risks, the reversibility of potential damage or the visibility of the risk?
- Are there differences in the assessment of nanotechnology depending on the application areas (food, cosmetics and consumer products)? Which analogies are drawn depending on the application areas to more well known and more widely discussed technologies (e.g. engineering context versus biotechnological context)?

2.2 Project concept and approach

The subject nanotechnology is characterised by the fact that the public opinion forming process has only just begun. One particularly important factor is probably that nanotechnology can be found in very different application areas, for example foods and building materials. This can influence perception and, more particularly, risk perception of the subject.

The project concept and methodology must be able to record and describe the complex contexts of the opinion-forming and image-shaping of nanotechnology in its development, and to ensure a comparison with existing psychological-sociological findings of risk research. The following points are of particular importance when it comes to selecting a suitable concept and an appropriate procedure:

- Consumers encounter an object which up to then had been the exclusive domain of scientific disciplines like quantum physics, chemistry or engineering that mostly had little to do with daily life. On the one hand this technology has already conquered various areas of consumer daily life. On the other, consumers are confronted with a flood of knowledge about technical innovations in general and nanotechnology in particular. Furthermore, the potential risk consequences cannot yet be assessed. Here, as in other areas, consumers need filters, simplifications or image programmes in order to structure their information level.
- Consumers are not fully informed about a subject of this kind (nanotechnology is not a risk subject from the very outset) not just because of a limited capacity to understand and process. Information itself can have a more or less unsettling effect and trigger defence mechanisms. Particularly when it comes to risk themes consumers develop ideas based on daily life which are in contrast to the level of knowledge in science. Furthermore, there is a tendency to ignore available information or to throw up perception barriers. This seemingly unreasonable behaviour is necessary from the psychological angle so that

consumers can develop behaviour which is deemed to be viable and practical not despite, but because of the wealth of information (Härlen *et al.*, 2004, p. 25 ff). Against this backdrop, the method to be used in the project must be able to establish effective legitimacy in consumers' minds and to explain their related areas of tensions and contradictions. In this way the factors which impact perception of the object nanotechnology can be accurately identified.

- The factors which determine the perception, processing and use of information are shaped to a large degree by the respective level of information. In order to record the different types and specificities of the subject, a method must be found which explains the specifically psychological aspects of nanotechnology that affect consumer behaviour and experiences.

Based on the above-mentioned requirements, a psychological research approach is one of the methods used to address the subject. The findings are compared with and supplement the results of the standardised consumer survey described in this report. Overall the project adopts a holistic approach as both methods do not exclude one another. Neither claims that it is the only sound way to research the subject. It is far more the case that this approach should be used for mutual interpretation and methodological exchange.

3 Results of the Quantitative Survey

The standardised survey referred to questions and areas of nanotechnology in which quantifications are possible and meaningful. Furthermore, it served to quantify the typical behaviours identified during the qualitative survey.

The questionnaire was drawn up in co-operation with BfR on the basis of the qualitative survey. The statements used to identify typical behaviour and the questionnaire as a whole were pre-tested for comprehensibility and content validity.[3]

Using the standardised survey, the following questions on nanotechnology were to be answered:

- How widespread is information?
- Does acceptance depend on the application area?
- How is the risk-benefit relationship perceived?
- Which information channels are important for the dissemination of knowledge?
- How important is this technology considered to be for the location Germany?
- What quantitative importance do the various forms of handling information have?

To this end, a CATI survey[4] with a random sampling scale of n=1000 was conducted during the period from September to October. The population consists of people aged between 16 and 60 who can be reached by telephone (listed in the telephone directory including mobile number) and who speak sufficiently good German in order to understand the interview. From the above-described population, a random sample was drawn up by federal state, gender and age.[5]

The frequency distributions by gender, age and education are given in Fig. 1.

The survey concept bears in mind the low level of knowledge about nanotechnology. In order to achieve robust results, a short description of the term nanotechnology was integrated at a suitable point into a short text to be read by the interviewer (Question 6). Furthermore, a question was asked about the acceptance of products using nanotechnology (Question 7). To this end, the special product characteristics and their importance for daily life were stressed (e.g. encapsulate vitamins in order to improve their impact in the body). Hence information was provided indirectly during the interview about the comprehensive possibilities of nanotechnology. The presentation of information referring to the product characteristics of relevance for the consumer helps the respondent to get to grips with the topic, nanotechnology, as can be seen from the qualitative survey. This makes it possible, despite the limited time, to include information in the interview and to activate any existing knowledge.

During the interview no information was provided about the potential risks of nanotechnology. Information in particular about “free” nanoparticles and the ensuing risks would have overly focused perception on these ideas and the related images. The qualitative survey showed that these images are so powerful that the robustness of the survey would have been very much focused on the problem of free nanoparticles and the acceptance and risk awareness of applications with bound nanoparticles could no longer have been reliably determined. It seems justifiable to leave aside the problem of the free nanoparticles seems to be justifiable

[3] The pre-test on the typical forms of behaviour was done as a short survey of 30 people to whom a list of statements about various-type-related items was read on the telephone or following a group discussion. The first version of the questionnaires was tested by the field institutes prior to their actual use for comprehensibility, consistency of questionnaire design and time taken to complete it.

[4] CATI: Computer Assisted Telephone Interviewing

[5] The Product + Markt GmbH & Co KG Institute was commissioned to carry out the survey.

above all because the information needed to estimate the possible developments in opinions could be obtained from the qualitative survey.

Fig. 1: Frequency distribution of socio-demographic characteristics in the random sample

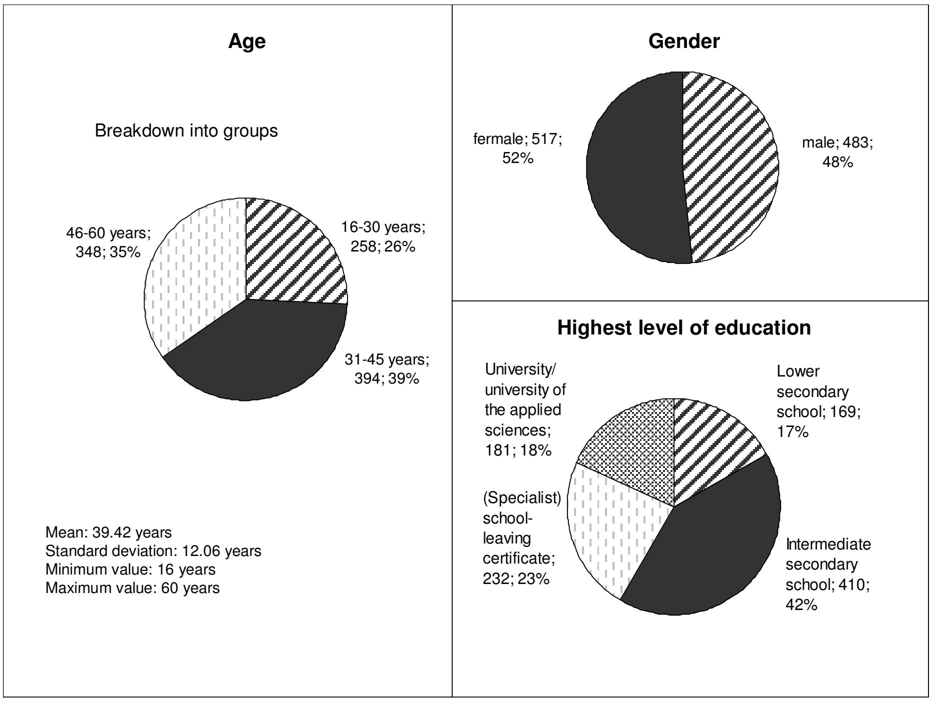


Table 1 gives the distribution of respondents in the federal states.

Table 1: Distribution of the random sample in the federal states

Schleswig-Holstein	3.3 %
Hamburg	2.1 %
Lower Saxony	9.6 %
Bremen	0.8 %
North Rhine-Westphalia	22.0 %
Hesse	7.4 %
Rhineland-Palatinate	5.0 %
Baden-Württemberg	12.7 %
Bavaria	14.7 %
Saarland	1.3 %
Berlin	3.9 %
Brandenburg	2.8 %
Mecklenburg-Western Pomerania	2.3 %
Saxony	5.5 %
Saxony-Anhalt	3.5 %
Thuringia	3.1 %

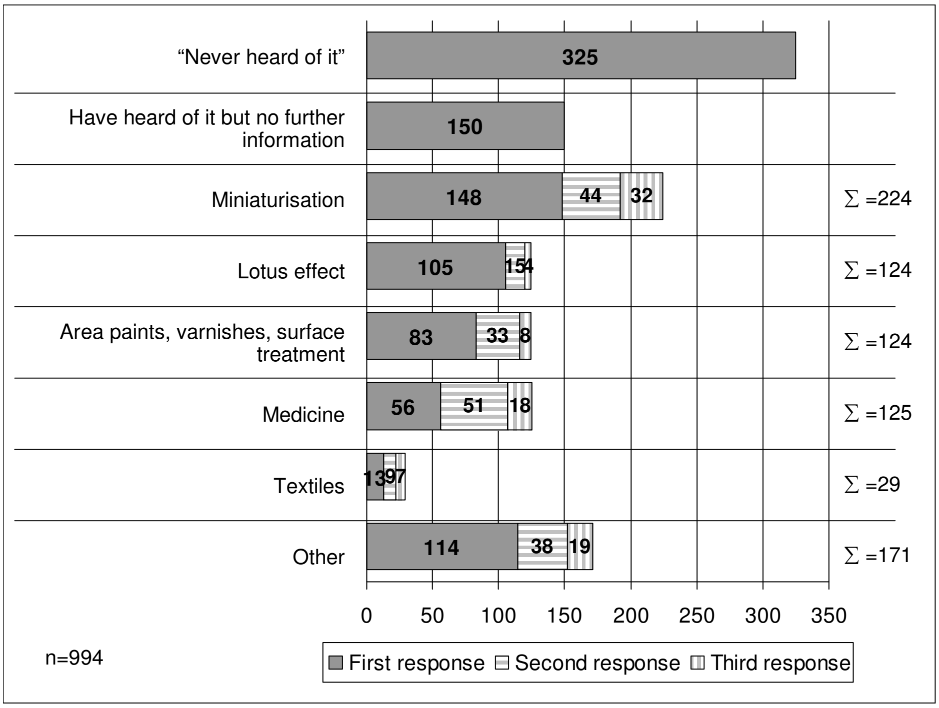
The questionnaire is attached in the annex to this report. The survey results are broken down according to the above-mentioned questions. The survey results of importance for the overall situation have been processed and integrated into the text part of this report. Detailed information is contained in the annex to the report and reference is made to this at the respective points in the text. This procedure was chosen as a compromise in order, firstly, to make this report easier to read and, secondly, to include the available information in the report.

When assessing the survey significant associations were identified and earmarked between variables. When assessing the importance of significant results with regard to a segmentation of respondents, attention is however drawn to the fact that the aim of this segmentation is to create homogeneous and heterogeneous groups. Significant differences between the groups are a necessary but not sufficient condition for this because small differences between the groups considered can already be significant in the case of a large random sample.

3.1 Dissemination of knowledge about nanotechnology

The analysis of knowledge about nanotechnology was introduced by an unprompted question (Question 5) and by the question "How much have you already heard about nanotechnology? (Question 6). Furthermore, the level of knowledge was examined compared with knowledge of other technologies (Question 11). The results show the following associations (Fig. 2):

Fig. 2: Unprompted responses to the terms nanotechnology or nanomaterials (Question 5)



For approximately 50 % of the respondents, the terms nanotechnology or nanomaterials did not mean anything at all or anything concrete. The other 50 % have, at least, more comprehensive ideas and can further specify the term (Fig. 2).

The specifications are concentrated on the categories "miniaturisation" and "surface treatment". Approximately 10 % mentioned the lotus effect, whereby its importance in the perception of nanotechnology is underlined. No statements were made about function (Fig. 2). This confirms the results of the qualitative survey about getting to grips with the subject which is done almost exclusively on the product level or through ideas about the miniaturisation of otherwise similar products.

Compared to the surveys from 2000 (KOMM.PASSION, 2004), awareness of the term has increased considerably. The question in the 2004 survey was, "Has the term "nanotechnology" cropped up frequently in recent times? Have you already heard of the term and, if so, what springs to mind?" The published results are classified in the following categories: (1) Unknown, (2) Known without any specifications and (3) Known with specifications. As the answers from the 2007 survey can be classified in these categories, the development in awareness can be identified by comparing the results (Table 2). By contrast, the results of the socio-economic panel (SOEP) from 2006 (ROSENBLADT 2007) can only be compared with those from 2007 to a limited degree. In the panel the question about familiarity with nanotechnology is formulated as follows: "Do you know or do you use nanotechnology products?" The responses to this question are classified as follows: (1) No responses, (2) Vague knowledge and (3) Sound knowledge. The formulation of the question differs considerably from that in the 2007 survey. However, what is noticeable in the case of the SOEP is that the responses on the subject of nanotechnology mainly refer to miniaturisation (49 % of the responses) and to the lotus effect or to surfaces and cleaning (12 % of the responses, see Table 2).

Table 2: Comparison of the results from the surveys in 2004 up to 2007 concerning familiarity with the concept nanotechnology

<table>
<tr><th></th><th>Sept. 2004
n=1019
(komm.passion)
(%)</th><th>Sept./Oct. 2007
n=1000
(BfR 2007)
(%)</th><th></th><th>2006. n=1063
(Rosenbladt et al.,
2007, p.676)
(%)</th></tr>
<tr><td>Term unknown</td><td>48</td><td>33</td><td rowspan="2">No responses on the term nanotechnology</td><td rowspan="2">64</td></tr>
<tr><td>Known without specifications</td><td>30</td><td>15</td></tr>
<tr><td rowspan="2">Known with specifications</td><td rowspan="2">15</td><td rowspan="2">52</td><td>Vague knowledge</td><td>22</td></tr>
<tr><td>Sound knowledge</td><td>14</td></tr>
</table>

In response to the closed question about the amount of information, around 10 % of the respondents stated that they had heard a great deal about nanotechnology. 68 % and 23 % had heard something or nothing at all respectively (Fig. 3). Here the percentages differed significantly depending on gender (p-value[6]: 0.000) and education (p-value: 0.000) (cf. Annex Fig. 36): The proportion of women who had already heard a great deal about nanotechnology is far smaller than that of men (4 % compared with 13 %); the proportion of those who had still not heard anything at all was far larger (30 % compared with 16 %). As the level of education increased, the proportion of those who had still not heard anything about nanotechnology fell.

Compared with other technologies less than 10 % of respondents feel that they are better informed about nanotechnology; approximately two-thirds believe they are less well informed (Fig. 3, below). This shows that there is awareness about the low level of information and that this is perceived above all in comparison to other technologies. No significant differences were observed depending on gender, age or education (Fig. 4). This is one indication that the differences identified in the upper part of Fig. 3 cannot be specifically attributed to nanotechnology alone but also to the general level of information about technology.

When comparing these results with results from other studies, attention should be paid to the exact question asked. In the analysis carried out a question was asked about how the respondents had **heard** about nanotechnology. This corresponds to the method of COBB & MACOUBRIE (USA, March/April 2004, n=1,536), who asked the following question: "How much have you heard about nanotechnology before today? Have you heard a lot, some, just a little, or nothing at all?" They indicate the following proportions for the individual response categories: "heard some" or "a lot" (16 %), "heard a little" (32 %) and "heard nothing" (52 %). When classifying the results, attention should be paid, in addition to the different population, to the different survey times which means that the differences cannot be clearly attributed to intercultural differences or to an increase in the spread of information about nanotechnology.

[6] The "p-value" is the result of a significance test to examine a previously advanced hypothesis (null hypothesis). If the p-value is smaller than the previously selected significance level (error level) α, then the result is deemed to be statistically significant.

Fig. 3: Estimation of the scale of already perceived information about nanotechnology (Question 6) and estimation of the level of information on nanotechnology compared with other technologies (Question 11)

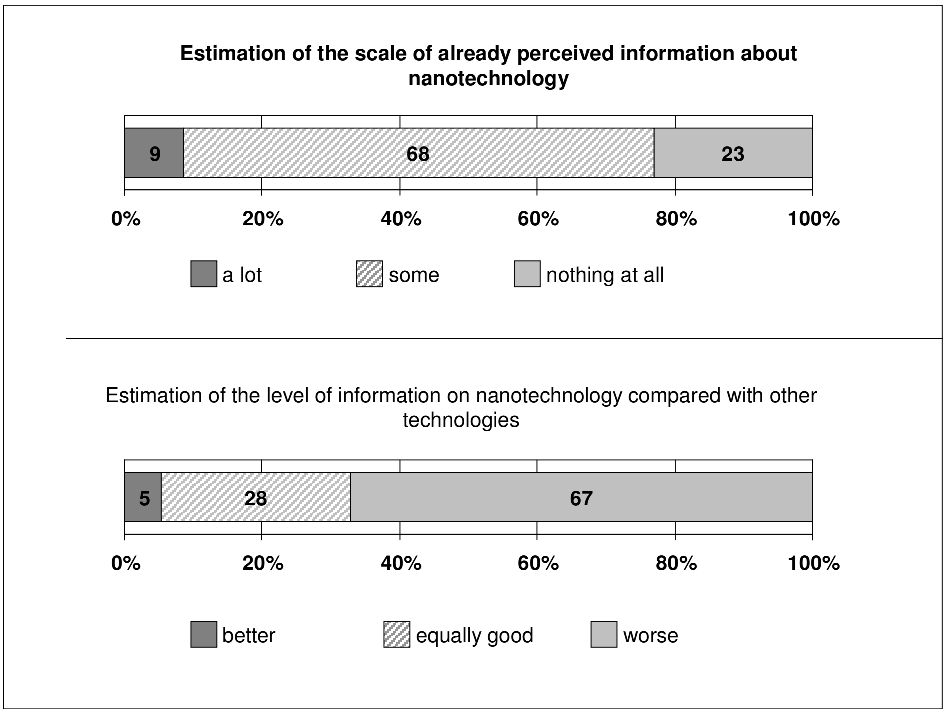
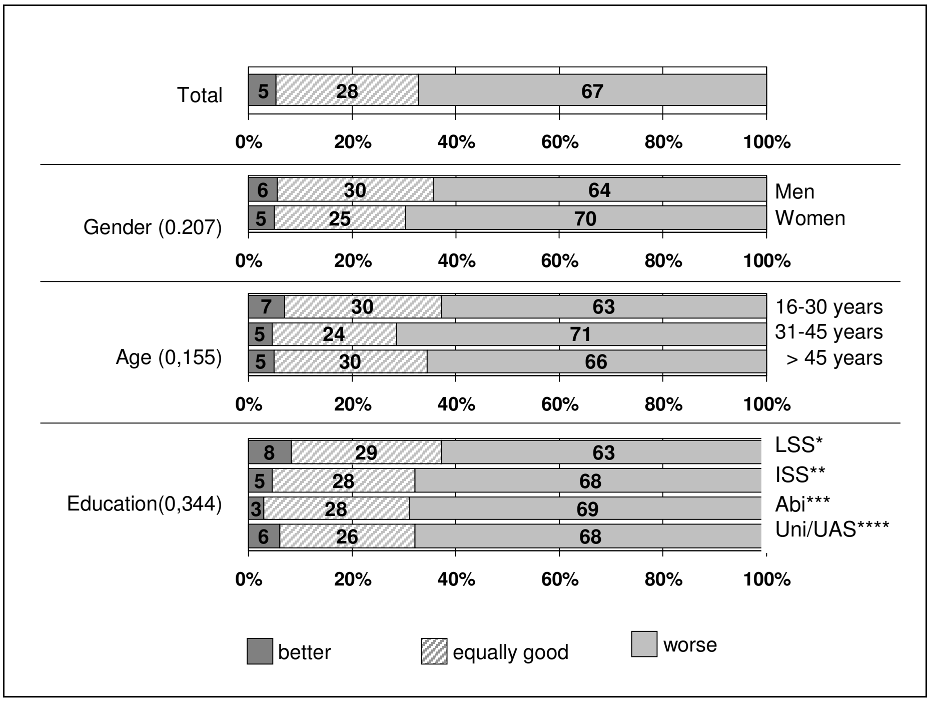


Fig. 4: Estimation of the level of information compared with other technologies (Question 11) depending on gender, age and education



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

* Lower secondary school (LSS

** Intermediate secondary school (ISS)

*** (Spezialist) school-leaving certificate (Abi)

**** University/university of the applied sciences (Uni/UAS)

KAHAN *et al*. (USA, December 2006, n=1,500) ask in their study about **knowledge** about nanotechnology and come to the following conclusions: “know nothing at all”: 53 %, “know just a little”(28 %), “know some” (14 %), “know a lot” (5 %). Given the differing questions put, no direct comparison is possible.

The Eurobarometer survey 64.3 (GASKELL *et al*., 2006, P. 15 ff) also provides findings on the dissemination of information about different technologies. It reveals that the dissemination of information about “genetically modified foods” (GM foods) is far greater than about nanotechnology. This applies both to the European Union overall and to the individual Member States. The comparatively low presence of nanotechnology in public debate supports the hypothesis that this technology is less controversial.

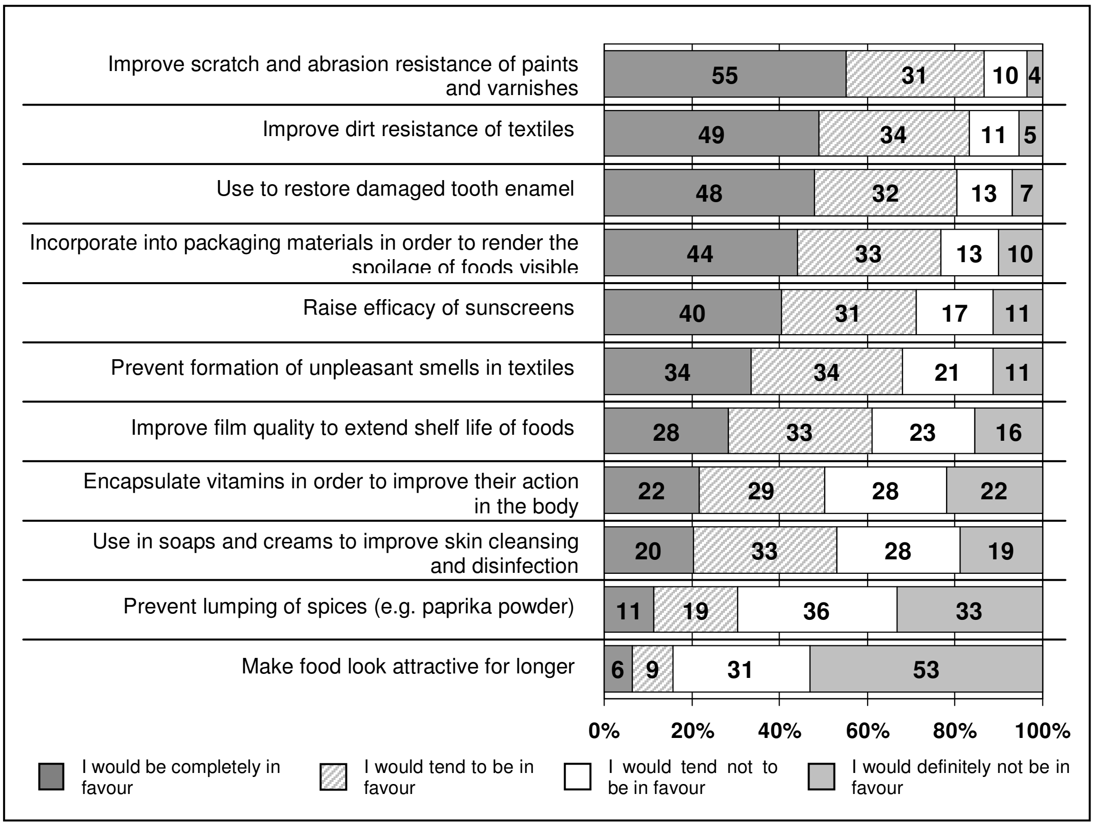
3.2 Acceptance of nanotechnology depending on the applications

In order to analyse the acceptance of nanotechnology, questions were asked about acceptance or rejection of applications of direct relevance for consumers through the use of corresponding products (Question 7). The questions were concretised along the lines that they identified the possible benefits of nanotechnology. A list (“Delphi theories”[7]) drawn up by BfR in conjunction with a Delphi survey of scientists served as the basis. As the number of possible questions is limited, only some of the possible applications could be considered in the questionnaire. Here, care was taken to ensure that the applications represent differing qualities of experience from the psychological angle.

Furthermore, the respondents were asked to decide whether they would buy products from the different product groups (Question 10). For the characterisation of the results, the following points are important (Fig. 5):

[7] See BfR Delphi survey, published in Zimmer *et al.* (2008b)

Fig. 5: Acceptance of the use of nanotechnology in different products (Question 7)



Surface sealing products have the highest level of acceptance. The proportion of respondents who reject a corresponding application is between 15 % and 20 %; the proportion of those who completely reject an application of this kind is far lower than 10 %. This also applies to the repair of dental enamel, an application which can be qualified as surface sealing in the medical area.

The acceptance of products that come into contact with the skin varies considerably. As there is no major difference between sun protection creams and creams to improve the disinfection and cleaning of the skin when it comes to the perception of risks, considerations of benefits seem to influence the differing levels of acceptance.[8]

Acceptance is lowest for foods. The differences within this area can be attributed to various reasons: acceptance is greater in the case of food packaging than in the case of an application which leads directly to a change in the food. Furthermore, benefit considerations seem to play a role. The differing acceptance of nanotechnology when it comes to encapsulating vitamins and improving the appearance of food seems to point in this direction.

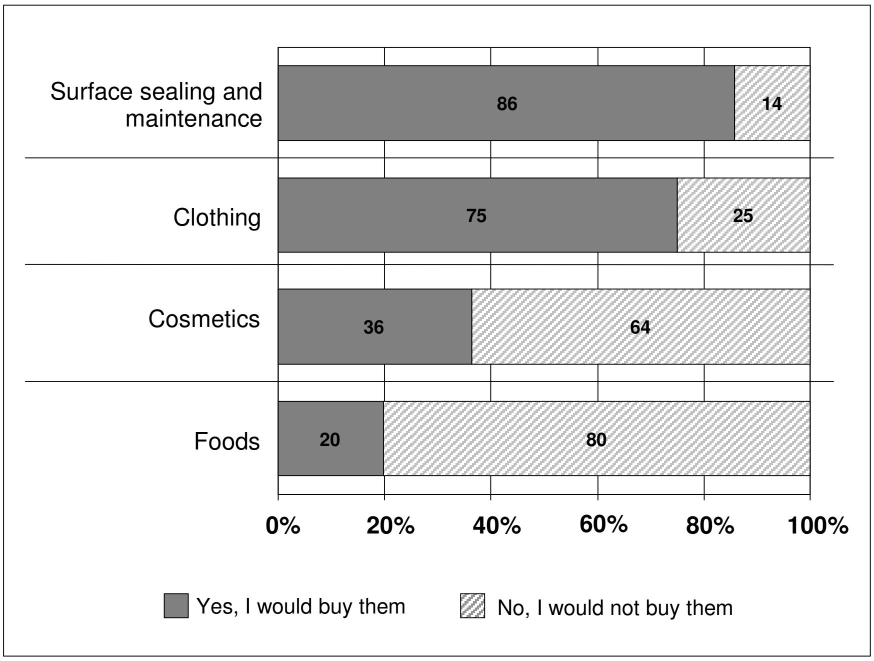
There are gender-specific differences. The acceptance of nanotechnology is generally higher amongst men than amongst women (cf. Annex, Fig. 37 and 40 and the p-values contained in the figures). The statistically significant differences often only amount to a few percentage points. The average value for the frequency with which the individual respondents choose “I would completely endorse it” out of the total eleven applications is 3.9 for men and 3.2 for women. Hence, acceptance is clearly associated to gender but not determined by this. The differences depending on applications are far greater.

[8] If there is a difference in risk perception, then this probably has more to do with the fact that sun protection cream is classified as more risky because it remains for longer on the skin than soap.

When it comes to age and education the trends are not as clear as they are for gender (cf. Annex, Fig. 38 - 42). In the case of individual applications there are statistically significant differences which result from the p-values in the figures. These differences, too, are restricted as a rule to a few percentage points. Based on the average value for the frequency of the response "I would completely endorse it", acceptance declines with increasing age and education level.

The differing levels of acceptance depending on product groups is clear if questions are not asked on the level of individual products and specific properties but in a general way about the respective product areas. This was the case for the question about willingness to purchase. The results show clear differences. What is noticeable is that overall acceptance falls considerably, the closer the products come to or enter the body, i.e. the more they are perceived to be "worrying" (Fig. 6).

Fig. 6: Willingness to purchase nanoproducts in various product groups (Question 10)



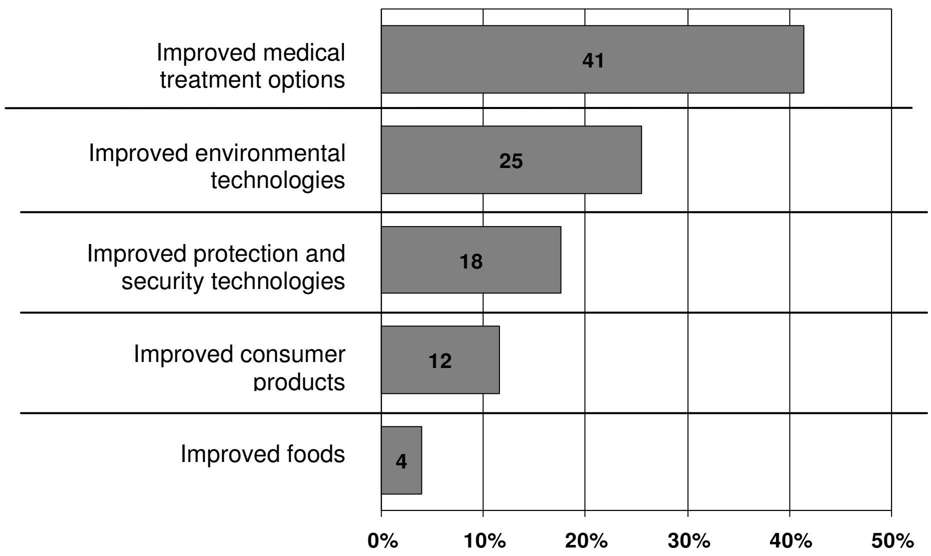
Significant differences in the acceptance of product groups are revealed for gender and age whereby men and the age group of 16 – 30-year olds demonstrate a greater willingness to buy (cf. Annex, Fig. 44 – 46 and the p-values listed there).

Question 9 drew attention to further nanotechnology applications. The respondents were asked to select the five applications which they thought would offer the greatest benefits.

These results show that great benefits are not seen in the case of products used directly by consumers, but rather in the areas of medicine and environmental engineering (Fig. 7).[9] Consumer products do help to depict developments and to acquire personal experience. However, the resulting benefits from this technology are deemed to be relatively small. These answers are compatible with the hope observed in the qualitative survey that nanotechnology can help to solve urgent problems of mankind.

[9] Information technology was not included because here it is not possible to clearly differentiate the extent to which information technology refers for the individual respondents to consumer products (PCs, navigation systems) or to only directly usable developments for consumers (networking of information systems).

Fig. 7: Estimation of the benefits of nanotechnology in different applications (Question 9)



In the case of the age groups there are only significant differences (p-value 0.006, cf. Annex, Fig. 46 – 49) in the assessment of the benefits of nanotechnology in different applications. This can be attributed above all to the fact that the application, environmental technologies, was mentioned far less frequently by the 16 – 30-year olds than by other age groups.

3.3 Estimation of risks and benefits

The estimation of the risk-benefit relationship was determined through a direct question (Question 8) and through a question about the overall feeling about nanotechnology (Question 15). The question about the overall feeling takes into account above all the emotional components in risk assessment.[10] In addition, a question was asked about trust in the effectiveness of state risk policy because this trust is deemed to be the determining factor for risk perception.

The evaluations of these two questions 8 and 15 underline the overall positive attitude towards nanotechnology (Fig 8 and 9).

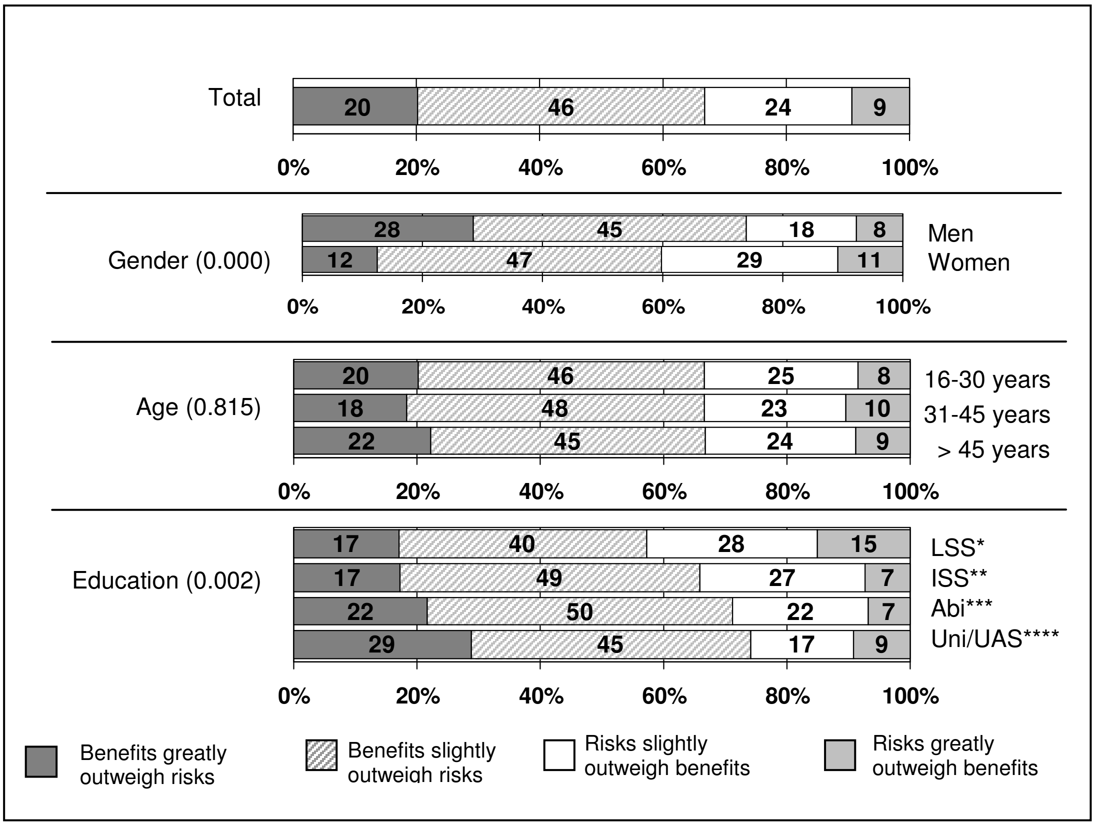
For about two-thirds of the respondents the benefits of nanotechnology appear to outweigh the risks. There are significant differences in the estimation by gender (p-value 0.000) and by education (p-value 0.002). But in the other groups, too, with a comparably higher risk assessment, the proportion of those who deem the benefits to outweigh the risks is at least 57 %. Using the common, socio-demographic categories, no group can be identified which completely rejects nanotechnology.

The socio-economic panel (SOEP) also contains results on the risk-benefit relationship. These results considerably deviate from those of the BfR 2007 survey (ROSENBLADT *et al.*, 2007, p. 676). This is mainly due to the fact that in the SOEP a 5-category scale and in the BfR survey a 4-category scale was used to assess the risk-benefit relationship. A 5-category

[10] Cf. Above all Kahan et al. (2007) and the references mentioned there about the importance of this component and operationalism.

scale gives respondents the option of not deciding – i.e. to select the middle answer category. In the case of a 4-category scale respondents are forced to take a decision. Approximately one-quarter of the respondents selected the middle answer category in SOEP. Furthermore, the proportion of those who did not respond was approximately 40 %. Aside from these differences, the positive assessment of nanotechnology was the predominant response in SOEP (cf. Table 3).

Fig. 8: Assessment of the risk-benefit relationship of nanotechnology (Question 8)



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

* Lower secondary school (LSS
** Intermediate secondary school (ISS)
*** (Spezialist) school-leaving certificate (Abi)
**** University/university of the applied sciences (Uni/UAS)

Table 3: Results of the socio-economic panel on the subjective assessment of the opportunities and risks of nanotechnology (5-category scale ranging from "Opportunities prevail" to "Risks prevail")

(1) Opportunities prevail	12 %
(2)	14 %
(3)	26 %
(4)	6 %
(5) Risks prevail	3 %
No data	40 %

Source: Rosenbladt *et al.*, 2007, p. 676. The results are merely depicted as a column without any wording in the source. However, the values can be derived with sufficient accuracy from the height of the columns.

In the study on knowledge about and on attitudes towards nanotechnology in Germany from 2004 (KOMM.PASSION), questions were only asked about the risk, not about the weighing up of risks and benefits, whereas on a 10-category scale, a differentiation could be made between subjective assessment "no risk at all" and "a very high risk". In this survey, too, the mean response categories were prevalent (cf. Table 4), which meant that the authors came to the conclusion that the Germans have not yet made up their minds about nanotechnology. What is also characteristic is that approximately one-third did not respond to this question. Besides estimating the risk of nanotechnology, the subject of this survey was also risk perception of incineration technology, nuclear energy and genetic engineering. It was revealed that the risk of nanotechnology was estimated to be far lower, particularly compared to genetic engineering and nuclear energy.

Table 4: Results of the komm.passion study on the estimation of risks of nanotechnology (10-category scale ranging from "No risk at all" to "Very high risk")

(1) No risk at all	19 %
(2)	
(3)	
(4)	37 %
(5)	
(6)	
(7)	
(8)	10 %
(9)	
(10) Very high risk	
No response	34 %

Source: KOMM.PASSION, 2004, p. 66. No detailed frequency distribution was published.

Taking into account the other surveys, the overall observation is that nanotechnology is perceived in a positive way. The proportion of those who see a major risk is small, particularly in comparison to genetic engineering and nuclear energy.

Similar statements can also be made concerning the general feeling about nanotechnology (cf. Fig. 9). Just over 20 % had a bad or very bad feeling. There are significant differences in terms of gender (p-value 0.000), age (p-value 0.030) and education (p-value 0.007).

Both the estimation of the risk and the general feeling about nanotechnology are linked to the level of information on the subject (cf. Fig. and Annex, Fig. 43 and the p-values presented in the figures). There are two possible explanations: (1) Knowledge leads to a more positive attitude towards nanotechnology or (2) People with a positive attitude towards nanotechnology are more inclined to acquire knowledge. Based on an experiment on the impact of information, KAHAN *et al.* come to conclusions that support the second interpretation of the association between knowledge and attitudes towards nanotechnology (KAHAN *et al.* 2007, P. 29).

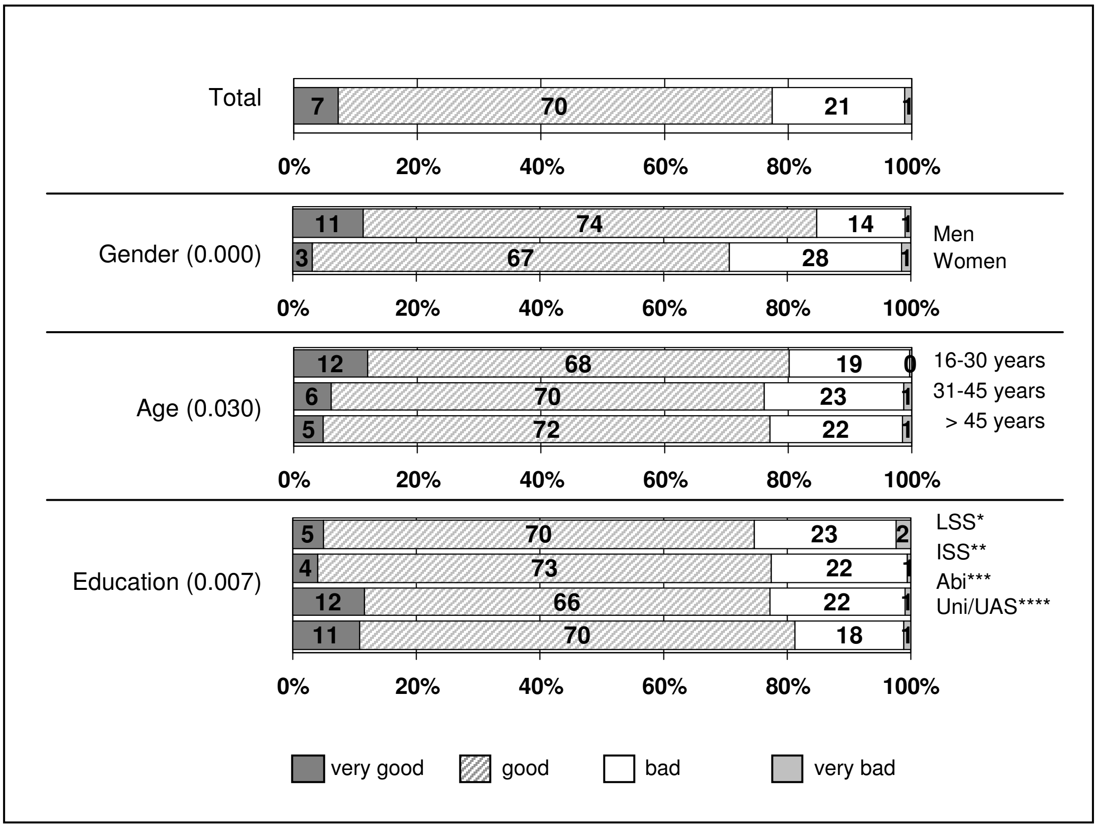
The minor contribution by sociodemography to explaining risk perception is highlighted by the regression calculations with the estimation of the risk-benefit relationship and the general feeling about nanotechnology as an independent variable. The degree to which the socio-demographic variables help to explain this is limited overall with a corrected co-efficient of determination of 0.053 and 0.050 (Table 5). The influence of gender and education is significant whereby women and respondents with a lower level of education estimate the risks to be higher than the benefits and generally have a worse feeling.

There is a small, statistically significant association (cf. g. Fig 11 and 12 the p-values given there) between the willingness to buy nanoproducts from various areas on the one hand, and the estimation of the risk-benefit relationship of nanotechnology and the general feeling about nanotechnology on the other.

Here there seems to be greater differentiation in the general feeling about nanotechnology than in the explicit assessment of the risk-benefit relationship. This, too, points to a judgement and decisions which result from rather diffuse ideas. Nevertheless, the general system for assessing decisions about purchasing behaviour retains its importance. Both the explicit and the emotional risk assessments merely contribute to differentiation within this system; they do not at all cancel the effect.

Based on the results of the qualitative survey, an estimate of this kind is not based on detailed knowledge of how technology works, but on an attitude shaped by hopes and expectations. Furthermore, attention must again be drawn in conjunction with the interpretation of the results to the fact that potential risks of free nanoparticles associated with high impact images were not mentioned in this survey. Hence the results tend to give rather a snapshot under specific conditions rather than to reflect a stable attitude towards nanotechnology.

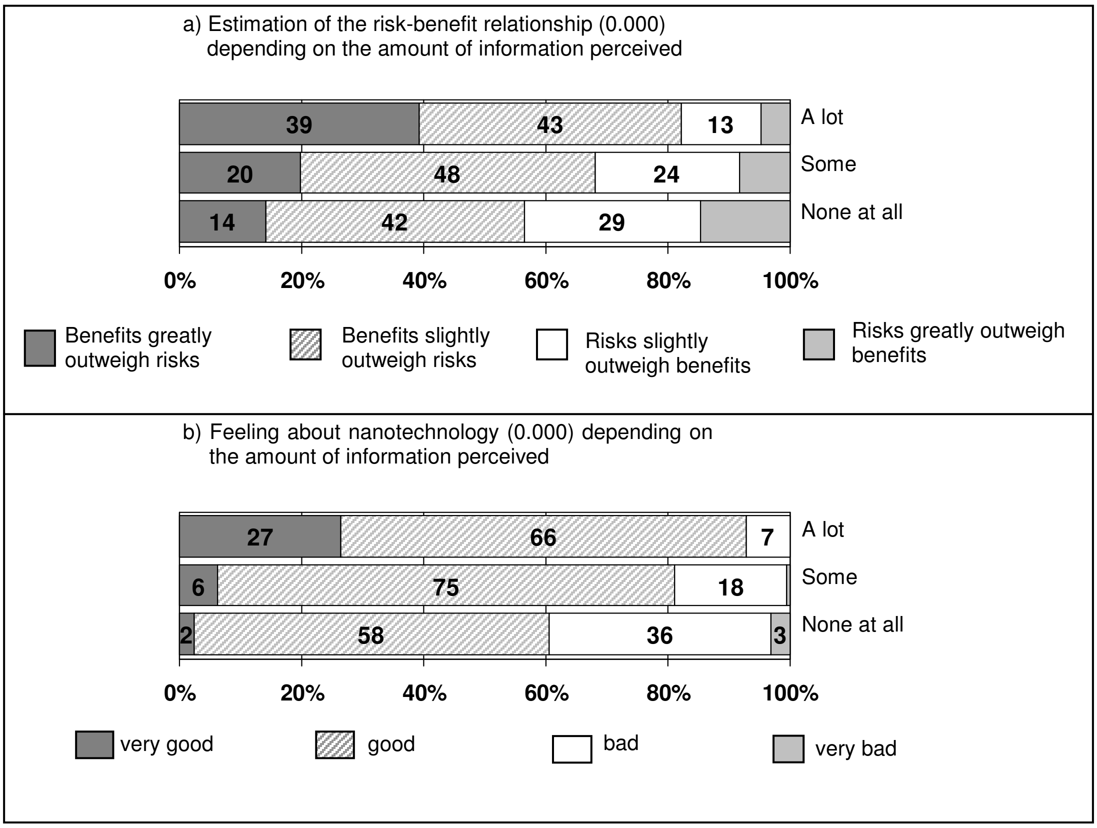
Fig. 9: Overall feeling about nanotechnology (Question 15)



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson.

* Lower secondary school (LSS
** Intermediate secondary school (ISS)
*** (Spezialist) school-leaving certificate (Abi)
**** University/university of the applied sciences (Uni/UAS)

Fig. 10: Estimation of the relationship between a) risks and benefits of nanotechnology (Question 8 with the response categories “Benefits greatly outweigh risks”, “Benefits slightly outweigh risks”, “Risks slightly outweigh benefits”, “Risks greatly outweigh benefits”) and b) overall feeling about nanotechnology (Question 15 with the response categories “Very good”, “Good”, “Poor”, “Very poor”) depending on the amount of information perceived (Question 6 with the response categories “A great deal”, “Some”, “None at all”)



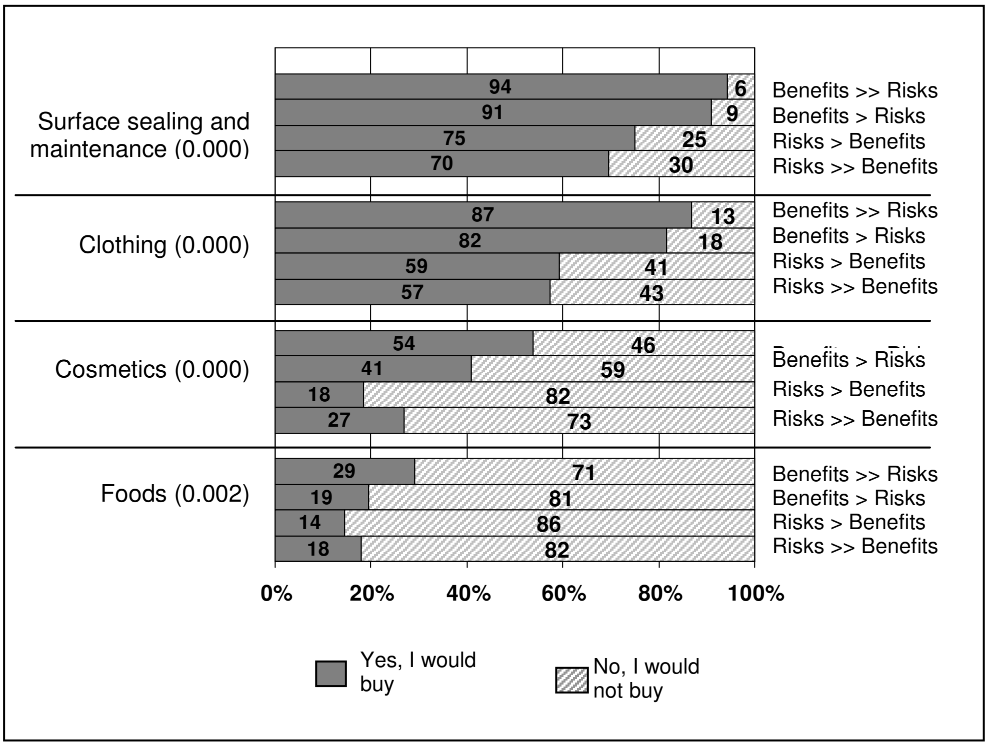
Values in brackets: 2-sided asymptotic significance (p=values) of the chi-square test according to Pearson

Table 5: Results of regression calculations[11] concerning the influence of socio-demographic variables on the estimation of the risk-benefit relationship of nanotechnology (Question 8) and the general feeling about nanotechnology (Question 15)

	Dependent variable: Risk-benefit relationship[12]		Dependent variable: General feeling about nanotechnology[12]	
	Regression coefficients	p-value	Regression coefficients	p-value
Constant	2.285	0.000	2.134	0.000
Gender[13]	0.332	0.000	0.231	0.000
Education	-0.104	0.000	-0.042	0.018
Age	-0.002	0.311	0.001	0.349
Income	0.037	0.105	-0.015	0.299
Corrected R^2		0.053		0.050

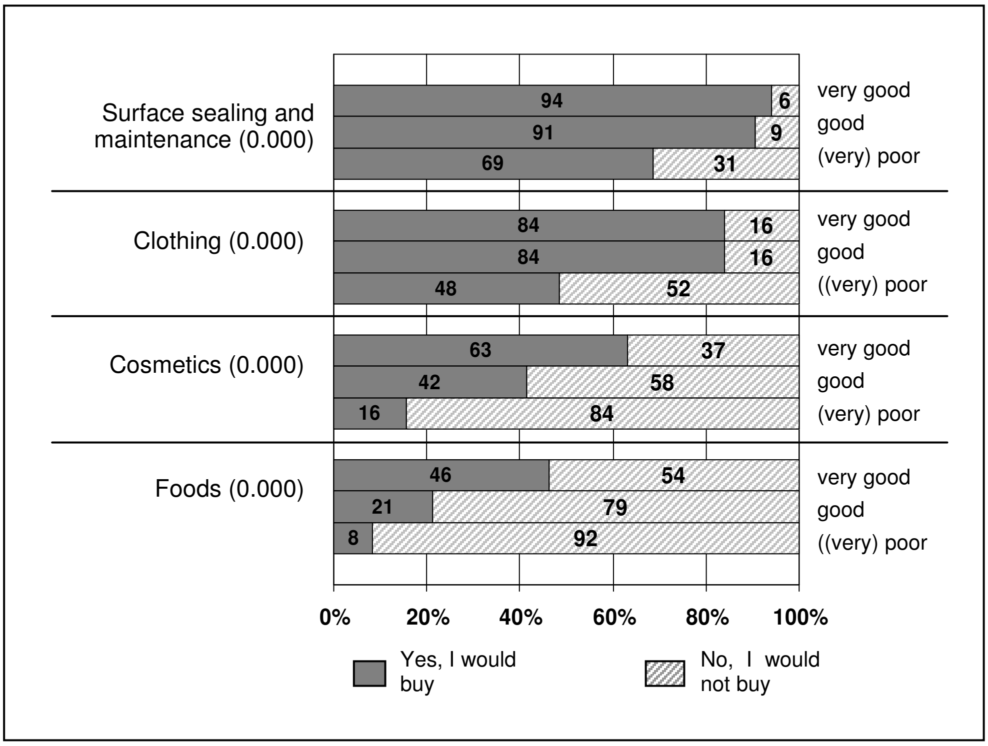
[11] Linear regression, smallest square estimate.
[12] The dependent variables are coded in such a way that higher values show a greater importance of benefits compared with risks and a worse feeling about nanotechnology.
[13] Coding: Men = 0, Women= 1, positive signs indicate that women consider the risk to be higher and have a worse feeling.

Fig. 11: Willingness to buy nanoproducts in various product groups (Question 10) depending on the assessment of the risk-benefit relationship of nanotechnology (Question 8)



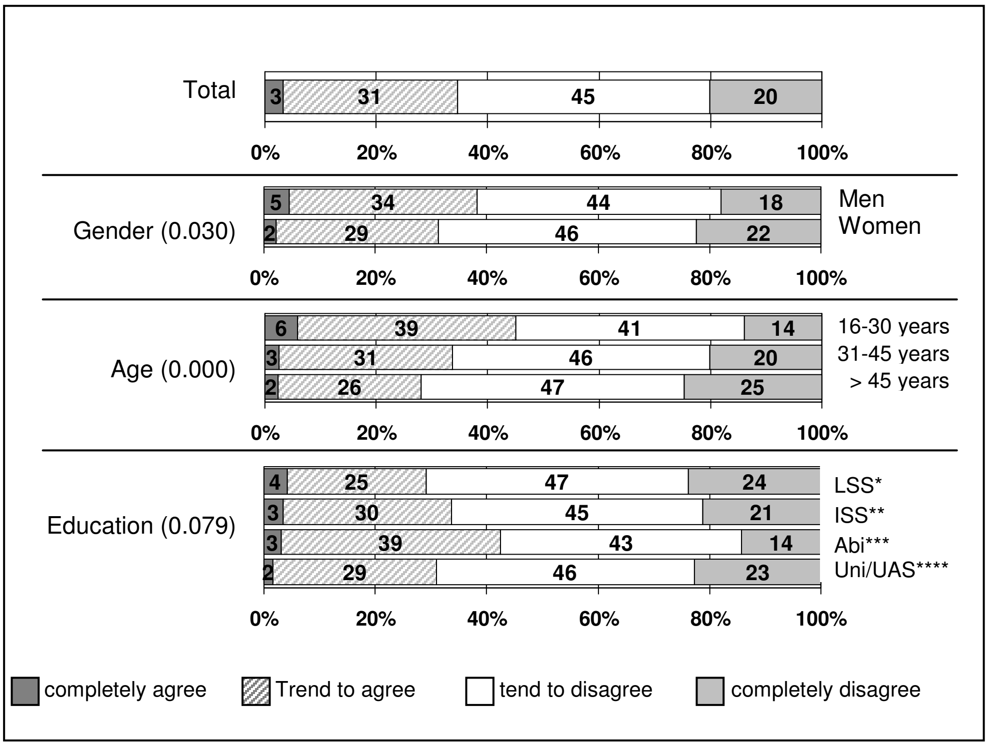
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 12: Willingness to buy nanoproducts in different product groups (Question 10 with response categories “Yes, I would buy”, “No, I would not buy”) depending on the general feeling about nanotechnology (Question 15 with response categories “Very good”, “Good” and together “Very poor + poor”)



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 13: Agreement with the statement that the government can be trusted to protect the public from environmental and technical risks (Question 18)



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

* Lower secondary school (LSS
** Intermediate secondary school (ISS)
*** (Spezialist) school-leaving certificate (Abi)
**** University/university of the applied sciences (Uni/UAS)

The evaluation about the question of trust in the efficiency of state risk policy seems to indicate that the overall positive assessment can change dramatically in the event of reports about risks (Fig. 13).

The agreement with the statement that the government can be trusted to protect the public from environmental and technical risks is very low. As a consequence of the lack of trust in the actions of the government, feelings of powerlessness would be exacerbated and considerably change both the general feeling and the explicit assessment of the risk-benefit relationship.

3.4 Information paths to disseminate knowledge about nanotechnology

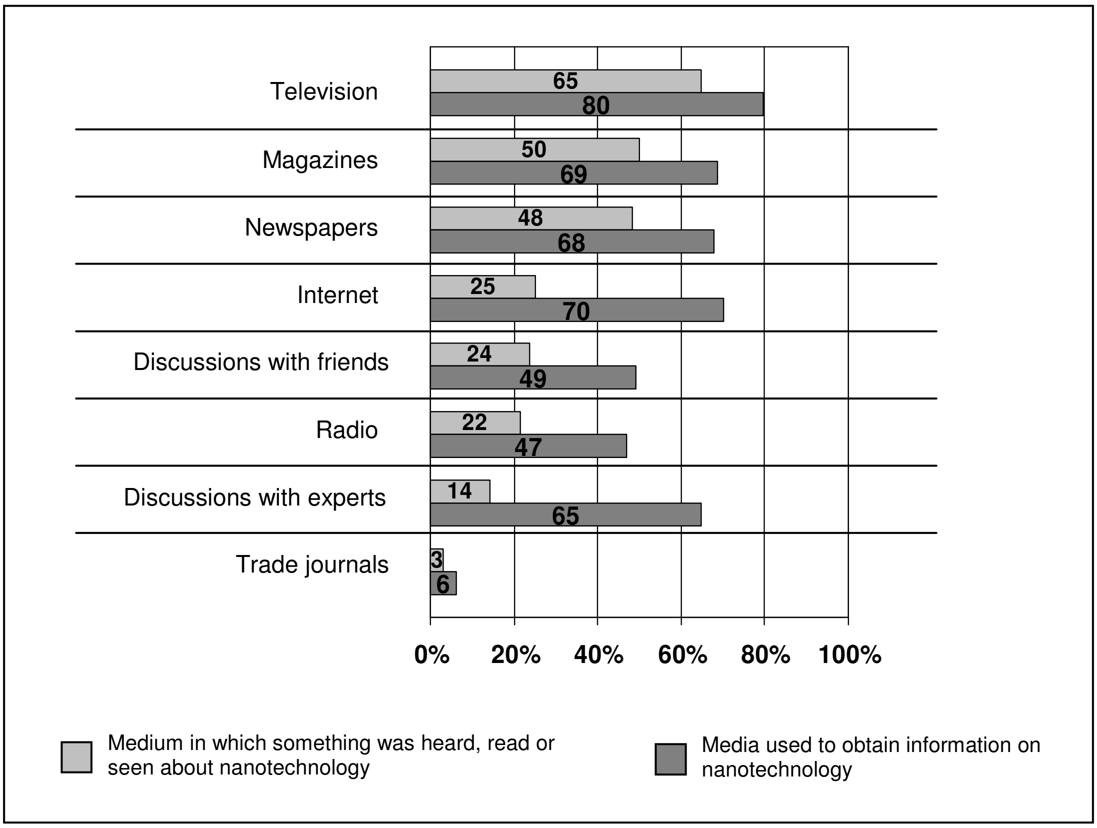
The importance of the individual media for the dissemination of knowledge up to now results from Question 12: Where have you already heard, read or seen something about nanotechnology? To answer this question, the different media were listed as possible responses which meant that the respondents only needed to answer yes or no. The results in Fig. show the major importance of television, newspapers and magazines. By contrast only approximately 25 % of respondents had found out something about nanotechnology on the Internet. This indicates that information is obtained in a more random and less targeted manner because the content of public media right down to content on the Internet can only be steered to a limited degree by the user.

There are differences in the way the media are used in respect of (cf. Annex, Fig. 50, 51 and 52)

- gender whereby all media aside from radio were mentioned significantly more frequently by men than by women.
- age whereby in the older age groups newspapers, magazines and radio play a greater role whereas the Internet is used to a relatively high degree above all by 16–30-year olds.
- education which has a significant impact on the use of print media, the Internet and discussions with experts.

Trade journals scarcely play any role at all as a source of information on nanotechnology.

Fig. 14: Importance of different media for the dissemination up to now of information on nanotechnology (Questions 12 and 13)



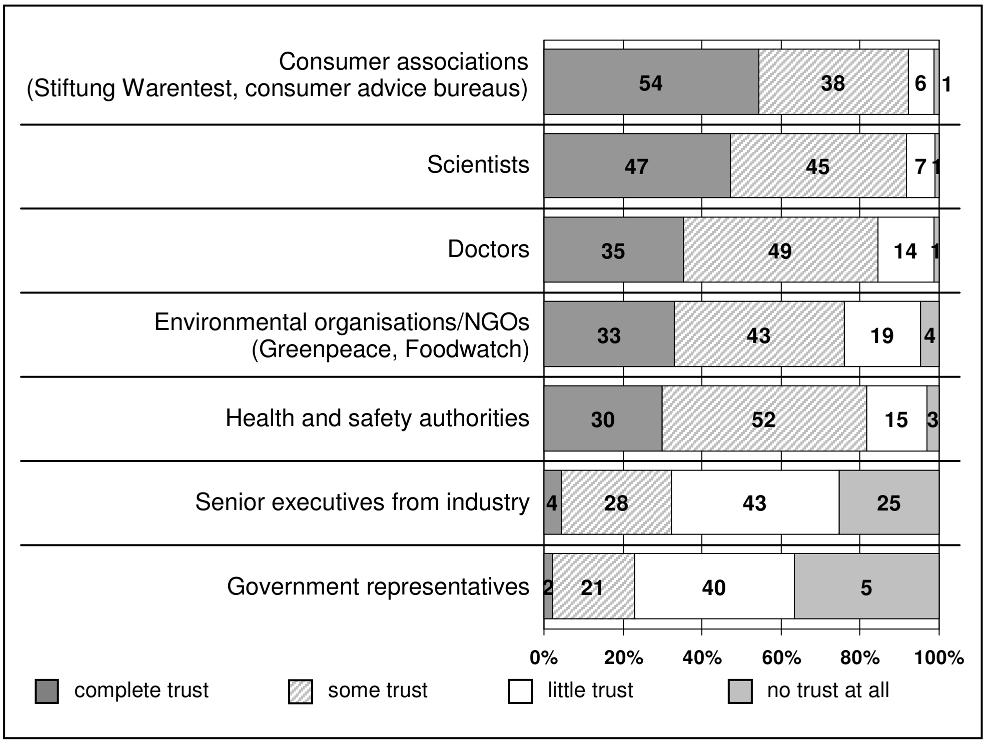
Medium in which something was heard, read or seen about nanotechnology

Based on the question whether the respondent was informed in the respective media about nanotechnology (Question 13, yes/no question), no priority can be identified for a specific medium and none of the media included can be ruled out. In the case of television, magazines and newspapers the proportion of “yes” responses is between around 70 % and 80 % (cf. Annex Fig. 53 – 55). Radio reaches approximately 50 %. Discussions with experts are particularly important. In this area, too, there are major differences above all for the Internet (gender, age, education, p-value 0.000 respectively) and for radio (age, p-value 0.000). From the results it can be concluded that no medium has to be ruled out for the dissemination of knowledge about nanotechnology.

Compared with this, there are considerable differences in the trustworthiness of groups of people and institutions (Fig. 15).

Consumer associations are in an excellent position. In the survey the terms used to describe them were "for example Stiftung Warentest or consumer advice bureaus". More than 90 % of respondents have some trust in these associations and more than 50 % have complete trust in them. Scientists have similarly high values to the consumer associations. Around one-third of participants have absolute trust in doctors, environmental organisations and health and safety authorities; around half have some trust. It should be stressed that the values of the environmental organisations are far lower than those of the consumer associations. It seems, therefore, to make sense to differentiate between the stakeholders which represent the interests of citizens. The values of senior executives from industry and government representatives are far lower than for the other groups and institutions. Not even one-third of respondents had at least some trust in industry and not even one-quarter of respondents had some trust in government representatives.

Fig. 15: Trustworthiness of groups of individuals and institutions in the dissemination of information on nanotechnology (Question 14)



The frequency distribution of the responses in the respective categories varies depending on gender, age and education (cf. Annex, Fig. 56 – 58 and the p-values given there). The differences are, however, small compared to the very major differences in some cases between the assessed groups of individuals and institutions.

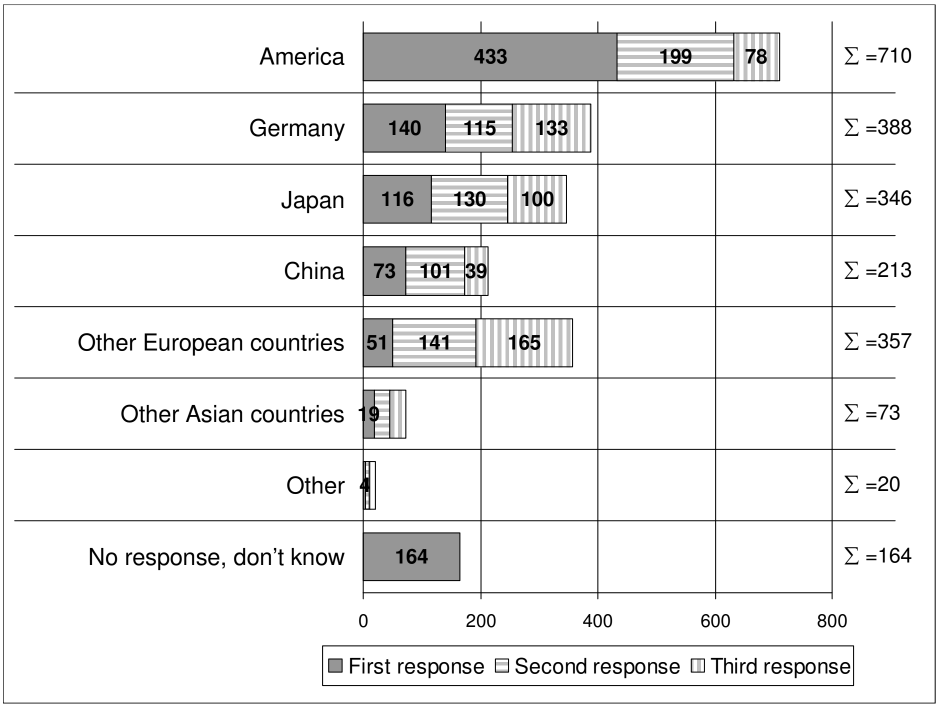
Whereas in respect of the media there are no special priorities for the dissemination of information about nanotechnology, the person providing the information is seemingly of major importance.

3.5 Importance of nanotechnology for the location Germany

40 % of the respondents deem nanotechnology to be of high importance and 40 % of medium importance for the location Germany. Only approximately 10 % rate its importance as low. USA is perceived as being the leading nation, followed by Germany on roughly the same level as Japan (Fig.). Nevertheless, approximately 40 % put Germany amongst the three leading nations for this technology. Hopes for improvements through nanotechnology are clearly spreading in the location Germany. This spread cannot, however, be generalised

on the basis of this survey. In the case of an assessment based on a very low level of knowledge, clear analogisms from the area of information technology play a role here.

Fig. 16: Estimation of the leading nanotechnology nations (Question 17)



3.6 Quantitative importance of the different forms of handling information

Seven statements were developed to quantify the forms of behaviour for handling nanotechnology (cf. Chapter 0) identified in the qualitative survey which refer to one of the forms of behaviour. Table 6 gives the classification of the statements on typical forms of behaviour.

The importance of the individual typical forms of behaviour can be derived from the agreement with these statements (Question 19). Furthermore, it was determined for each respondent which of the statements he agreed with most (Question 20). In this way the respondents can be assigned to one of the forms of behaviour.

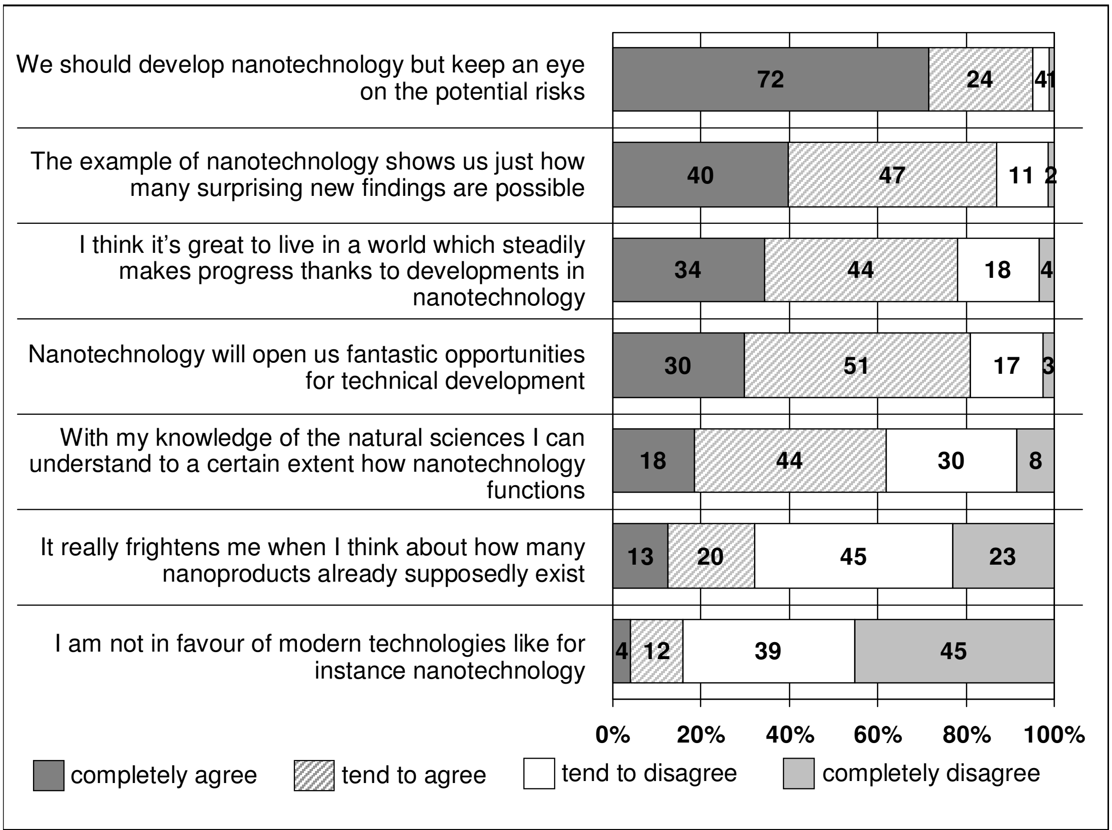
The frequency distribution of agreement with the statements is further proof of the positive attitude towards nanotechnology (Fig.). The high level of agreement with the statement "We should develop nanotechnology but keep an eye on the potential risks" should not be interpreted as meaning that there is concrete risk awareness. It is far more the case that agreement with the statement reflects the fact that there are few concrete ideas about nanotechnology but, at the same time, positive expectations.[14]

[14] By contrast, a similar statement on genetic engineering is likely to produce different values for agreement. For a direct comparison of different technologies, cf. also Gaskell *et al.* (2006), p. 15 ff.

Table 6: Classification of the statements on typical forms of behaviour

Statement	Typical behaviour
We should develop nanotechnology but keep an eye on the potential risks	Pragmatism
The example of nanotechnology shows us just how many surprising new findings are possible	Open-mindedness
I think it's great to live in a world which steadily makes progress thanks to developments like nanotechnology	Naive optimism
Nanotechnology will open up fantastic opportunities for technical development	Visions
With my knowledge of the natural sciences I can understand to a certain extent how nanotechnology functions	Science-like illustration
It really frightens me when I think about how many nanoproducts already supposedly exist	Reversal fears
I am not in favour of modern technologies like for instance nanotechnology	Rejection of progress

Fig. 17: Assessment of the statements on handling nanotechnology (Question 19)



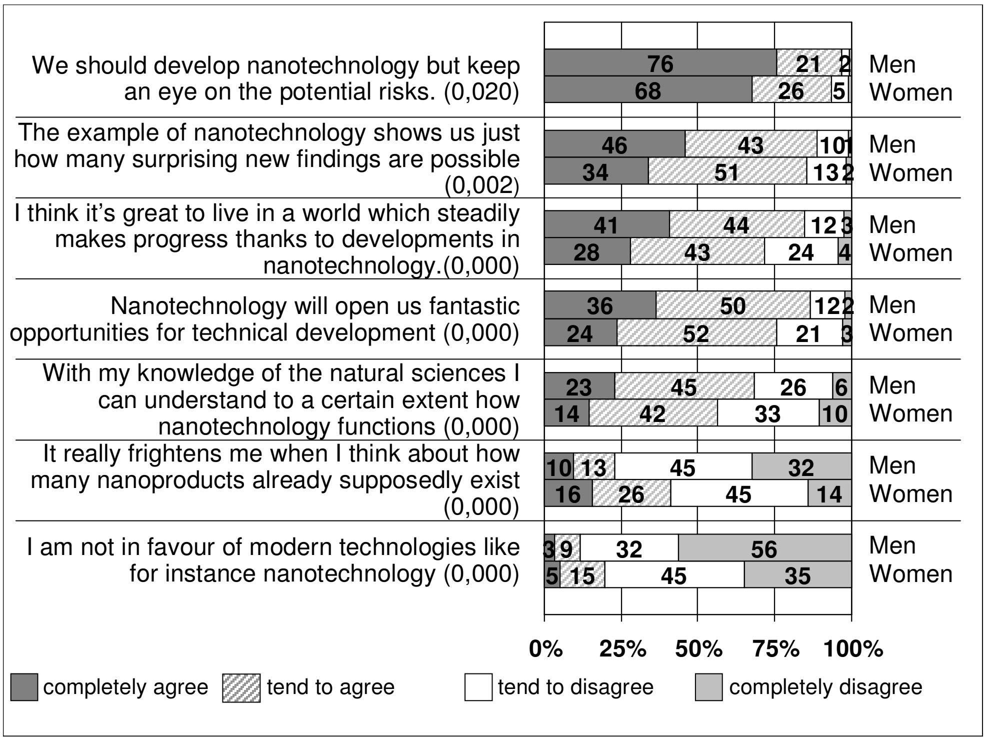
The statements that were least agreed with have to do with reversal fears and a rejection of progress. Awareness about limits to understanding is expressed in the assessment of the statement "With my knowledge of the natural sciences I can understand to a certain extent how nanotechnology functions".

There are significant differences in the assessment of the statements depending on gender, whereby a higher percentage of men agree with the statements which express hope and fascination (the first five statements) than women. The proportion of agreement with the statements on reversal fears and the rejection of progress is far higher amongst women (see Fig. 18).

In the case of age there are no major differences and in the case of education only when it comes to statements on reversal fears and the rejection of progress. Agreement decreases as the level of education increases (cf. Annex, Fig. 59 and 60 and the p-values given there).

The socio-demographic variables differ less when it comes to statements on handling nanotechnology than the differences between the statements. In the case of women, too, the statements on reversal fears and the rejection of progress attract far less agreement than the other statements; however the gap is slightly smaller than in the case of men.

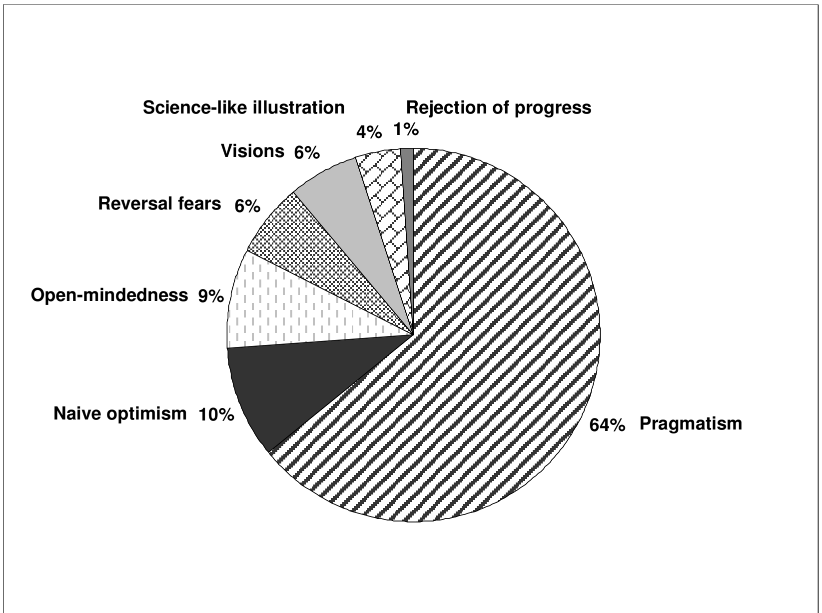
Fig. 18: Assessment of the statements on handling nanotechnology (Question 19) by gender



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

If the respondents have to decide which statement they agree with most, this leads to the distribution given in Fig. 19.

Fig. 19: Distribution of predominant types of behaviour when dealing with nanotechnology (Question 20)

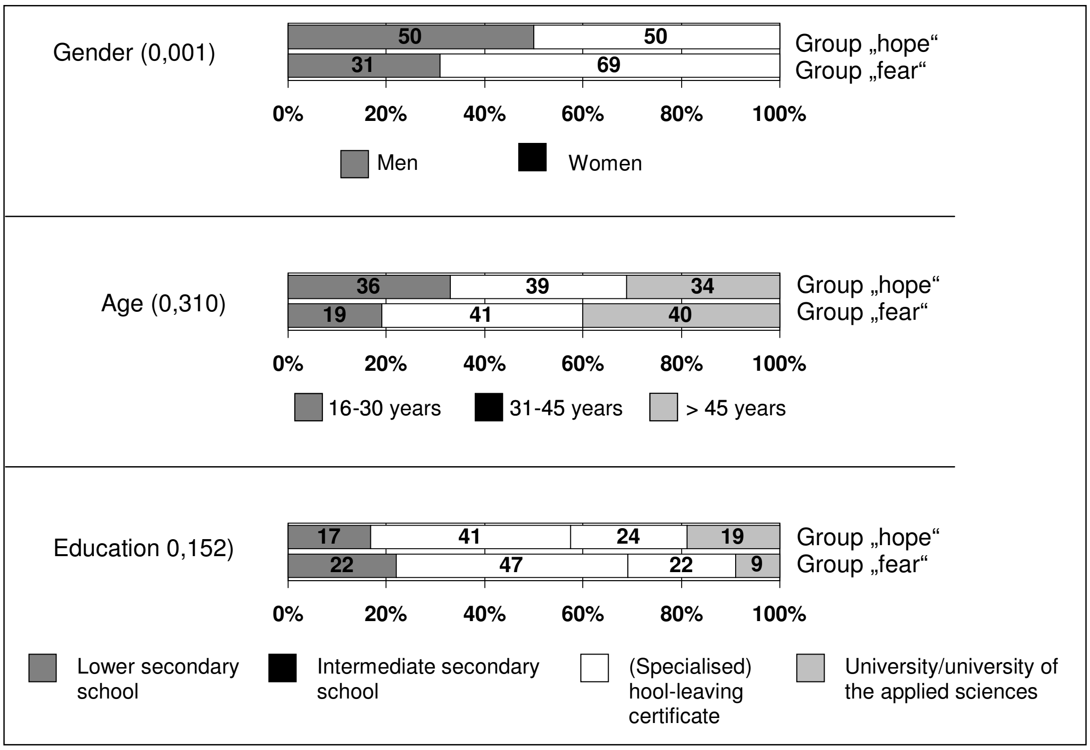


The respondents can be split into two groups depending on the types of behaviour which became apparent in the statements. The first group can be described using the label “Fear of the consequences of nanotechnology” and the second group with the label “Hopes for the success of nanotechnology”:

- The first group contains those respondents who agree most with one of the two statements: “It really frightens me when I think about how many nanoproducts are already supposedly exist” or “I am not in favour of modern technologies like for instance nanotechnology”. These two statements represent the typical forms of behaviour “reversal fears” and “rejection of progress” and stand for a rejection of nanotechnology. The share of this group in the total number of respondents is less than 10 %.
- The second group encompasses the other respondents (approximately 90 %). The characteristic feature is that they agreed most with one of the statements which deal with the hopes and fascination linked to nanotechnologies. By endorsing the statements they express overall approval of nanotechnology.

The two groups differ above all concerning the proportion of men and women. In the group “Fear of the consequences of technology” the proportion of women is far higher (Fig. 20). There are no significant differences in terms of age and education. When evaluating significance, it must be borne in mind that the group which rejects nanotechnology (n=75) is very small. Under these circumstances, the acuity of the statistical test is far lower than in comparison to a situation in which both groups are roughly of the same size.

Fig. 20: Differences between the groups “Hopes for the success of nanotechnology” and “Fear of the consequences of nanotechnology” (compilation of dominant types of behaviour when dealing with nanotechnology from Question 19) differentiated by socio-demographic characteristics (gender, age, education)

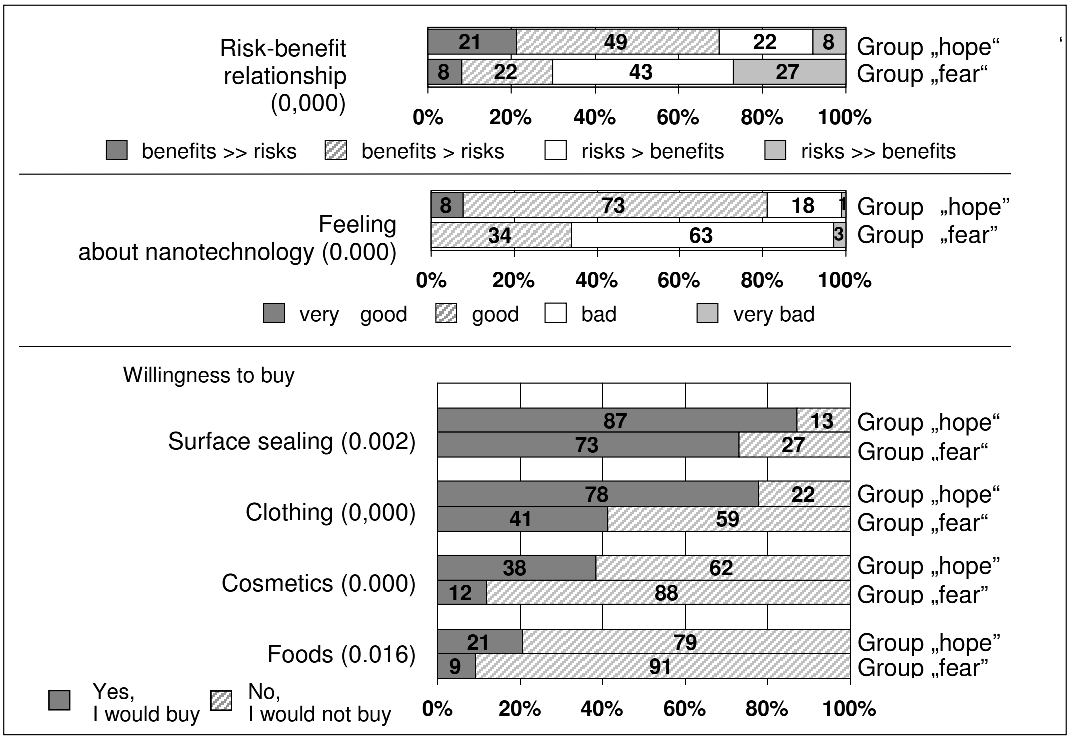


Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

There are major, highly significant differences when it comes to estimating the risk-benefit relationship of nanotechnology and the overall feeling. There are also major differences between the groups when it comes to willingness to buy (Fig. 21).

The annex (Figs 61, 62 and 63) contains detailed evaluations of the typical forms of behaviour when dealing with nanotechnology by gender. The form of behaviour "rejection of progress" was not included in the evaluation because, with n=11, it had not been selected often enough for the statistical tests.

Fig. 21: Differences between the groups "Hopes for the success of nanotechnology" and "Fear of the consequences of nanotechnology" (compilation of dominant types of behaviour when dealing with nanotechnology from Question 19) differentiated by assessment of the risk-benefit relationship of nanotechnology (Question 8), general feeling about nanotechnology (Question 15) and willingness to buy (Question 10)



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

3.7 Overview of the results of the quantitative survey

Based on the questions listed at the beginning of the chapter, the results of the quantitative part of the study[15] can be summed up as follows on the basis of these questions:

How widespread is the information?
Approximately 50 % of the respondents can specify the term nanotechnology. The ideas associated with nanotechnology concentrate on the categories miniaturisation, lotus effect or surface sealing. Information about how nanotechnology functions, by contrast, seems to be scarcely disseminated at all.

Does acceptance differ depending on the applications?
There is a substantial level of acceptance for consumer products above all in the area of surface sealing. The more nanoproducts come into contact with the body (textiles and cosmetics) or even enter the body (foods), the more acceptance falls. The hopes connected to nanotechnology are not concentrated, however, on consumer products but on the medical field and on environmental, protection and security technologies. Hence a high level of acceptance is to be expected in these areas.

[15] Further detailed evaluations from the population survey are contained in the annex in the figures in section 9.3 "Supplementary results of the quantitative survey".

How is the risk-benefit relationship perceived?
The vast majority of respondents estimate the risks of nanotechnology to be lower than the benefits (66 %) and therefore have an overall good or very good feeling about the technology (77 %).
Which information channels play a role in the dissemination of knowledge?
For the dissemination up to now of information about nanotechnology, the media which played a major role are the ones which do not involve any active search for information (television, magazines, newspapers). When it comes to an active search it is above all the Internet that comes into play.

How important is nanotechnology deemed to be for the location Germany?
For the location Germany the importance of nanotechnology is deemed to be high by approximately 40 %. However, the USA is considered to be the leading nation in the field of nanotechnology, followed by Germany and Japan, whose importance is deemed to be roughly equal.

What quantitative importance do the different ways of handling information have?
Out of the typical ways of handling information identified in the qualitative survey, pragmatism is the predominant attitude (64 %). Refusal and typical forms of behaviour involving fear (rejection of progress or reversal fears) have, by contrast, a low proportion.

Overall, the standardised survey reveals a positive attitude towards nanotechnology. The differing levels of acceptance depending on the applications do, however, indicate that this positive attitude is not necessarily stable. When assessing the results it should be borne in mind in particular that possible fears identified in the qualitative survey were not activated in the standardised survey. Public opinion can possibly change through the activation of these fears, for instance as a consequence of reports about damage caused by nanotechnology.

4 Results of the Basic Psychological Study

4.1 Theoretical background and method

The qualitative-psychological consumer survey was conducted using methods of morphological impact and communication research because they largely meet the requirements formulated in the introductory chapter to this report. The methods of morphological effect and communication research are particularly suitable for recording the development logic of opinion-forming processes which are not yet really structured. With this method it is possible to comprehensively reconstruct the dynamics triggered by looking at the subject nanotechnology and identify the emotional moments that play a role.

The methodological approach based on Morphological Psychological according to SALBER, which builds on Gestalt, depth psychology and phenomenology develops these foundations into its own theory system. Morphological Psychology directs its attention towards experience and behaviour processes and the importance of products of information within these processes. In this way it also answers the question about how products and information are integrated into daily life and culture or remain disintegrated.[16] One fundamental assumption of Morphological Psychology is that in psychological terms no objective reality independent of experience and behaviour processes "preceding" these processes can be described. It is far more the case that emotional reality is constituted through productions within which the physical environment, physical or other stimulations and information first become an experienced something or become something emotional. Perceived ("believed to be true") reality in psychological terms always looks at the production and results of experience processes: "Examining a something psychologically merely means that one turns this something – whatever it might be – into the object in the reality of the behaviour and experience referring to this something."[17]

Psychological surveys were oriented towards the following examination units:

1. The impact unit. The impact unit describes the common experience and behaviour structures, including the motivation structures, which describe a preoccupation with the subject nanotechnologies independently of personal-individual traits. Transpersonal motivation structures of this kind are analysed in Morphological Psychology using a category system consisting of six fundamental emotional states which are related to one another in supplementary relationships and tensions: aptitude – transformation, impact – arrangement - spread – equipment. Depending on interdependence, these emotional states are to be detected and specified linguistically.

2. Typing forms of behaviour. Based on the impact unit typical experience and behaviour patterns when dealing with information on nanotechnologies could be identified and described.

3. The image of nanotechnologies from the consumer angle. Image analysis in Morphological Psychology is also done using a set of categories consisting of six basic dimensions which are effective in each image and which are systematically examined.

The impact unit, the typical forms of behaviour and the image analysis provide insight into how communication measures can be used for intervention in experience and information processes on nanotechnology, for instance in the form of images, symbols, terms, slogans or hypotheses.

[16] For the theoretical approach Morphological Psychology see Salber, 1981, 1986, 1988; Fitzek, Salber, 1996, and Schulte, 2005.
[17] ubach (2002, p. 10)

4.1.1 Consumer surveys in Morphological Psychology

The collection of material in conjunction with Morphological Psychology was done by means of in-depth interviews. They are organised in such a way that they are oriented towards specific questions and nevertheless give the respondents sufficient opportunity to present their own view of the subject being examined. The in-depth interviews can be conducted as individual interviews or as group discussions.

The in-depth interview based on individual interviews offers an individual set-up in which thoughts, fantasies and also the emotions of the interview partners can be expressed without being influenced by a high degree of social control. Discussions of this kind create a situation of trust in which distorting factors like social desires, moral demands etc. are thematised and therefore rendered more controllable. Important determining factors above all for the perception of information and the carrying over of information into behaviour are thus determined with a high degree of validity.

Furthermore, on the basis of individual morphological interviews, the effective images and ideas can be described. This is particularly relevant because important information especially in conjunction with the use of everyday things (food, cleaning agents, cosmetics) is not stored cognitively, but in images, and translated into verbal information. In the set-up outlined above and through appropriate methods, highly effective emotional determining factors can also be identified which lead to the ignoring of risk information or prevent its carry-over into behaviour.

The individual interviews are supplemented by group discussions. In these group discussions the dynamic should reflect public opinion-forming and render it observable because a theme develops under conflicting opinions, opinion pressure and opinion leadership. Besides recording this on the basis of language statements and behaviour-driven observations, collages were made on the subject of “Our image of nanotechnology” during the group discussions by participants and then interpreted.

The production of collages of this kind is done using a flipchart with the help of scissors and glue. The discussion participants are given recent tabloids or special interests material which they can use however they choose by taking images, ads, slogans, headlines from the newspapers and sticking them on the flipchart. This leads to an “image” of the subject. Imaging methods of this kind help to formulate associations which are difficult to verbalise and facilitate greater access to the images and fantasies linked to the topic.

Both the individual interviews as well as the group discussions normally last two hours and their success is dependent on particularly well trained facilitators who, because of their training, are in a position

- to secure the necessary willingness and ability to provide information by means of special interview techniques which vary for each respondent.
- to filter out contexts from the opinions and images of the respondents which are difficult to verbalise.
- to examine the subject in a differentiated manner and to gain an optimum overview by varying the way questions are asked.
- to already proceed to psychological systematisations during the interviews.

The in-depth interview and the ongoing exchange within the team of interviewers are also an opportunity to constantly adapt the formation of hypotheses and questions throughout the entire study process.

Because of the special requirements only certified psychologists who are trained and experienced in this method are used as interviewers.

4.1.2 Questions on the use of qualitative survey methods

Questions which are frequently asked in conjunction with in-depth morphological surveys address the theme of objectivity and the special influencability of responses through the setting of the survey. Doesn't the interviewer introduce his own, preconceived opinions into the interview?

Particularly in the behavioural sciences, forms of influencing – irrespective of which interview setting one chooses – cannot be ruled out. Ruling out any form of influencing would require the separation of object and observer. As a constellation of this kind cannot be established or doesn't make sense, influencing is assumed to be a basic condition for impact in Morphological Psychology, i.e. as a basic condition for psychological reality and any interview (in particularly the in-depth interview) is deemed to be a joint work between the psychologically trained interviewer and respondent (test person).[18]

What's special about the morphological interview (also called in-depth interview) is that influencing processes, like for example transference and counter-transference, are seen as a given between interviewer and interview partner and can, therefore, take place under largely controlled conditions. Hence, an in-depth interview is far more than just "brainstorming". Furthermore, an in-depth interview of this kind is not solely characterised by the fact that it is described as non-standardised.[19] It's far more a question of using directional interview techniques in a methodological manner and encouraging participation in order to comprehensively reconstruct the function logics of the respective examination object in a theory-driven manner.

The method that acts as knowledge about what one is doing is the control instrument here. The special feature of the in-depth interview is that the interviewer draws on self-methodological control for instance as an instrument to observe and protocol his own counter-transferences. This provides insights which are not available when using other techniques. Another control structure is evaluation by psychologists who are part of the team. This evaluation structure serves both to identify influencing and transference processes and to make them controllable, and also to reconstruct the constantly observed structures of the subject being examined.

Examination of the conditionalities reconstructed from the individual interviews during group discussions also serves the purpose of methodological control. Here projectional methods are used like the above-mentioned collage technique. A gradual procedure as well as the ongoing exchange between theory and the phenomenon level turn the interview method used and group discussions into a tool that "learns" along the subject being examined and

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[18] "One of the recurring subjects (…) refers to reality and the importance of conscious and unconscious interactions between observer and object. Now and again it becomes clear just how many difficulties in the behavioural sciences can be attributed to rejecting or ignoring interaction of this kind, particularly the fact that the observation of the object by the observer has its complement in the counter observation of the observer by the object. This realisation forces us – at least in a naive manner – to abandon the idea that the basic operation of behavioural science was the observation of an object by an observer. This must be replaced by the idea that this is about the analysis of the interaction between the two, in a situation in which both play the role of observer and object for the other." (Devereux, 1998, P. 309 FF.)

[19] The purpose of the in-depth interview is to create an interview situation in which the interviewer in line with his expression possibilities and his attitudes touches on a subject. Hence this kind of interview must be described as "open" or "non-standardised". The openness of in-depth interviews, however, is set against their structure and concept. The interview is not "open for everything" and is definitely not a cosy chat. The interviewer must retain control of the interview process. He must know what is happening in the interview and what he and his counterpart are doing. Concept-bound guidelines and goals, which are to be found in the project and theme-driven preparation of a questionnaire, therefore, also determine the orientation of the in-depth morphological interview (for the interview method see inter alia Grüne, Lönneker, 1993; Dammer, Szymkowiak, 1998).

the related research process. Viewed in this way, the in-depth morphological interview is necessarily “non-standardised” for methodological reasons.

4.1.3 Scope, quotas and recording sites

The records on this morphological-psychological study are based on surveys involving a total of 50 people. The survey procedure is broken down into two steps: first, the conducting of individual interviews, followed by group discussions.

In the basic morphological-psychological research only so many cases (here in-depth interviews) are used as are needed for functional understanding of the respective context examined. A total case number of 50 persons is sufficient within the framework of intensive interviews. It is possible to analyse the structural relationships of information behaviour, the use of information in typical behavioural patterns and the image of nanotechnology amongst consumers and, in this way, to gain a psychological, functional understanding of the subject being examined. Upwards of a certain number of individual and group interviews, no additional findings that are justifiable in terms of the research required can be obtained.[20]

Overall 30 individual interviews were staged in Cologne, Munich and in the Rhine-Sieg district in July/August 2007. These were in-depth interviews, each lasting two hours. The random sample was composed of individuals

- aged between 18 and 60,
- from different occupations,
- living in households of different sizes,
- of both genders,
- who had at least a middle school-leaving certificate.

A middle education level at least was necessary for participants to be able to reflect, discuss and also express themselves on the subject in hand.

The two group discussions with ten participants each were held in September 2007 in Dresden and Bonn. The group in Dresden consisted of people

- of both genders,
- aged between 35 and 55,
- from various professions and levels of education (middle level of education),
- living in households of different sizes.

One special feature of the discussion participants in Dresden was that they are classified as “early adopters” who because of the specific regional features (Dresden as a cluster with numerous research institutes and nanotechnology companies) had a relatively advanced level of knowledge about the subject.

The discussions in Bonn were held at the Technischer Berufkolleg Heinrich-Hertz School with pupils aged between 16 and 19 who were not familiar with the subject. One of the questions of importance here was how young people react to the subject, nanotechnology.

[20] The specification of a relatively small number of cases compared with representative surveys has of course also to do with pragmatic restrictions. In-depth interviews involve a time-consuming recording and evaluation process and corresponding costs. The specification of a limited number of cases is, however, based on experiential processes like the ones used in psychological impact and market research for decades. Politicians, the business community and industry have used studies with case numbers of this kind for a long time when preparing their decisions. In methodological terms, Morphological Psychology is oriented in its research into impact associations towards a functional concept of representativity. It pursues a different goal from socio-demographic representativeness where it is necessary to use larger case numbers in order to describe quantitative magnitudes and differentiations.

The goal was to examine the handling of a technology which, according to all the forecasts, will spread and only be fully deployed in the near future.

Identical magazine packages were used for the collages in the group discussions.[21]

Test studios were used to pick the survey participants for the individual interviews and for the group discussions. That was also where the interviews took place. They used their mailing lists to pick participants and supplemented or extended the group by contacting potential participants by phone.[22]

All respondents received a fee for their participation.

The material from the interviews and observations in the study are stored as audio and video recordings, Word files, handwritten minutes, notes and photo files.

4.2 Analysis of the motivation structures when dealing with the subject nanotechnology

Within the framework of the basic psychological study, ideas about the subject nanotechnology were initially analysed in an unprompted manner. As it could be assumed that most consumers knew very little about nanotechnology, additional information about nanotechnology was introduced during the course of the interviews. This information referred to more exact delimitations of the term nanotechnology, possible areas of use and also conceivable risks. In this way it was possible, despite the low level of knowledge, to achieve a comprehensive survey of the subject under examination. The information used in the qualitative survey is compiled in the Annex (Chapter 7.1).

The focus on the specificities of the subject under examination and on the resulting experiential processes in conjunction with the subject requires reporting which describes these processes in a phenomenon-driven manner. For the purposes of illustration relevant quotes and images from the collages made during the group discussions are included in the report. The paragraphs with quotes are more indented than the rest of the text and are in italics.

The analysis of the handling of the subject, nanotechnology, produces three fundamental psychological tensions and complementary relationships. Understanding of these relationships and of typical ways of dealing with the subject and image analysis are important in order to describe development paths for perception. Furthermore, information can be obtained for the targeted steering of communication with consumers.

The psychological tension and complementary relationships vis a vis nanotechnology are described in detail below. For each relationship a summary is given against a grey background.

[21] Magazines used: Spiegel 36/07, Bunte 18/07, Focus 35/07, Autobild 36/07, Computerbild 18/07, Wirtschaftswoche 35/07.
[22] Test studios involved: K&M Forum (Cologne), Marktforschungsservice Dukath (Dresden), Qualitative Marktforschung Pott (Munich).

4.2.1 First tension: Return to a belief in progress – surprise about illustration limits

Nanotechnology is mainly perceived on the level of product developments and seen to be fascinating whereas understanding for the functional relationships of this technology is shaped by limits. Risks are ignored. The technology triggers above all optimism and is, therefore, in sharp contrast to the widespread, pessimistic comments about other technical developments like genetic engineering or nuclear energy. Nanotechnology stands for the promise of a return to a belief in progress.

Return to a belief in progress

Consumers seek to understand nanotechnology mainly via products. Practical qualities which simplify daily life are to the fore.

> *"Glasses that no longer mist up"*
>
> *"Wash hand basins and urinals which you don't have to clean as frequently"*
>
> *"Paint that doesn't scratch"*
>
> *"Textiles which no longer have stains"*
>
> *"Gutters you no longer have to clean that, even when the weather is damp, don't develop mould and still look as good as new after decades."*

In these descriptions, the respondents very much remained on the surface. Any critical examinations that go deeper are if possible avoided. The fact that they remained "stuck" to the surface was not initially clear to the respondents. Quite the contrary, fascination with the surface is so strong and unconscious in the psychological context of nanotechnology (along the lines of not consciously available) that even people who see themselves as highly intellectual did not initially grasp this association. A seemingly paradoxical situation: to have your eye on and deal with something but not understand its context.

The respondents were not interested first and foremost in extending their knowledge about nanotechnology. Nanotechnology is far more instrumentalised in order to set an optimistic tone amidst the cultural pessimism that is criticised on all fronts. Nanotechnology, as an experienced context, encounters a mish-mash of public opinion which can be described as "being fed up with pessimism". It is an opportunity to see things positively for once in life, particularly as this is a largely "unused" object which has not been researched to any great degree so far. Nanotechnology provides a new and different stimulus to the discussion about the location Germany and contrasts with the frequently negative headlines in the media.

> *"Germany is a society on the way to retirement."*
>
> *"First we had a whole lot of unemployed engineers and now we don't enough."*
>
> *"I'm sick to death of all the complaining and laments!"*

The connotation of the term technology changes when you add "nano" to it. Technology is no longer seen as boring and linked with negative experiences from schooldays but as something that is exciting and fascinating.

> *"Lotus effect sounds very nice – it smacks of Far East religion and not of something purely technical."*
>
> *"I thought we were going to simply talk about technology in our discussions. Now that I know we're going to talk about nanotechnology, I find it far more interesting."*

The fascination with product developments can fuel positive feelings about a turnaround and promising new beginning despite the lack of understanding about the technology. In this context, the technology is linked with varying degrees of a belief in progress that contrasts with the negatively perceived reports and ensuing fears about the future.

> *"Nanotechnology offers the chance of a new beginning."*
>
> *"Nanotechnology could re-establish Germany as a leading research location."*

So initially nanotechnology seems to be "immune" to major criticism or risk awareness. "Superficiality" seems to be one characteristic in dealing with this subject. Nanotechnology seems to initially remove itself from differentiated consideration and goes beyond the horizons of many consumers. Nevertheless, it manifests at the same time fascinating, highly application-driven results in the "material" reality. When consumers talk about this subject, they frequently mention surfaces and their treatment through dirt and cleaning.

As nanotechnology has not been extensively researched so far and seems to be broken down into subcategories and even experts have reached the boundaries to their knowledge, the observer feels he is entitled and has the "permission" to approach the subject in an impartial manner fuelled by a naive belief. The hope that this belief can be transposed positively to product and brands is one of the reasons why "nano" is frequently used as a positive concept in marketing and perceived by some consumers (e.g. car drivers).

The other side to the naive, impartial handling of the subject of nanotechnology is a certain lack of concern and, by extension, of risk awareness.

> *"I recently used a new nanotechnology product for surface treatment called "Invisible Shield". I didn't wear gloves."*

As the subject nanotechnology is difficult to classify using existing categories, this leads to classifications which are linked to high expectations and are almost quasi religious. The implicit message when examining this subject carries hopes of a new beginning. Positive feelings about belief in progress are rekindled in consumers.

> *"With the help of nanotechnology Germany will be able to drag itself out of the mire."*

In this context people remember books or films in which fantastic journeys through the human body are featured for instance in a miniature submarine.[23] People like to echo the positive mood of that time.

> *"During the economic miracle the world was still okay."*
>
> *"When I was a boy growing up I saw films like that. They were black and white films and I can still remember them very well."*

Literature which stresses the downsides to nanotechnology takes a back seat.[24]

The extension of discussions to the location Germany underlines the strong positive attitudes towards the subject.

Amazement about illustration limits

In the context of approaching the subject nanotechnology it can be observed that fascination and enthralment are the predominant feelings. The respondents are less uneasy or fearful and are very curious about the subject. Even when confronted with the potential risks of nanotechnology, the respondents do not quickly become uneasy or abandon their curiosity and enthusiasm. The promises of progress and innovation through nanotechnology are

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[23] One film quoted in this context is the American science fiction film "The Fantastic Journey" from 1966 (Director: R. Fleischer). Numerous other films and books like, for instance, the film "The Journey to Myself" (USA 1987, Director: J. Dante), are based on that film.

[24] One example of the downside to nanotechnology is the bestseller "The Prey" by Michael Crichton (2002).

stronger than the fears. It is far more the case that “a certain degree” of understanding keeps unease under control. The subject is “on the other side” of the comprehension horizon and is, therefore, located in psychological terms beyond feelings of unease. Only in isolated cases were vague fears expressed:

> *“We don’t at all know where we are in all this.”*
>
> *“It’s so small that it could scare you.”*

What seems to be particularly impressive is the manageability of even the minutest parts and structures in the nanoscale range. In the case of a more in-depth examination of this subject, it becomes noticeable that nanotechnology can no longer be depicted with ideas about miniaturisation and is scarcely comprehensible for the everyday person.

> *“It’s too small to be able to imagine it.”*
>
> *“You have to develop completely new ideas in order to be able to understand this.”*

Miniaturisation processes on this scale are not immediately accessible and increase the feeling of amazement. The respondents describe being confronted with their own limits or a quasi-religious experience which supports a belief in progress.

> *“We respect the huge scale of the dimensions on which we move with our world in the cosmos. And now we’re surprised how small the dimensions can be in which we live.”*
>
> *“The incredible possibilities of nanotechnology make you feel very small.”*
>
> *“It’s as if you were moving from one element into another. Like when you dive into the sea and you realise that there are completely different realities from your daily life which we see as being normal.”*

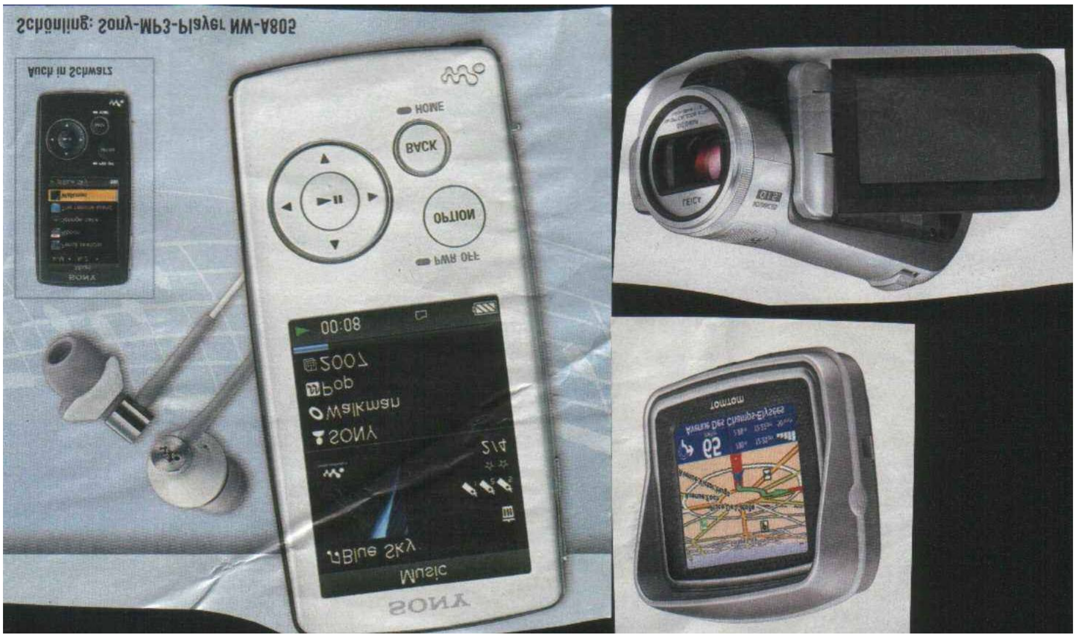
Fig. 22, which was given to respondents during the interviews as information on nanotechnology, taps into this feeling of amazement (see also Chapter 4.4).

Fig. 22: Information material for the interviews – excerpt from the website “nanoTRUCK” of the Federal Ministry of Education and Research (BMBF) – “Station 1 Foundations – Definitions”

In order to depict nanotechnology, people draw on well-known concepts. Already today the respondents experience miniaturisation processes in their daily lives on a scarcely conceivable scale (see Fig. 23). People see for themselves how in the course of technological development, more and more functions take place on increasingly small areas and how that has prompted revolutionarily changes to our daily lives.

> *“Only four years ago I would never have imagined that my mobile and my MP3 player could fit in my pocket.”*
>
> *“Navigation systems which are no bigger than my hand and which can guide me from A to B throughout Europe are particularly impressive.”*

’Fig. 23: “Miniaturisation” – excerpt from a collage made during the group discussion in Bonn



Given the miniaturisations which seem possible in the course of future developments in the field of nanotechnology, this amazement takes on another dimension. In order to express that dimension, a comparison is made with space. The infinity of miniaturisation is compared with the infinite expansion of space.

> “The subject nanotechnology makes me feel like I’m being immersed in a film or dream in which the worlds of the infinitely minute become bigger and bigger and reveal completely *new* cosmic dimensions.”
>
> *“I remember the exciting moments in science fiction films where the hero had to penetrate a kind of membrane in order to enter into contact with another dimension.”*
>
> *“Can you make a space extremely small from outside and then once you are inside, enlarge it dramatically as well?”*

Fantasies expressed about “explosives” made from nanomaterials can be understood along the lines that nanotechnology is a subject which explodes the limits of one’s own perception. Initially many things seem to be unimaginable:

> *“How can you expect to steer nanotechnology in the nanoscale range? It’s not possible to have such small pincers.”*
>
> *“Something that we cannot steer must steer itself.”*
>
> *“You have to develop completely new ideas in order to understand this.*

4.2.2 Second tension: becoming irritated about the disappearance of customary categories – making the subject manageable through decisions and concretisations

In the further confrontation with the subject nanotechnology, awareness is raised that customary categories for presenting technical developments are not adequate when it comes to nanotechnology. This initially leads to irritation. The importance of nanotechnology for everyday life means, however, that consumers make the subject manageable and take decisions about their attitude towards nanotechnology and its products. Against the backdrop of their own boundaries and limited knowledge, various control mechanisms play a role in these decisions.

Irritation about the disappearance of customary categories

The in-depth interviews were designed in such a way that there was an increasingly forced confrontation with nanotechnology. The more intense the preoccupation, the more the respondents realised themselves that they knew very little about the subject and that the customary illustration categories did not suffice to understand or manage it. In the course of the further critical confrontation they showed a sense of unease about the gaps in their knowledge. Only very few of them realised that nanotechnology plays a role in diverse areas like materials development, information technology, sensor technology, foods or cosmetics. This meant that sometimes the subject moved closer than some of them wanted:

> *“Goodness, you find it in food too? Did I miss something there?”*
>
> *“The nanoparticles are possibly so small that they can cross the blood-brain barrier.”*
>
> *“Can nanoparticles penetrate cells?”*

The realisation that nanoparticles could enter the body meant that this subject “gets through to them” and forces a confrontation which leads specifically in the context of food to distancing mechanisms like avoidance, relativisation or the apportioning of blame (Fig. 24).

> *“I don’t buy any food if I see nano on the packaging.”*
>
> *“Nanoparticles are not necessarily harmful because they are small. I bet there were nanoparticles in food before anyone really noticed.”*
>
> *“If nanoparticles are contained in foods and industry doesn’t state this on the packaging then it will have to pay for any damage.”*

Nanotechnology breaks with customary categories. The creation of completely new properties of materials and structures through miniaturisation is seen as a link between the natural sciences and magic. These ideas are strengthened by the fact that myths of invincibility are supported by the new developments according to which the materials act like an invisible protection shield. Furthermore, miniaturisation is described in such an extreme and incomprehensible manner that it is tantamount to a fluid transition down to the dissolution of matter.

> *“Nanotechnology does not lend itself to a clear order but does mean that my sink stays clean.”*
>
> *“Does this subject belong in the area of physics, chemistry or biology?”*
>
> *“Nanotechnology operates the transition line between matter and nothing.”*
> *“Soon it will be just a small step from the energy of thoughts to their implementation into the minutest matter.”*

Fig. 24: "Nanoparticles in foods" – excerpt from the collage prepared during the group discussion in Bonn

Making the topic manageable through stances and concretisations

Even if the consumer doesn't know very much he must still position himself vis a vis the subject because it is relevant for his everyday life. He sees himself forced to take a decision about the purchase and use of products or about his attitude towards nanotechnology. In the final instance it is about making nanotechnology manageable.

> *"Nanotechnology could be defined as 'making the minutest things manageable.'"*

For the evaluation of technology and its use in everyday life, stances must be taken about what is acceptable and what isn't. In this context a stance can mean that a position is adopted to oppose pessimistic cultural trends which are seen to be *negative* (see above) or that one invests in corresponding shares, and bets money or adopts precautionary strategies.

> *"I always say better safe than sorry."*
>
> *"When I use a cleansing agent for surface treatment containing nanoparticles I put on gloves as a precautionary measure."*

In the group discussions which were designed to advance the development of opinions on nanotechnology, disputes started to emerge about the above described stances. The one position tends to stress the positive potential of nanotechnology whereas the other focuses on the risks. In this context of course the different importance of nanotechnology in the individual areas plays a role. For instance, this new technology is supported in the areas of information technology or material development whereas it encounters considerable scepticism in the field of food.

Various control strategies can be identified when it comes to these stances:

a) Stance against negativity

This strategy is an attempt to control nanotechnology possibly by applying moral categories. This explains the need to have nanotechnology embedded in orderly structures. When nanoparticles seem to begin to develop a life of their own, then from the psychological angle they appear to be extremely dangerous.

In the Dresden group discussion this battle about stances was very noticeable. At the same time, nanotechnology is “demonised” and “idolised” as if the group was struggling to establish whether it thinks nanotechnology is good or not. The group discussion can here by seen as a simulation of the opinion-forming process. The split and “splitting” attitude towards the subject went so far that one group member talked about his plans to invest in nanotechnology shares and then a few minutes later, launched an attack on companies that use nanotechnology.

Orderly structures like for example nanotubes seemed to have a calming effect. Nanoparticles that are bound in water or in solid bodies are deemed to be less dangerous and cause less unease than those which float in the air. As soon as nanoparticles are thought to be “embedded” they appear to be manageable.

In some interviews in this context a comparison is made with free radicals. Some respondents remember at this point media reports about subjects like fine dust or nanoparticles from laser printers.

Consumers would like to establish controllability by defining areas in which nanotechnology is defensible and in which it is not. For instance, people immediately start to distance themselves when nanotechnology is linked to food. In the medical field it does, however, seem acceptable for nanoparticles to be used in or allowed to penetrate the body.

> *“Without the nanostitches in my shoulder I wouldn’t be able to move my arm today.”*

> *“When medicines or antibiotics are carried straight to the focus of infection, then we might need less of them and suffer fewer side effects.”*

b) Nanotechnology as a tangible material

When it comes to controllability a line is drawn between nanotechnology and other topics. For instance nanotechnology in contrast to subjects like radiation, nuclear energy and genetic engineering seems to be tangible. Nanotechnology is seen in the context of direct use as a tool or agent whereas in the case of genetic engineering the focus tends to be on misuse.

> *“Nanoparticles, in contrast to radiation, are tangible matter.”*

> *“Unlike genetic engineering, nanotechnology does not interfere with the blueprint for life.”*

In line with the slogan “What’s so small, can’t be so bad”, consumers would like to play down the risks whereby they frequently fail to consider the fact that miniaturisation can also lead to the creation of completely new material properties. In the first stage of critical examination of this subject, many respondents think that structures in the nanoscale range are more or less unchanged miniature versions of larger structures.

> *“Recently we were in Legoland. There you can look at miniature versions of cities, buildings like the Eiffel Tower or Frankfurt Airport.”*

Here playing down seems to be a defence mechanism which is activated when aspects of a subject are “superficially” brought to the surface and disputes which go deeper are initially avoided. What is noticeable is the predominant mentioning of surface sealing, car paint and the lotus effect (Fig. 25).

Concrete and visible results from nanotechnological applications are, in the opinion of consumers, the most appropriate way of making this subject comprehensible.

Fig. 25: “Surface sealing” – excerpt from a collage made during the group discussion in Bonn

4.2.3 Third tension: the painting of promising visions – accepting a change in perspective and altered thought patterns

Developing future visions of nanotechnology is easier when you can rely on different thought patterns and a change in perspective. This is dependent on the reflected handling of the subject nanotechnology which, in turn, is a precondition for the identification of certain risks and for successful teaching and communication of this subject.

Painting promising visions

The expectations of nanotechnology are turned into visions of progressive daily life. In the mainly positive visions, the experienced daily routine becomes a promising everyday routine,[25] in which far more seems possible than is the case today. In these visions, the desires for immortality and fantasies of being invincible play a major role. The visions draw on breakthroughs from very different areas which are expected in the near or distant future. Examples were mentioned from the following areas:

Medicine and tumour research

> *“Thanks to nanotechnology it will soon be possible to destroy a tumour more precisely than with radiation. The advantage is that there will be less damage to healthy tissue.”*
>
> *“The more precisely antibiotics can be transported to the infected site and used there in a targeted manner, the less we will need of them.”*

Space research

> *“Today we are already working on producing a nanofibre rope to elevate a lift into space. With traditional steel rope that wouldn’t be possible.”*
>
> *“Perhaps nanotechnology will lead to humans really being able to conquer space and populate Mars in future.”*

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[25] See also Salber, 1989, p. 198: “Der Alltag behandelt den All-Tag.”

Material development

> *"When surfaces can be treated in such a way thanks to nanotechnology that we will never have to clean them again, then we will use less energy and fewer chemicals."*

Information technology and consumer electronics

> *"Just imagine that all the knowledge in the world will soon fit into a key ring."*

Fire protection

> *"The idea is really quite crazy that we will soon be able to develop clothing which enables you to walk through fire."*

Sensor technology and analytical methods

> *"Perhaps it would really mean an end to traffic jams when cars would move at perfect distances like along a chain of pearls. That would also mean there would be even more room for cars."*

The above examples of positive visions in the field of nanotechnology "join forces" with positive visions from other areas – like an ecological lifestyle. For instance consumers associated the reduced need for cleaning thanks to nanotechnology with reduced consumption of water and chemicals too. These synergies again support the above described process of a belief in progress. In other words, this gives consumers additional justification and confirmation that they should see nanotechnology positively and discourages them from considering potential risks and downsides.

Some visions go even further and show quality leaps in reflection whereby human life would merge with nanotechnology and could therefore change radically. For instance ideas of prosthetics are developed where a new level of human development – along the lines of a "homo nano" – could be achieved. Some of the respondents think for example of a fusion between the areas of information technology and neurobiology.

> *"Just imagine there are neurobiological storage chips which mean you don't have to learn anything. A chip is implanted and you already have your school-leaving certificate."*

Sometimes clear utopias and wishes are expressed which play on the transition between big and small. People would like to have cars which they could fold up into a jacket pocket in order to avoid the wearisome search for a parking space.[26] A young respondent compared the development potential of nanotechnology with the "Hoi Poi" capsules in Japanese Manga comics.[27]

The painting of unlimited civilisational opportunities can also extend to negative visions. Some comments refer for example to the reversibility of protection. Technical blessings like for example "nanotechnology as an invisible shield" can go against one's own interests.

> *"We will be under complete surveillance."*

> *"That goes against my right to self-determination."*

[26] Fantasies of this kind are boosted by media reports that car manufacturers and IT companies plan extensive co-operation and joint product developments. In the summer of 2007 there was various media speculation about the future co-operation between the car manufacturer Volkswagen and the computer/consumer electronics manufacturer Apple to develop an "iCar". Source: www.spiegel.de/auto/aktuell/0,1518,502790,00.html, entitled "Talks with Apple: Volkswagen thinks out loud about iCar."

[27] According to the comic, Hoi-Poi capsules are capsules in which large objects (e.g. a house or an aeroplane) can be reduced to the size of a pea. By pressing a button on the capsule and throwing it on the ground, the objects return to their normal size.

"Nanotechnology becomes a system that organises itself and then can no longer be steered by human hand."

Accepting a change of perspective and altered patterns

A more in-depth handling of the subject nanotechnology initially implies a break with customary thought patterns and a certain degree of irritation because of phenomena which appear irrational and make your own horizons appear limited. When this irritation leads to the realisation that previous (natural scientific) illustration categories do not apply or begin to "become clouded" that is when an idea develops about which new perspectives are linked to nanotechnology and the realisation dawns that this technology also means a radical change in thinking.

Different qualities of figures are demonstrated for instance in the realisation that miniaturisation doesn't just mean a change in the size of a material but also its quality and its substance. This leads not only to miniaturised "versions" of something big but also to other and completely new structures and material properties. One example for this change in the qualities of figures linked to nanotechnology is the thought about a different quality of oversummativity?[28] Whereas a normal car consists of several thousand parts that can nonetheless still be counted, people imagine that nanotechnological structures entail billions of parts which have to be organised in the course of the production process.

"How can you organise billions of these parts … how can you get them to move in one direction … perhaps by "feeding" all these particles with the same information …. And how do you give all these particles the information? … perhaps by keeping them in a nutrient solution."

A change in perspective and amazement that there may also be differing attitudes to physical reality are closely linked to the experienced peculiarities of nanotechnology.

"Questions that crop up and mind games: how big things can become very small – that something can be solid and liquid at the same time – that something appears to be particularly "smooth" because it has a structured, "non-smooth" surface etc."

The change in thinking experienced by some of the respondents is the precondition for being able to imagine a future with nanotechnology. The space analogy mentioned above already means a change in perspective. You direct the telescope at the same time towards the smallest particles and structures of the microcosm and can in this way discover a great deal or far more than there is to discover in space. As if he had anticipated this attitude more than 50 years ago, a speech by Richard Feynman is entitled "There is plenty of room at the bottom".[29]

Some respondents also came to realise that a more in-depth look at nanotechnology can also lead to a completely new way of seeing the "surface". Surface is no longer something smooth but takes on structure and depth. And people no longer remain stuck on the "beautiful" surface of useful nanotechnological products but can have fun in seeing that surfaces have "depth" and in reflecting on the superficialities of thought.

The experiences of one grammar school teacher describe the constellation of a change in perspective using the example of "surface properties". In order to demonstrate the lotus effect to senior school pupils, she asked them to prepare the print of a kohlrabi leaf. However, because of its water-repellent properties, paraffin leads to a rejection effect (normal understanding) whereas liquids are "actively forced" through the special

[28] "Oversummativity" of figures is described in Gestalt psychology as one of the fundamental Gestalt laws of figural perception. This Gestalt law of oversummativity says, "The whole is more than the sum of the individual parts" (see Fitzek, 1996, p. 18 ff.).

[29] The title of a speech given in 1959 by the US American physicist which today is deemed to be one of the founding speeches and legends of nanotechnology (Feynman, 1960).

“nanotechnological” quality of the kohlrabi leaf (structured, non-smooth surface) into droplet form and run off (new understanding). When talking about her didactic efforts the teacher began to reflect on the fact that she had fallen back on something old in order to teach the pupils something new. The example shows how during a change of perspective and when rethinking didactic categories, the old and the new perspectives may co-exist in parallel for a long time.

Thinking in terms of a change in perspective is not only the precondition for the more extensive examination of nanotechnology but can also be useful for identifying the risks of this technology. Overall it is shown in this study that most of the respondents only have very limited risk awareness. Only someone who can envisage the potential in the development of nanotechnology is protected against the naive playing down of the risks and can consciously deal with potential but, as yet, unresearched risks.

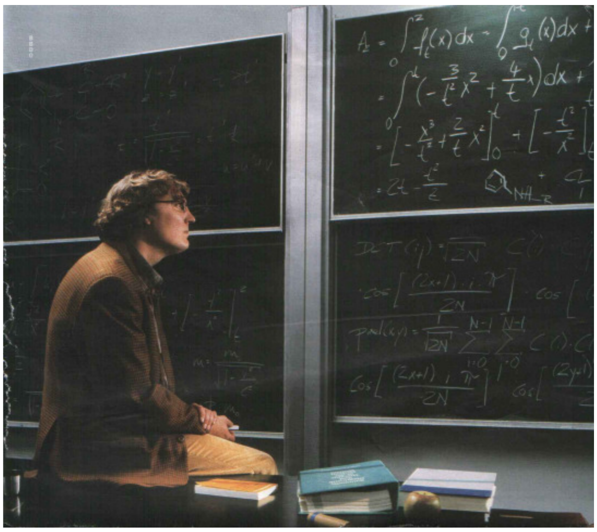
For the didactics and communication of nanotechnology some respondents also thought it was necessary to take leave of old thought patterns.

> *“The traditional curricula in schools do not go far enough, in my opinion, to teach the contents of nanotechnology particularly as the subject traverses the traditional boundaries of subjects (physics, biology, chemistry etc).”*

During the group discussions with young people at the technical vocational college, it was shown that learning processes along a subject like nanotechnology may take a different course from what is normally envisaged in schools. The discussions revealed that the positive potential of the subject currently linked to a belief in progress can be of didactical use. it can lead to a, by no means common, liveliness in learning where pupils can be motivated by stimulating their curiosity and interest. In concrete terms “knowledge” and “no knowledge” about technology was used or a hypothesis was developed about the understanding and use of nanotechnologies where the discussion participants themselves were surprised about the results afterwards.

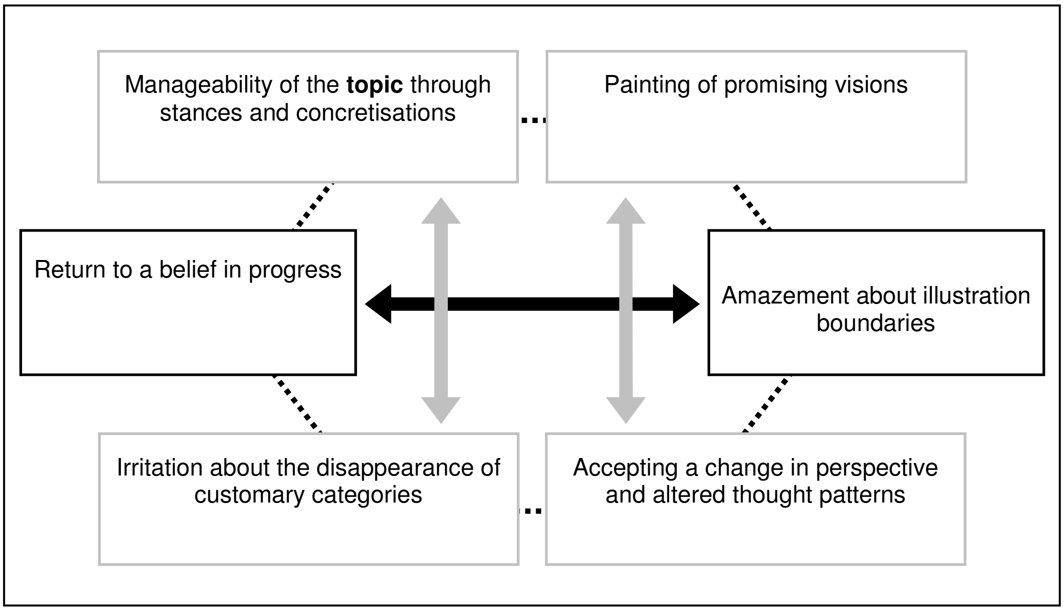
Images or films are deemed to be helpful in order to impart information on nanotechnology. Fig. 26 gives an impression of the experience of amazement and also about how technology is seen as something which can move beyond the framework of existing categories and does not remain “neatly” in “its” field but stretches over several fields.

Fig. 26: “Nanotechnology moves beyond boundaries” – excerpt of a collage prepared during the group discussion in Dresden



The structures for dealing with the subject nanotechnology are presented in the following figure:

Fig. 27: Overview of the motive structures for dealing with nanotechnology



4.3 Typology of dealing with nanotechnology

Based on the motive structures for dealing with nanotechnology, typical patterns of behaviour and experience emerge. For the targeted approaching of consumers, knowledge of these typical behavioural forms is helpful because they differ when it comes to the willingness and ability to process and select information. The typical patterns are outlined below and described with reference to the motivation structures.

Behavioural form 1: Naive optimism

One optimistic attitude towards nanotechnology is Naive Optimism. This behavioural form mainly involves being able once again to believe in progress and establishing a counter-stance to the much criticised cultural pessimism. Because most consumers find it difficult to classify nanotechnology, they think they can react to it naively. From the perspective of this behavioural form it's not about taking an intensive look at nanotechnology. It is far more the case that this unreflected attitude is the precondition for cultivating carefree optimism about nanotechnologies.

> *"I believe that we should restore our belief in progress."*
>
> *"When it comes to nanotechnology I mainly see the positive sides. This differs from how I see subjects like Avian flu or genetic engineering. I simply believe that nanotechnology is positive for the development of mankind."*

From the perspective of naive optimism this means focusing above all on the fascinating aspects of nanotechnology and looks first and foremost at concrete opportunities for nanoproducts to facilitate daily life. More comprehensive ideas are not desirable. There is a preference for mentioning applications on the "surface" (see above).

> *"I have heard that nanoproducts really simplify work."*

"When you think that this technology will make everything easier! You won't have to carry so much weight around with you and you'll have all the electronic gadgets you need on you."

Risk awareness in this behavioural form is not particularly developed. Curiosity prevails and the carefree handling of nanoproducts or reports could reveal downsides that people could be unprepared for and could upset them.

From the angle of the motivation structures, this behavioural form constitutes an early, holistically undifferentiated development phase in which an opinion is still emerging about nanotechnology. The respondents grasp that this is an area which can develop very quickly but about which there is still very little information. A specific "way" has not yet been found for how this subject can or should be discussed by the public at large. Nor are there any criteria for consumers to assess nanotechnology.

Type II: Rejection of progress

In the case of the behavioural form "rejection of development" it could be observed that those concerned could not get involved in this subject and did not wish to make either positive or negative comments. Respondents of this kind did not participate or seemed to have a block and did not allow themselves to be won over by the positive euphoria surrounding the subject. Typical statements in this context are:

"I have no faith in modern technologies like for instance nanotechnology."

"I have never heard anything about nanotechnologies and I don't need to know about them."

In the group discussions this type of attitude was expressed in silence or through withdrawal signals. In one concrete case the participant was no longer "at the table" but distanced himself as if he wanted "to keep out of it". In the case of individual interviews this rejection of progress was expressed in incomprehensible comments, the rejection or lack of interest in the subject or tiredness.

The rejection of progress is far more than a specific form of action. Here decisions take effect by means of which confrontation with a subject is "suspended".

Type III: Visions

In the visionary behavioural form we see a spread of the motive "Return to a belief in progress". Old science fiction dreams and utopias are fuelled by nanotechnology. Examples of these visions can be found in the section "Painting promising visions" (see above). On the one hand, the uncertainties surrounding this subject promote the production of daring designs; on the other hand, there is a need for knowledge and imagination in order to develop visionary nanotechnology designs. Here are some examples of this behavioural form:

"Nanotechnology will revolutionise human life."

"Nanotechnology will open up to us fantastic opportunities for technical development."

"With nanotechnology we can achieve progress which seems impossible to us right now."

In the face of the fascinating opportunities of nanotechnology, risk awareness tends to take a back seat. The visionary behavioural form differs from the "analogous scientific illustration" (see below) to the extent that it is less related to reality.

Negative visions have one characteristic: they develop from a sound confrontation with ethical-anthropological and application-driven consequences of the object.[30]

Type IV: Pragmatism

Pragmatism constitutes an attitude towards new developments in nanotechnology which are not accepted without criticism. The motives of dealing with nanotechnology are addressed in a balanced way. Statements which typify this behavioural form are:

> *"We should develop nanotechnology but keep an eye on the potential risks."*
>
> *"I don't really think that nanotechnology is dangerous but we should give some thought to the potential risks."*

Reflected pragmatism has not yet really developed a clear profile because opinions on nanotechnology are very much in the initial stages. It is not shaped by naivety but by a feeling for what is interesting in nanotechnology and by rudimentary knowledge about nanotechnological associations as well as by a desire for an impartial confrontation. Consumers with this behavioural form find it interesting to think themselves into the object for which the precondition is once again an abandonment of perspectives and a restructuring of thought patterns (see above). However they do not allow themselves to be tempted into speculation but tend to think through the subject in a rather sober manner, right down to the possible consequences. Hence risk awareness in this behaviour form is far more developed. What is typical for this is the following statement which comes from a group discussion:

> *"If I were to use a cleaning agent containing nanoparticles I would put on rubber gloves as a precautionary measure. At the same time, the particles might be so small that they can effortlessly pass through the gloves."*
>
> *"I always say, 'Better safe than sorry'."*

For this type the emphasis is on usefulness and pragmatism for everyday life in addition to safety:

> *"How does it benefit me? What does it offer? Can I use it or should I keep my distance?"*

The risks and benefits are weighed up against each other in a pragmatic manner.

Type V: Open-mindedness

The behavioural form "Open-mindedness" is similar to the science-like behavioural form. Its main trait is objectivity. Amazement and fascination are to the fore. It's less about usefulness and more about fun in the subject itself, about trying out thought constructs and about what effect the subject has on you.

> *"I would never have thought that I would learn so many new things today about an area that I scarcely knew."*
>
> *"I'm surprised about the interesting new findings on the subject of nanotechnology."*
>
> *"When dealing with this subject it almost becomes philosophical."*

The subject nanotechnology is accepted here in its provisional state as if it were an interesting phenomenon. It is not functionalised in any direction or rendered useful in a short term manner, e.g. through the spread of visions or by a fixation on use and implementation.

[30] This is also the context for the positions of scientists who, based on their knowledge and their experience with modern technologies, "switch to the other side" and develop critical or negative visions also on nanotechnology. One example for this is the position of Bill Joy (Co-founder and chief scientist of Sun Microsystems; JOY, 2000).

The focus is more on fun. The open-minded type is close to amazement and engages in a type of pre-scientific epistemology by reflecting on his own thought movements.

Type VI: Science-like illustration

The pattern "science-like illustration" describes information behaviour which is oriented towards a rational, scientific method.[31] This permits an intensive yet distant preoccupation with the subject nanotechnology. Nanotechnology is to be rendered controllable by a trust-based linking to the science system with its solution competences.

> *"I try to understand nanotechnology by drawing on my knowledge of physics, chemistry and biology."*

Consumers with this prevailing behavioural form experience their own limits when it comes to getting to grips with nanotechnology and have to rethink or reconsider how they themselves could make the subject more comprehensible and present it to others in a didactic manner. In this context there is a certain fascination with the change in perspective offered by this subject. Comments like the following are examples of this type:

> *"In order to explain nanotechnology, we need new forms of illustration."*
>
> *"I am of the opinion that nanotechnology requires a rethinking of the sciences."*

The prevailing motive here is interest in knowledge and the transfer of knowledge and less a naive belief in progress. They would like to find out more about how nanotechnology works and grasp or pass on their understanding and ways of illustrating this subject.

Type VII: Reversal fears

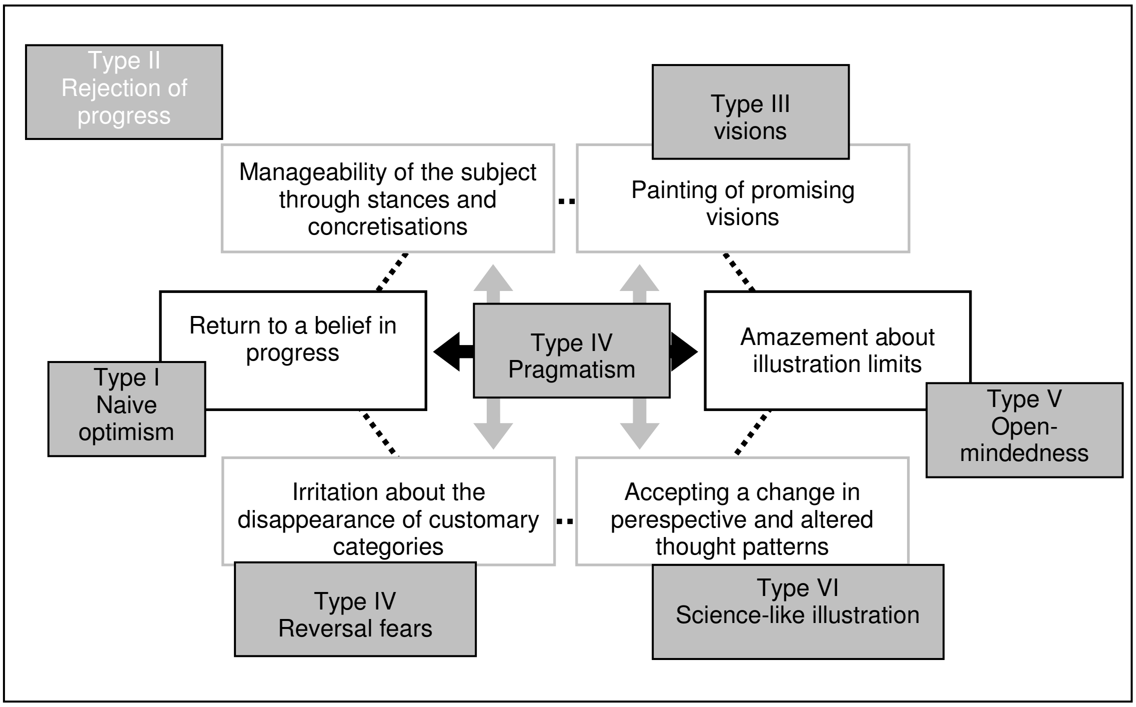
The behavioural form "reversal fears" was only observed in isolated cases. Here the irritations which crop up when examining the subject nanotechnology gain the upper hand (irritation about the disappearance of customary categories). Minute and invisible nanoparticles are the trigger for the painting of unlimited risks and catastrophes. The panic side of the subject is activated. For this type the fantasies go in the direction of growing surveillance by means of miniaturisation or in the direction of the development of weapons of mass destruction. There are fears that nanoparticles could have long since invaded the body.

> *"Our everyday lives are already full of synthetic nanoparticles. Just look at the car wash. Nano is everywhere."*
>
> *"Recently I sealed the windscreen of my car with a nanoproduct. Now that we're talking about this, I am filled with a feeling of horror that the nanoparticles may have entered my body. I'll have to go and see the doctor but wait a minute, the doctor won't find anything because the particles are too small."*

In Fig: 28 the ways of dealing with nanotechnology are assigned to the respective motivation structures in this context.

[31] The description and naming of this behavioural form corresponds to a behavioural form which we found in the research project on information behaviour on foods (Härlen *et al.*, 2004).

Fig. 28: Typical ways of dealing with the subject nanotechnology



4.4 Image of nanotechnology

In addition to the analysis of the motivation structures for dealing with the subject nanotechnology described above, the image of nanotechnology was also analysed. An analysis of this kind seeks to explicitly identify the differing levels of importance which the respondents attribute to the subject, and how these different interpretations come together in an overall picture. This is done by asking targeted questions in the interview about image aspects or by including other observation material (like for instance collages) in the analysis. In this way it is possible to determine how the subject is perceived at the present time, and how it is experienced. The differentiated analysis also throws light on problems or dynamics which point to possible or likely changes in its image in the future.

The analysis and categorisation of images are based on the concept of image impact units used in Morphological Psychology (SALBER, 1981; VIERBOOM, 1985; MELCHERS, ZIEMS, 2001). With the help of this concept images are classified both by their different dimensions and in a summary manner. The concept is based on the guiding principle of the interaction of various tense structures. These structures are examined with the help of the following categories:

Tradition and Change. What is of importance for the overall image of a product, brand or even a concept and its history is firstly the importance of the image it had in the past and whether its image is linked to continuity and stability. On the other hand, the aspect of innovations and flexibility of image play a role for the overall image in the area of tension between tradition and change.

Impression and Classification. The term impression sums up the moments of an image which cause effects like attraction or rejection, for instance temptation or annoyance. The word classification describes the positioning of an image in its environment. This is how the impressive dimensions of an image take on their specific value for the overall image.

Perspectives and Factualities. The image dimensions of perspectives describe the further development of an image in terms of perceived target or development directions. What is of importance for the overall image is whether it will be enhanced or deteriorate in future. Set against this are the factualities which describe the concrete benefits, services or shortcomings of an image.

The interest which consumers may develop in nanotechnology and the image that they create of it are not measured in this image analysis in terms of scientific knowledge. The focus of analysis is far more on the question about what consumers tend to do with this topic in respect of their daily lives and naivety. In its image qualities nanotechnology currently thrives on an expectation; to a certain degree it stands for the open attitude towards the future and its technical innovations.

The various image dimensions of nanotechnology are described in detail below. Each image polarity is preceded by a summary on a grey background.

4.4.1 Tradition and Change: Sympathetic figures – fountains of youth for believers in progress

Nanotechnology is well regarded in the areas of the natural sciences and technology, with a focus on the development of new materials. It is attributed the potential of making major contributions to solving urgent problems. With it people could envisage that belief in progress would once again become acceptable in Germany and that it is a kind of fountain of youth for the German research landscape, particularly in the field of natural sciences and technology.

The fundamental attitude towards nanotechnology is positive. It is used to restore more esteem to developments and findings from the natural sciences and future-centric technologies. Nanotechnology could help to encourage a less prejudiced and more open attitude towards technology in the natural sciences. It stood for the general trend for finally restoring Germany's belief in its abilities:

> *"Tinkering, researching, developing."*
>
> *"We only have our qualifications and our engineering skills. We don't have energy or mineral deposits."*
>
> *"It's about time we remembered what we are capable of."*

Some of the respondents linked their image of nanotechnology to older traditions. The discoveries in nanotechnology weren't so new. East Germans remembered that during the GDR era there had been discussions about orienting research and technology towards the "minutest milieu" so as not to miss the boat in terms of developments around the world.

The positive attitude towards nanotechnology feeds above all on the expected benefits. People hope to see practical applications for areas in daily life (cleaning, dirt protection) for maintaining value, longevity and aesthetics (car paint, gutters) or for protective clothing, medical engineering and pharmaceutical products. Young consumers are particularly interested in the product benefits which could result from miniaturisation in the field of consumer electronics and data processing. In this context the name Apple is frequently mentioned. The users of products like these have not missed the fact that this brand manufacturer uses the dual syllable "nano" (iPod nano) for one of its product groups in the field of MP3 players.[32]

[32] In conjunction with the trend towards miniaturisation, reference should be made at this point to the product names used by Apple and use of the small "i" by the company for some years now: iMac (computer) – iPod / iTunes (consumer electronics) – iPhone (mobile phone). With this wording that extends down to the level of small letters, the company seems to be placing its strategic bets in its product marketing on a fascination with miniaturisation.

Overall consumers see themselves as supporting nanotechnology. The following excerpts from the group collages (Fig. 29) illustrate how close they see themselves to it and just how some of them at the same time feel themselves to be closely surrounded and supported by "cool" nanotechnology (Fig. 29).

Fig. 29: "Nanotechnology is cool" – excerpts from the collages prepared during the group discussions in Dresden and Bonn

During the interviews it gradually became clear just how widespread nanotechnology is in our daily lives and society and in how many products it is already present. This realisation led to the estimation that nanotechnology was gaining more and more ground.

> *"This technology is fine and gentle, it's not a bulldozer."*
>
> *"As the name already says, these are dwarfs. They shouldn't be underestimated."*

Nanotechnology is seen as a technology which itself triggers change. These changes are not restricted to products; they can also refer to mentalities and social structures. Nanotechnology is, therefore, a carrier to which different, actual or desired changes are attached. It stands for a dynamic which above all makes natural scientific research once again acceptable in society. It stimulates a mood in which optimism and a belief in progress can emerge. It encourages a critical debate about sceptical attitudes towards progress. Just for once, people would like to see a great technology programme that bypasses premature concerns, criticisms and fears:

> *"What about research in Germany?"*
>
> *"Do you always have to be sceptical?"*
>
> *"Why not be more optimistic as far as research and development in Germany is concerned?"*
>
> *"Are we really going to be able to move forward if we immediately dwell on the dangerous consequences of every development?"*

At this point nanotechnology is assigned an image quality which is seen as the driver for renewal. Some people suddenly see German research and technology as a player of global dimensions. New thoughts are awakened in which a certain pride and fantasies of empowerment play a role. The collage excerpts (Fig. 30) presented below highlight the dynamics of empowerment.

Fig. 30: "Power for Renewal" – excerpts from the collages prepared during the group discussions in Dresden and Bonn

The main characteristic of these images is immunisation: arm yourself against objections, leave stress behind, let difficult things drip off you. The image of water running off the skin presents nanotechnology as a refreshing, therapeutic agent – modern technology in the role of a healing agent which gives free rein to the dynamics of research and development instead of bringing it to a grinding halt with red tape and concerns.

The special thing about these images and their use for the collage is that they express the special promise of the benefits of nanotechnology both in a detailed application (surface properties) and in general (the new technology as the protagonist of a mentality which seeks to establish itself and protects itself from too many obstacles to development). Here nanotechnology stands for successful surfaces and successful "superficiality" by means of which critical reflections must be pushed aside in order to help to achieve favourable growth conditions.

4.4.2 Impression and Order: Fascinating penetration in the microcosm – intelligent dwarf world with paradoxical orders

What is impressive here is above all the idea of penetrating the smallest dimensions of reality with nanotechnology and encountering a cosmos which seems to be as infinite as space. This microcosmos is assigned intelligence and order as well as usefulness and diverse application opportunities for human life.

Most consumers find it difficult to imagine how exactly nanotechnology functions, what effect it has and what substances or tools are used. However, during the critical dialogue, they still want to try and describe it and develop appropriate images. They also express emotional aspects of their reflective and imagination efforts:

> *"What sizes are conceivable in the small dimensions!"*
>
> *"It almost makes you feel small yourself when you imagine the nanoworld. I feel as if I could immerse myself in it like drowning."*
>
> *"I try and imagine these things as animations like you used to see in the children's programme (Sendung mit der Maus) on TV. Loads of sweet, little dwarfs."*

"Perhaps this could give us access to the source of matter. That can make you feel a bit strange."

However the respondents did also approach the subject with rational impetus. In this case the descriptions are empty in content; however, they don't let themselves be misguided and postulate a world of the smallest dimensions and what it must be like:

"Purely theoretically there could be a gigantic, infinite extension into the small or? I just find it difficult to visualise that."

"This is something completely new. The smaller you imagine something to be, the more you can perhaps fit into it."

"You are on the level of the smallest particles like atoms. Nanotechnology operates on the molecular level. I don't know how it works but I have already read that it is being used."

"I've heard that nanotechnology comes from space. That people work there with substances that can withstand the greatest extremes in terms of heat and cold, extremes you don't find on Earth. Then people go to the laboratory and workshops to do research on the minutest."

Attempts to rationally understand the topic are not easy and tend to return to what are deemed to be the attractive aspects of nanotechnology (Fig. 31). The respondents sense the abstract terrain they are entering, but don't let themselves be deterred from their fascination:

"How gigantic the expansions are that you can imagine in the small!"

"You have to try and understand that it's like a giant expansion but on the inside."

"Material science of the very best."

These fantasies of a nanotechnological cosmos and its emotional attractiveness are not easy to sway. Their strength is drawn from childhood and adolescent memories of certain science fiction films (see Chapter 4.2.1).

Classifications of the subject are marked by the attempt to reformulate something that is unimaginably modern into something daily, in other words: to turn the experienced cosmos, the "space" of nanotechnology into something in everyday life.[33] The promise of diverse applicability along with the application opportunities for nanotechnology projected into the future support this stance. In conjunction with the daily usability of nanoproducts, an image of nanoparticles is created as a mass of intelligent midgets or "dwarfs" which – be it as substance and material, be it as technology and tools – already simplify life right now but will do even more in the future.

[33] See also Salber, 1989, p. 198: "Der Alltag behandelt den All-Tag."

Fig. 31: "The expansion of the minutest" – excerpt from a collage prepared during the group discussion in Dresden

Whereas daily usability can be easily illustrated through the benefits of the products, there are some forms of this technology which are dependent on a certain willingness to take a look at paradoxical relationships. Critical assessments of this kind may be perceived as interesting mind games.

> *"Nature with its living beings and plants is in many ways far smarter than us and can serve as a model; this is demonstrated for instance by the lotus flower or fish which organise themselves in shoals and can react as fast as lightning to new situations – this is something we could draw on for road traffic. Or the shark with its intelligent skin whose construction principle is imitated for modern swimsuits and divers' suits."*

> *"Perhaps nanotechnology is also ecological? When for instance you need fewer cleaning agents and other harmful additives like for instance for varnish?"*

Nanotechnology can also be seen as a yardstick of intellectual flexibility. It creates irritation, challenges proven thought categories and calls for a new attitude:

> *"How can a nanosurface make a liquid drip off when it's not even smooth but rough or structured? And what does this surface do to make a liquid assume a droplet form?"*

> *"How can a nanosurface be both solid and liquid at the same time and, after it has been scratched, more or less repair itself (car paint)?"*

> *"If you imagine yourself in the world of the really minute, then it looks as if everything there is suddenly big, like in a film."*

> *"It might be that the smallest particles of matter reach a threshold where they become nothing?"*

> *"The idea is fascinating that simply by means of a thought or a desire and some kind of link to technical apparatus in the physical world you can move something without the nerve endings, muscles or arms which are normally available to the body. You already hear about experiments of this nature which are said to work."*
> *"It is strange that there are nanomaterials which can help to perfectly seal something but which can penetrate the body and skin because they are so small."*

"Surfaces aren't as smooth as we always imagine perfect surfaces to be."

"How should we imagine materials becoming another substance simply because minute parts are produced from them?"

The critical evaluation of nanotechnology leads to new questions which have never been asked before. Some respondents feel like they have returned to their puberty or adolescence, a period in their lives which they associate with in-depth or even "weird" questions. They start to realise that nanotechnology could lead to completely new considerations, that it demands intelligence, awareness perhaps even respect for something

"Nanotechnology can be used for good and bad purposes. You have to realise that."

"It's less problematic in its simulation of nature whereas genetic engineering intervenes directly in life."

"It's not subatomic, there's no splitting of the atom. Matter is not tortured."

"A technology enabling you to deal with the world in a clever way."

"Nanotechnologies always sound like they were tools. You think of use and not of misuse of nature."

Fig. 32: "Nanotechnology as a teacher" – excerpt from a collage prepared during the group discussion in Dresden

4.4.3 Perspectives and factualities: Source of undreamt-of opportunities – promising opportunities and reversal risks

The generally friendly response to nanotechnology shows that it is granted some advance praise. Nevertheless, the exploitation of its technical opportunities seems to be linked to careful processes. Under these circumstances it is deemed to offer major benefits when it comes to solving and miniaturising the problems of mankind. However, there is some remaining unease; people don't know where the reversal risks of such a new and unaccustomed technology are lurking.

Nanotechnology promises to exploit completely new "spaces" and opportunities. This perspective is not very concrete; it is not clear what these spaces look like and what individual opportunities will emerge from this technology. Nevertheless, this perspective sounds like a promise. The idea of a "minute", "inwardly oriented" boundlessness of the physical world means it is possible for some respondents to start to see the world with its deposits and resources not as a limited "fixed apple pie", but as something with completely new extensions, i.e. new uses, too.

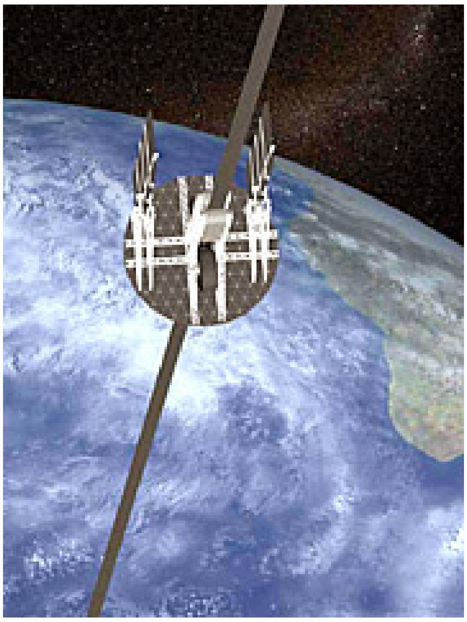
"Twice as fast, twice as productive, half as big. That's what we already experience with some developments."

Miniaturisation activates reflections that one should deal carefully and non-violently with nanotechnology as well. Nanotechnology stands for the mastery of fine structures and for a process of tapping and discovering, instead of conquering and exploding (Fig. 33).

"Grid electron microscope instead of a space telescope."

This cautious attitude leads on to the prospect of completely new developments. Being able to develop is then an attitude and stance which becomes “a resource” to which expectations and future visions are linked.[34]

Fig. 33: “Discover instead of conquer” – excerpts from the collages prepared during the group discussions in Bonn and Dresden



Because of the suspected development potential, nanotechnologies awaken hopes of “miniaturising” the problems of mankind. They are linked to the

“Repairing of civilisation and environmental damage.”

“Treatment of disease.”

“Creation of new resources and energies.”

Uncertainty and moves to awaken risk awareness are set against these hopes of far-reaching benefits. There was still only very little robust knowledge about nanotechnology. The viability of the many applications was still mostly unclear. Here and there the suspicion is also voiced that some of the promises from industry could turn out to be pure marketing gags.

When it comes to foods all the critical evaluations touch on questions of the meaning of life. When it comes to the idea of using nanotechnological substances and technologies in the production of food, the respondents are downright indignant and sensitive. They are worried about the unnoticed penetration of substances into their everyday lives. Nanotechnological substances could multiply freely in the body and air because of their low expansion and cause havoc as “hostile dwarfs” (Fig. 34).

“They’re not just getting onto your back, but passing through your skin.”

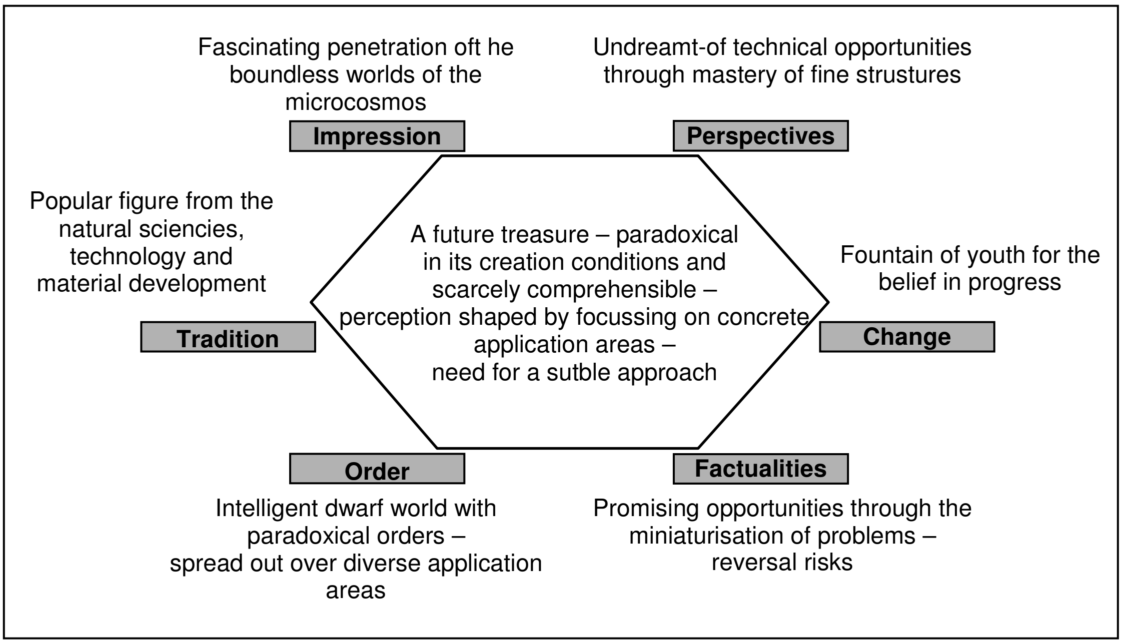
[34] In the context of this image dimension, the discussions about and appeals for research, education and development as the “resources of Germany” are given new input and perspectives.

Fig. 34: "Hostile nanodwarfs" – excerpt from a collage prepared during the group discussion in Dresden

Summary
Amongst consumers nanotechnology has the image of a future treasure. The view of this technology is shaped by fixations on concrete applications. However, consumers do not ignore the difficulties of understanding this subject but are prepared to start to accept that they are dealing with paradoxical legitimacies and forms of appearance. There is also a feeling for the fact that nanotechnology calls for a subtle approach.

The results of the image analysis are compiled below in Fig. 35. The figure aims to present the image dimensions and their internal classification described above.

Fig. 35: The image of nanotechnology and its individual dimensions



4.5 Effect of various information contributions on nanotechnology

Given that most consumers know very little about nanotechnology, additional information on the subject was introduced later into the unprompted questions. This information concerned definitions of the term nanotechnology, possible areas of use and also conceivable risks (cf. Annex 7.1, Information material for participants in the qualitative survey). In this way it was possible not only to achieve a high degree of intensity in dealing with the subject and a comprehensive survey of the subject under examination despite the low level of knowledge. In dealing with various information materials on nanotechnology, it is also possible to a certain extent to observe how they are received. The extensive description and analysis of the reception effects was not part of this project. The observations on the critical evaluation by the respondents and on their responses to the information material were, however, so insightful that they are described below briefly and compared with the focus on the impact structures of dealing with nanotechnology (see Chapter 3.2).

Response to the BMBF website "nanoTRUCK" – "Station 1 Principle – Definitions"

- The website initially meets consumer needs for manageability; this is done by the provision of various communication pathways and resources (images, texts, highlights, comparisons).
- Belief in the future is awakened: the website has an optimistic basic tone (airy impression because of the blue background colour); one would however like to apply a brake to this overly simple optimism – "too superficial".
- At the same time the observers are amazed by the comparison "hazelnut – earth in the centre" and its image logic; here it can be observed how in some cases a change in perspective can be triggered by irritating magnitudes.
- By linking this to images like "space" or "cosmos" the observers move more deeply into the subject nanotechnology.
- The first efforts to understand, which have already been triggered ("stumbling into the" topic, being amazed), are not continued. The terms "top down" and "bottom up" are not comprehensible to most people; respondents feel that the promises of "paths into the nanoworld" are "not kept".

Response to "Frequently Asked Questions (FAQs) about nanotechnology" – excerpts from the BfR website

- The BfR comments on nanotechnology are interesting at first sight and taken note of. With this format people as recipients participate in the progress, by using a modern medium – an effective setting which promotes the processing and digestion of information.
- The question and answer format on the formal level constitutes a directly perceivable technique of change in perspective: questions are asked, answers given, alternating between "positive" and "negative" aspects of nanotechnologies.
- The information on novel topics takes place in a clear setting – no-one needs to feel overtaxed or irritated; everyone can approach this topic at his own pace "in small doses" and whilst reading easily jump ahead or go back.
- The needs for manageability are served by impartiality, details, "can" formulations, listing of unanswered questions.
- Overall the information material is stimulating; it triggers further interest in information by treating the topic and the uninformed reader gently. The website is not seen as a "show" which is shaped by a simple belief in progress or pessimism. This is a functioning

information platform for the transfer of knowledge that draws on various forms (pragmatism, science-like illustration, open-mindedness).35

Response "Exercise caution when using "nanosealing sprays" containing a propellant!" – BfR press release 08/2006, 31 March 2006

- This information also offers the recipients the initial promise of managing the topic, for instance by listing and describing concrete risk cases and numbers.
- The introduction to nanotechnology is, however, soon interrupted and the subject "aerosols" moves centre stage. The recipients react to this by remembering known associations; aerosol sprays should not be inhaled and some people knew that – no need for a rethinking of attitudes.
- The recommendation that the sealing spray should not be used in confined spaces prompted bad feelings and irritation in some interview partners and even to irony and sarcasm. Were you supposed to carry your sink into the garden and spray it there and then reinstall it in the bathroom?
- The last paragraph contains unsettling information about the notification obligation for doctors and on further procedures. BfR, therefore, presents itself as an institution which calls for a stance to be taken and sees itself as having an obligation to provide information.
- In terms of overall impact this information only attracts the interest of the respondents to a limited degree; also because of the focus on another subject complex (aerosols), the motivation structures for a critical evaluation of the subject nanotechnology are not actually touched on.

[35] The described responses to the FAQ format on nanotechnology are similar to the responses to "BfR FAQs on Acrylamide" (Vierboom *et al.*, 2007). Confirmation of the productive effect of this information format on the critical evaluation of difficult or not overly differentiated subjects permits the conclusion that FAQs are not just a modern but are an essential communication tool for institutions like BfR. With this communication tool BfR can provide consumers with important information which stimulates their interest and critical evaluation of risk topics.

5 Summary and Conclusions

5.1 Summary

Based on the questions formulated in the introduction, the results of the empirical studies can be summed up as follows regarding the preconditions for risk communication:

How widespread is knowledge about nanotechnology in the population?

Roughly 50 % of the population are not familiar with the term nanotechnology or cannot really imagine anything concrete about it. The other 50 % are able to specify nanotechnology in one way or another. Based on the survey results from previous years, the proportion of those who are not familiar or have no concrete knowledge about this subject has fallen from around 80 % in 2004 (komm.passion, 2004) to around 65 % in 2006 (Rosenbladt, 2006, p. 676).

The typical consumer specifications of the term nanotechnology have been restricted so far to categories like “miniaturisation” and “surface treatment”. Detailed knowledge about the specificities of nanotechnology and how it works could only be identified to a limited degree in the qualitative survey. It was of no relevance in the answers to the question about knowledge of nanotechnology in the standardised survey.

Is the public perception of nanotechnology in Germany population more from the risk or the benefit angle?

Overall, the perception of nanotechnology is characterised by the fact that the vast majority of the respondents deemed the benefits to be greater than the risks. When it comes to the feeling about nanotechnology, too, more respondents had a very good or good feeling. In the qualitative survey, scarcely any of the respondents spontaneously developed terrifying images in conjunction with nanotechnology. Nevertheless, ideas about “free” nanoparticles can trigger fears because they lead to fantasies about small, non-controllable particles and parallels are drawn to “free radicals” or “fine dust”. From the angle of consumers a considerable risk seems to be imaginable.

When are risk aspects and when are benefit aspects predominant in the public perception?

Nanotechnology creates hopes of substantial improvements in many applications. The hopes are mainly linked to the field of medicine and environmental engineering. Possible improvements to products, which are directly purchased by consumers, have, by contrast, a far lower weighting. The hopes linked to nanotechnology can extend far beyond the area of improvements to products. Nanotechnology can be instrumentalised as a force against cultural pessimism and hostility to progress. It, therefore, offers an opportunity for a return to belief in progress or hopes of a positive development of the location Germany. This spread of hope is possible above all because the subject is perceived in a holistic manner and there is only very basic concrete knowledge about how this technology works.

What psychological and cultural factors determine the public perception and assessment of “nanotechnology”?

When it comes to nanotechnology, it is mostly the fascinating sides that are stressed. This fascination relates both to miniaturisation and to the perceived potential for solving the urgent problems of mankind, e.g. the “miniaturisation of problems” through diverse simplifications in daily life, a reduction in environmental problems and the creation or discovery of energy resources. What is characteristic for this fascination is amazement about the diverse opportunities of the technology and about one’s own comprehension limitations. The quantitative survey provides insight into this fascination above all in the area of surface sealing. Although no questions were directly put about this fascination, the high acceptance values in this area provide empirical evidence of this.

How is nanotechnology to be classified on the basis of classic determining factors for risk perception, particularly regarding voluntary risk exposure, familiarity with dealing with risks, the reversibility of possible damage or risk visibility?

Amongst consumers there is no developed risk perception of nanotechnology at the present time. This also means that here are no highly profiled fears either.

The almost unnoticed spread of nanoproducts in daily life can become a problem when images develop of an industry which has joined forces and seems to be working against consumer interests. Above all in the context of “free nanoparticles – food production”, this unnoticed spread can lead to a high degree of sensitivity and fear because then two contexts that are deemed to be “uncontrolled” are potentiated and exacerbate one another.

What analogies can be established depending on the application areas to known technologies that are discussed more?

One specificity when dealing with nanotechnology is that, despite its labelling as a modern technology driven by industry and despite the perceived lack of transparency, it has not been dragged into negative assessments like genetic engineering or nuclear energy. In terms of its mainly positive image, nanotechnology enjoys a special position and so far consumers have succeeded in separating it from other technologies that are deemed to be threatening.

When assessing nanotechnology do differences arise depending on the application areas (food, cosmetics and consumer products)?

The overall highly positive general assessment of the topic nanotechnology becomes more differentiated when it comes to acceptance of different application areas. In this context additional assessment categories and schematas play a role. What are mainly noticeable in this context are the following points:

- Acceptance falls as the products come closer to the body or are seen as having an impact in the body. Hence, the acceptance for products for surface sealing or for improving the properties of textiles are far more accepted than products in cosmetics or even foods.
- In the medical field there is also acceptance when the substances penetrate the body and act there. The perceived benefits of the technology are shaped by fear of disease or the hope that they can be treated (even with the help of nanotechnology). Here value hierarchies come into play which we already know from the evaluation of “red genetic engineering”.
- Fears are triggered above all by ideas about “free” nanoparticles. By contrast, the embedding of the particles in “grids” or other “binding” structures does not give rise to hardly any fears at all.

Concrete experience of the benefits are linked to or can be easily associated with nanotechnology. Benefits play a role above all in the field of medicine. In the case of consumer products, benefits that involve easing the daily burden are not necessarily deemed to be essential. Nevertheless, many consumers are of the opinion that nanotechnology does ease the burden of daily life.

5.2 Conclusions

For risk communication this leads to the fundamental challenge that it can only draw to a limited degree on existing knowledge because getting to grips with nanotechnology does not pass through its rational functioning but more through the (hoped for) applications. Nevertheless, preparations can be made which make possible targeted steering even in a crisis situation. What is of particular importance in this context is the development of images and explanations by means of which nanotechnology can be presented in a simple manner. Images and explanations of this kind can also be made available to multipliers in order to inform citizen or consumers.[36] This offering helps to maintain the power to act in the event of a risk and not to leave public opinion forming to its own devices.

The better the images and terms reflect the factual and knowledge logics when handling the subject described in this report, the more they are in a position to foster understanding of nanotechnology as a whole or individual aspects of it.

The differentiated depiction of nanotechnology in risk communication may offer the following advantages:

1. It reduces reactions to risk communication. In the study a major fascination with the opportunities of nanotechnology was observed. The hopes placed in this technology can lead to a lack of willingness amongst some of the population to critically evaluate risk information. Reactance can be reduced if the message can be successfully put across that risk information does not refer to nanotechnology as a whole but only to some parts of it. Appropriate images and explanations, therefore, help to increase willingness to engage in risk communication.

2. This prevents a general condemnation of nanotechnology. Because of the lack of knowledge about nanotechnology it is likely that some members of the public will react with an undifferentiated condemnation of nanotechnology in response to reports of damage. A general reaction of this kind can be countered by a differentiated depiction. Appropriate images and explanations can, therefore, help to limit fears about nanotechnology.

One differentiation which is comparatively easy to communicate is the distinction between bound and free nanoparticles. When risk information refers to free nanoparticles, a distinction between these two areas does seem to be possible. For other areas it may be necessary to develop further explanations and to test them for their viability.

The population is ready to accept differentiating, risk-oriented and user-oriented communication. This is shown by the major importance of the behavioural form “pragmatism”. Subject to the precondition that appropriate images are developed to communicate risk information, this form of communication strengthens the information power of BfR.

Although the overall mood regarding nanotechnology is positive, there are major reservations particularly about food. Nanotechnology and nanoparticles are not seen as “natural”. Based on the widespread judgement schema in the field of food that natural is “good” and non-natural is “bad”, nanotechnology and nanoparticles tend to be generally seen as a threat from which food should be protected. Hence, in this area risk communication encounters completely different preconditions from those found in other nanotechnology applications. The challenge in the case of nanotechnology and food is probably less the reaction to the perception of risk reports and more the reaction to a differentiating depiction as this could

[36] On the standing of BfR amongst multipliers from the media, particularly amongst those who feel obliged to engage in useful journalism, cf. VIERBOOM *et al* (2007).

contradict the assessment schema "Naturalness is good". By labelling nanoparticles on packaging, this could strengthen the impression that nanoparticles are threatening, because they have to be specifically listed.

Furthermore, the specificities of the subject nanotechnology lead to consequences for the authority of a scientific institution. Against the backdrop of the study the following points should be mentioned in this context:

1. Based on the hopes and expectations and the limited knowledge about nanotechnology, an institution of this kind that publishes information about potential risks could be seen as a "spoilsport" that interferes with positive expectations and people no longer want to listen to it. To reduce the dissonance between hopes and expectations on the one hand, and reports about risks on the other, either the hopes and expectations or trust in the scientific integrity of the institution may be reduced. A development of this kind can be contained by means of a differentiated depiction of the different application areas.

2. Besides interaction with all the stakeholders from politics, industry, science, non-governmental organisations and associations, close co-operation with consumer associations can help more particularly to demonstrate BfR's duty to consumers. For instance, consumer conferences can help to strengthen trust when they are perceived as a sign of the identical interests of consumers and the work of BfR.

3. Ongoing documentation of the work on nanotechnology helps to present BfR as an active and not as a reactive institution:
   - "They are working on the field of nanotechnology."
   - "They are engaged in research, collecting and bundling information, staging events and keeping an eye on the subject."

The communication medium "Frequently Asked Questions" that is continuously used by BfR meets these requirements. Thanks to its format and its embedding in modern technology, it provides important information for consumers in such a way that it stimulates their interest and their willingness to take a critical look at risk topics. Furthermore, this format gives readers the feeling that they can digest a subject at their own pace and needn't worry about being inundated with risk information.

Against the backdrop of the results of this project, the hypothesis seems to make sense that in future there will be battles about the stances on and attitudes towards the shaping of public opinion. For the purposes of describing the possible, future development paths of opinion-forming, it would be possible to work with scenario and simulation techniques like the ones used for instance in the group discussions within the framework of this project or in consumer conferences.[37] The results of a process of this kind can help to prepare for future questions of risk communication. Nanotechnology can be a very emotional subject.

[37] See BfR-Wissenschaftsheft on the Consumer Conference Nanotechnology (Zimmer *et al.* 2008a).

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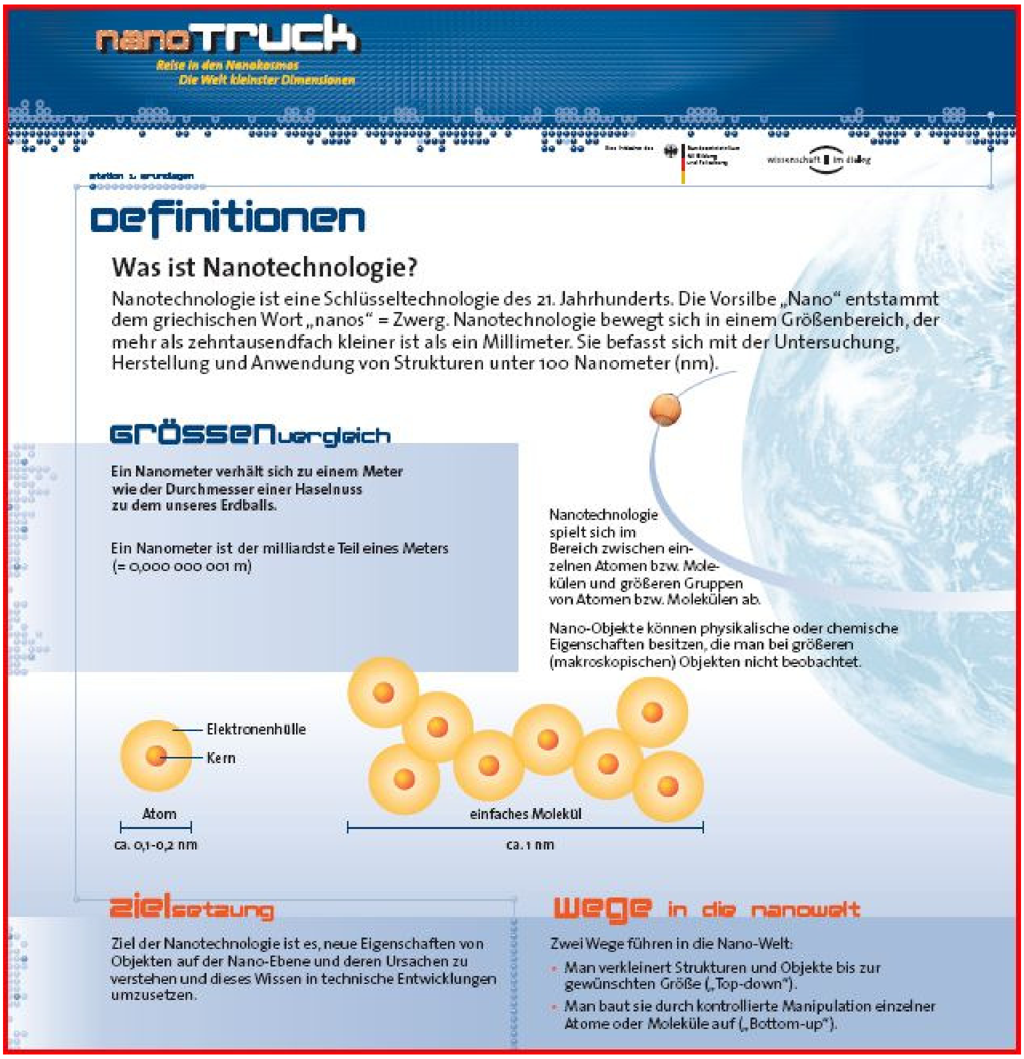
7 Annex

7.1 Information material for participants in the qualitative survey

7.1.1 Website “nanoTRUCK” of BMBF – “Station 1 Basics – Definitions”



7.1.2 “FAQs Nanotechnology” – excerpts from the BfR website

What does the term nanotechnology mean?

Nanotechnology is the generic term for a wide range of technologies that are used in various natural sciences like physics, chemistry, biology and medicine. It would in fact be more correct to talk about nanotechnologies. Nanotechnology involves research into, the processing and production of structures and materials with at least one dimension smaller than 100 nanometres (nm). Nanomaterials are "dot shaped" structures (nanoparticles, nanocapsules, clusters or molecules), "linear" structures (nanofibres, nanotubes, nanotrenches) and ultra-thin coatings. Inverse structures (pores) also come into this category.

With the help of nanotechnology it is possible to develop structures, techniques and systems with completely new properties and functions. Industry, medicine, science and consumers hope that this potential will lead to beneficial applications for instance in robotics, sensor technology, process engineering, biotechnology and medicine as well as for the further development of foods, consumer products and cosmetics.

How small is a "nano"?

"Nanos" comes from the Greek and means dwarf. "Nano" is the term used for the billionth part of a metre (= 1 nanometre).

What do we mean by nanoparticles?

Nanoparticles are particles with a diameter of less than 100 nanometres (nm). Because of their small size nanoparticles have different physical properties to larger particles of the same substance. This makes them interesting for various applications. At the same time, however, the smallness of nanoparticles can lead to adverse reactions.

In which products has nanotechnology already been used?

Already now consumers come into contact with products whose components have been produced with the help of nanotechnology, be they cosmetics, foods or textiles. The market for nano products is growing rapidly. It is the nano dimensions alone that make it possible to produce substances with completely new properties: car paint that is scratch resistant, a tie that is dirt repellent or sunscreens that offer better protection against UV light.

Are nanomaterials used in foods?

It is reported that nanomaterials are used as auxiliaries and additives in foods. For instance, silicic acid and other silicon-containing compounds are said to be used as trickling or thickening agents to prevent sodium chloride crystals and powder-form foods from sticking together and to make ketchup pour more easily. Silicic acid is also used as a flocculant in wine and fruit juice production. It is not yet clear whether nanoparticles are actually used and, if this is the case, whether free nanoparticles then occur in foods.

The food industry is currently developing functional foods in which vitamins, omega 3 fatty acids, phytosterols and aromas are enclosed in nanocapsules and then released in the body.

Is there a specific health risk from nano products?

In order to estimate whether nano products constitute specific health risks it is important to know whether the nanomaterials used are bound in a matrix or are present in the product in unbound form. In particular free nanoparticles, nanotubes or nanofibres could lead to health risks through their small size, form, high mobility and higher reactivity.

Unbound nanoparticles could reach the human mechanism via three paths and develop a toxicological impact under certain circumstances: the respiratory tract, the skin and the gastrointestinal tract. Scientists believe that the greatest risks stem from the inhalation of nanoparticles. The latest scientific findings largely rule out the possibility of nanoparticles penetrating the human skin. We do not yet know whether there are any risks involved in the uptake of nanoparticles from the gastrointestinal tract.

Up to now most nano products consisted of nanoparticles that are enmeshed in a solid matrix or liquid suspension. Furthermore, nanoparticles tend to aggregate into larger unions which are generally larger than 100 nm. The toxic effects of nanoparticles linked to their small size and higher reactivity are then no longer relevant.

In principle, manufacturers are obliged to guarantee that their products are safe.

Has a product containing nanomaterials already caused damage to health?

So far BfR has not received any reports about cases in which health damage was shown to have been caused by nanoparticles or nanomaterials. The health disorders, in some cases severe, which occurred after the use of so-called nano sealing sprays were not due to the nanoparticles according to the BfR findings. More than 110, in some instances, severe cases of health disorders had been reported to the poison control and treatment centres and BfR by the end of March 2006. Consumers had used the products Magic Nano Glass Sealer and Magic Nano Ceramic Sealer in spray doses with a propellant. Initially it was thought that nanoparticles were involved in the lung function disorders. According, however, to information from the manufacturers and tests by BfR, the products did not contain any nanosized particles. It is still not clear what caused the respiratory disorders.

7.1.3 "Exercise caution when using "nano-sealing sprays containing a propellant!" – BfR press release 08/2006, 31 March 2006

Sealing sprays for glass and ceramics containing moisture-repellent nanoparticles and a propellant should not be used in confined spaces. The Federal Institute for Risk Assessment has good reason for pointing this out. Over a short period of time the poison control and treatment centres of the federal states have reported 39 cases involving serious health disorders following the use of household products of this kind. All the people involved complained of respiratory distress. In six cases pulmonary oedemas were diagnosed which had to be treated in hospital.

Sealing sprays with nanoparticles for ceramic and glass surfaces are a new type of household chemical. In the bathroom and toilet they are said to make surfaces water and dirt-repellent. Liquids are said to trickle off without leaving behind any rings or lime spots. This product is sold in pump bottles and aerosol cans.

Some users suffered severe health disorders after using aerosol cans. It seems they had inhaled components of the spray which had remained in the ambient air as fine particles of the aerosol. The particles from the spray may have disrupted the function of the alveolar and bronchial tissue in the lungs and, by extension, the oxygen and moisture exchange. This led to respiratory distress and, in severe cases, to accumulation of water in the lungs (pulmonary oedemas).

No such incidents have been reported in conjunction with products applied to surfaces using pump bottles.

The competent regional authorities and the poison control and treatment centres of the federal states have since issued warnings about two products which were sold in Penny stores according to the manufacturers (e.g. www.giz-nord.de/php/index.php?option=com_frontpage&Itemid=1). The incidents have also been recorded in the European rapid alert system for non-food products RAPEX. The distributors have launched a recall and advised against using the sprays.

As the exact cause of the health disorders has still to be established, BfR advises all consumers, who have already purchased nano-sealing sprays on a propellant base, not to use them in confined spaces.

No information is available as to whether other products with nanotechnological components and a propellant (e.g. shoe care products, impregnating agents, moisture blockers, etc.) are also on the market which may constitute a hazard. If respiratory disorders should occur after using sprays of this kind, the consumers affected should immediately contact a doctor or a poison control and treatment centre. It is important to bear in mind that in order to fully understand the situation they need to see the product used!

Because of these recent incidents BfR points out that, in accordance with the Chemicals Act, doctors in Germany are bound to notify the BfR Poison and Product Documentation Centre of any health impairments in conjunction with chemical products.

BfR is working flat out to establish the cause of these recent health disorders. There are plans for scientific discussions.

7.2 Questionnaire for the standardised survey

Consumer Survey September 2007

Hello, my name is ....
I work for the Market Research Institute Produkt + Markt. We are currently conducting a short telephone survey on the subject "New Technologies". The interview takes approximately 10 – 15 minutes.

INTERVIEWER: If asked about this:

The Institute explicitly assures you that all your details will be handled confidentially and will be evaluated in a compiled form in such a way that they cannot be traced back to an individual.

Screening

1. **Federal state (Quota)**

2. **For statistical reasons I would like to begin by asking you for some general details. Would you please tell me how old you are?** (Quota, individuals aged between **16** and **60** are interviewed)

   |___|___| Years

3. **Gender** (Quota)

   INTERVIEWER: Don't forget to read out the question!!

   Male ☐ 1
   Female ☐ 2

4. **The next questions are about new technologies. I will begin by reading you the names of various technologies. Please tell me which ones, in your opinion, will become more or less important for our lives or the ones which will neither lose nor gain in importance.**

   INTERVIEWER: Read out!

EDP: Rotation of statements	Importance increases	Importance remains the same	Importance decreases	Term unknown
Nanotechnology	1	2	3	4
Biotechnology	1	2	3	4
Environmental engineering	1	2	3	4
Information technology	1	2	3	4

5. **What have you heard or read about nanotechnology or nanomaterials? Please tell me everything you know about this!**

   INTERVIEWER: Ask for more details! Note down everything!

   ____ |___|___|

   ____ |___|___|

   ____ |___|___|

6. **Now we would like to know what you think about nanotechnologies. I will explain briefly to you what nanotechnology is. Nanotechnology makes it possible to produce particles which are roughly as big as atoms or individual molecules. Materials made of these particles have special physical, chemical and biological properties. How much have you heard already about nanotechnologies?**

   INTERVIEWER: Read!

   Nothing at all ☐ 1
   A little ☐ 2
   A lot ☐ 3

7. I'm now going to read you some applications for nanomaterials and would like to know whether you approve or disapprove of the respective application. Please distinguish between "I would completely endorse it", "I would tend to endorse it", "I would tend to reject it", and "I would completely reject it".

INTERVIEWER: Please read the entire question (all answer options) and then ask about the individual statements! The respondent should comment on each statement! Ensure that the respondent is always aware of the fact that the questions are about the use of nanomaterials!
EDP: After asking about the 5 statements insert the following: "We're still talking about the question about the extent to which you endorse the use of nanomaterials in the respective area."

EDP: Rotation of Statements	I would completely endorse it	I would tend to endorse it	I would tend to reject it	I would completely reject it
Encapsulate vitamins in order to improve their action in the body	1	2	3	4
Prevent lumping of spices (like paprika)	1	2	3	4
Make food look more appealing for longer	1	2	3	4
Increase the efficacy of sun protection creams	1	2	3	4
Use in soaps and creams to improve skin cleaning and disinfection	1	2	3	4
Use to repair damaged dental enamel	1	2	3	4
Prevent formation of unpleasant odours in textiles	1	2	3	4
Improve dirt repellence of textiles	1	2	3	4
Improve film quality to extend the shelf life of food	1	2	3	4
Incorporate into packaging materials in order to render food decay visible	1	2	3	4
Improve scratch resistance and dirt repellence of paints and varnishes	1	2	3	4

8. When you think about the explanations of the term nanotechnology which I have just read to you, how do you see the risk-benefit relationship? Which of the following statements would you agree with?

INTERVIEWER: Read! *EDP: Alternate by starting with the risks (Codes 1 to 4) or the benefits (Codes 4 to 1)!*

The risks of nanotechnology greatly outweigh the benefits. ☐ 1
The risks of nanotechnology slightly outweigh the benefits. ☐ 2
The benefits of nanotechnology slightly outweigh the risks. ☐ 3
The benefits of nanotechnology greatly outweigh the risks. ☐ 4

9. In which of the following areas do you see the biggest benefits of nanotechnology?

INTERVIEWER: Read! Only one response possible! *EDP: Rotation of Statements*

Improved medical treatment options ☐ 1
Improved environmental engineering ☐ 2
Improved protection and safety technologies ☐ 3
Improved consumer products ☐ 4
Improved foods ☐ 5

10. Would you buy products from the following groups if they contain nanomaterials? Please answer "Yes, I would buy them" or "No, I would not buy them".

INTERVIEWER: Read!
EDP: Rotation of Statements

	Yes	No
Surface sealing and care	☐ 1	☐ 2
Clothing	☐ 1	☐ 2
Cosmetics	☐ 1	☐ 2
Food	☐ 1	☐ 2

11. How well informed do you think you are about nanotechnology compared to other modern technologies like biotechnology, information technology?

INTERVIEWER: Read!

Better	☐ 1
Equally good	☐ 2
Worse	☐ 3

12. Where have you already heard, read or seen something about the subject nanotechnology? I'm going to read you some responses. Please tell me if you have heard something about nanotechnology from that source!

INTERVIEWER: Read!
EDP: Rotation of Statements

	yes	no
Television	☐ 1	☐ 2
Radio	☐ 1	☐ 2
Internet	☐ 1	☐ 2
Newspapers	☐ 1	☐ 2
Magazines	☐ 1	☐ 2
Conversations with friends, colleagues, etc	☐ 1	☐ 2
Conversations with experts, e.g. doctors, tradesmen, chemists, etc	☐ 1	☐ 2

Are there other information sources from which you heard, read or saw something?
(Other: ____)

13. Where or how would you find out about the subject nanotechnology? Again I will begin by reading you some response options.

INTERVIEWER: Read!
EDP: Rotation of Statements

EDP: Rotation of points	yes	no
Television	☐ 1	☐ 2
Radio	☐ 1	☐ 2
Internet	☐ 1	☐ 2
Newspapers	☐ 1	☐ 2
Magazines	☐ 1	☐ 2
Conversations with friends, colleagues, etc	☐ 1	☐ 2
Conversations with experts, e.g. doctors, tradesmen, chemists, etc	☐ 1	☐ 2

Are there other information sources you would use?
(Other: ____________________________)

14. How much trust would you place in the following persons or institutions when they inform you about nanotechnology? Please rate your answers in the following way: "Complete trust", "Some trust", "Little trust" and "No trust at all".

INTERVIEWER: Read!

EDP: Rotation of Statements	Absolute faith	Some faith	Little faith	No faith at all
Managers from industry	1	2	3	4
Government representatives	1	2	3	4
Scientists	1	2	3	4
Health and safety authorities	1	2	3	4
Doctors	1	2	3	4
Consumer associations (Stiftung Warentest, consumer advice bureaus)	1	2	3	4
Environmental organisations (Greenpeace, Foodwatch)	1	2	3	4

15. What's your overall feeling about nanotechnology?

INTERVIEWER: Read!

Very bad	☐ 1
Bad	☐ 2
Good	☐ 3
Very good	☐ 4

16. What is the relevance, in your opinion, of nanotechnology for the location Germany?

INTERVIEWER: Read!

Major importance	☐ 1
Average importance	☐ 2
Little importance	☐ 3

17. In your opinion which are the leading countries in nanotechnology?

INTERVIEWER: Ask follow up questions! Maximum 3 main countries!

1. ____ |___|___|

2. ____ |___|___|

3. ____ |___|___|

18. To what extent do you agree with the following statement: The government can be trusted to protect the public from environmental and technical risks.

INTERVIEWER: Read!

Completely agree	☐ 1
Tend to agree	☐ 2
Tend to disagree	☐ 3
Completely disagree	☐ 4

19. I'm now going to read you some statements and opinions of consumers. Please tell me to what extent you agree with the statement or whether the statement personally affects you, too. You can decide whether the statement applies completely to you, tends to apply to you, tends not to apply to you, does not apply at all to you.

INTERVIEWER:	Please read all the answer options slowly and then ask about the individual statements! The respondent should comment on each statement!

EDP: Rotation of Statements	Applies completely	Tends to apply	Tends not to apply	Does not apply at all
I think it's great to live in a world which steadily makes progress thanks to developments like nanotechnology.	1	2	3	4
The example of nanotechnology shows us just how many surprising new findings are possible.	1	2	3	4
I am not in favour of modern technologies like for instance nanotechnology.	1	2	3	4
Nanotechnology will open up fantastic opportunities for technical development.	1	2	3	4
We should develop nanotechnology but keep an eye on the potential risks.	1	2	3	4
With my knowledge of the natural sciences I can understand to a certain extent how nanotechnology functions.	1	2	3	4
It really frightens me when I think about how many products already supposedly exist.	1	2	3	4

EDP: Only put Question 20 when the respondent answers several questions with "1" applies completely, i.e. not just one statement which elicits comparatively high agreement.

20. Which of the above mentioned statements do you agree most?

EDP: Include all the statements with the highest (same) approval.

INTERVIEWER: Please read once more!

....	☐ **1**
....	☐ 2

21. At the end of the interview I have a few general questions. Would you please tell me your level of education for the statistics?

INTERVIEWER: Read!

Primary/lower secondary school, no apprenticeship	☐ 1
Lower/intermediate secondary school with apprenticeship	☐ 2
Intermediate/advanced/specialised/commercial school, no final-school leaving certificate	☐ 3
Final school leaving certificate/university entrance requirement	☐ 4
University/university of the applied sciences	☐ 5

22. Are you currently in employment?

INTERVIEWER: Read!

Yes, full time	☐ 1
Yes, part time (part time, hourly basis)	☐ 2
No, temporarily not employed / unemployed	☐ 3
No, no longer employed / pensioner	☐ 4
Housewife / houseman	☐ 5 -> go to question 24
Trainee	☐ 6

23. Which of the following corresponds or corresponded most to your professional activity? I will read you the various options!

INTERVIEWER: Read!

Hotels, restaurants, food, domestic engineering	☐ 1
IT, EDP, computer, media	☐ 2
Art, design	☐ 3
Nature, natural science, animals, environment	☐ 4
Law and order, security, protection	☐ 5
Production / processing, construction	☐ 6
Law, tax (management consulting)	☐ 7
Social, education, health, fitness	☐ 8
Traffic, transport, logistics	☐ 9
Industry, public authorities	☐ 10
Science, research	☐ 11

24. How many people, including yourself, live in your household?

|___|___| persons

25. How many children under the age of 18 live in your household?

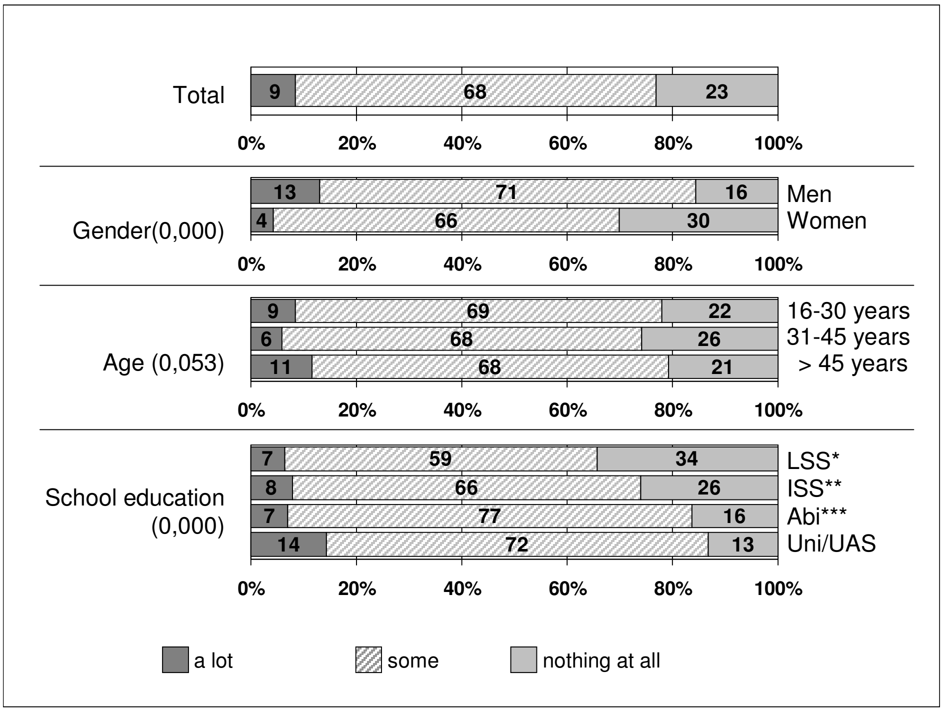
EDP: Only ask question if the response to Question 24 is more than one person

|___|___|

Thank you for taking part in the survey!

7.3 Additional results of the quantitative survey

Fig. 36: Estimation of the scale of information on nanotechnology already perceived (Question 6) by gender, age and education



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

* Lower secondary school (LSS
** Intermediate secondary school (ISS)
*** (Spezialist) school-leaving certificate (Abi)
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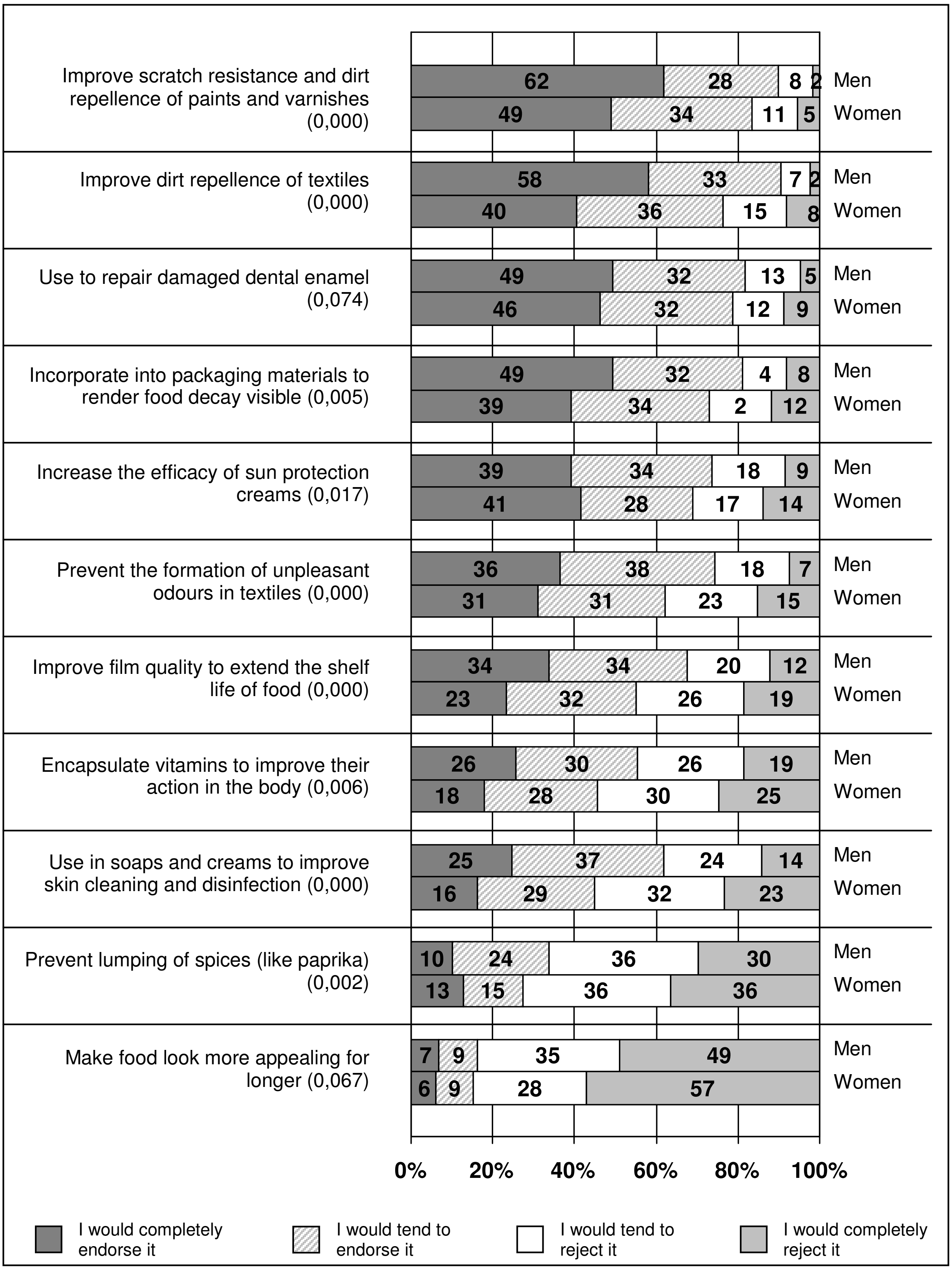
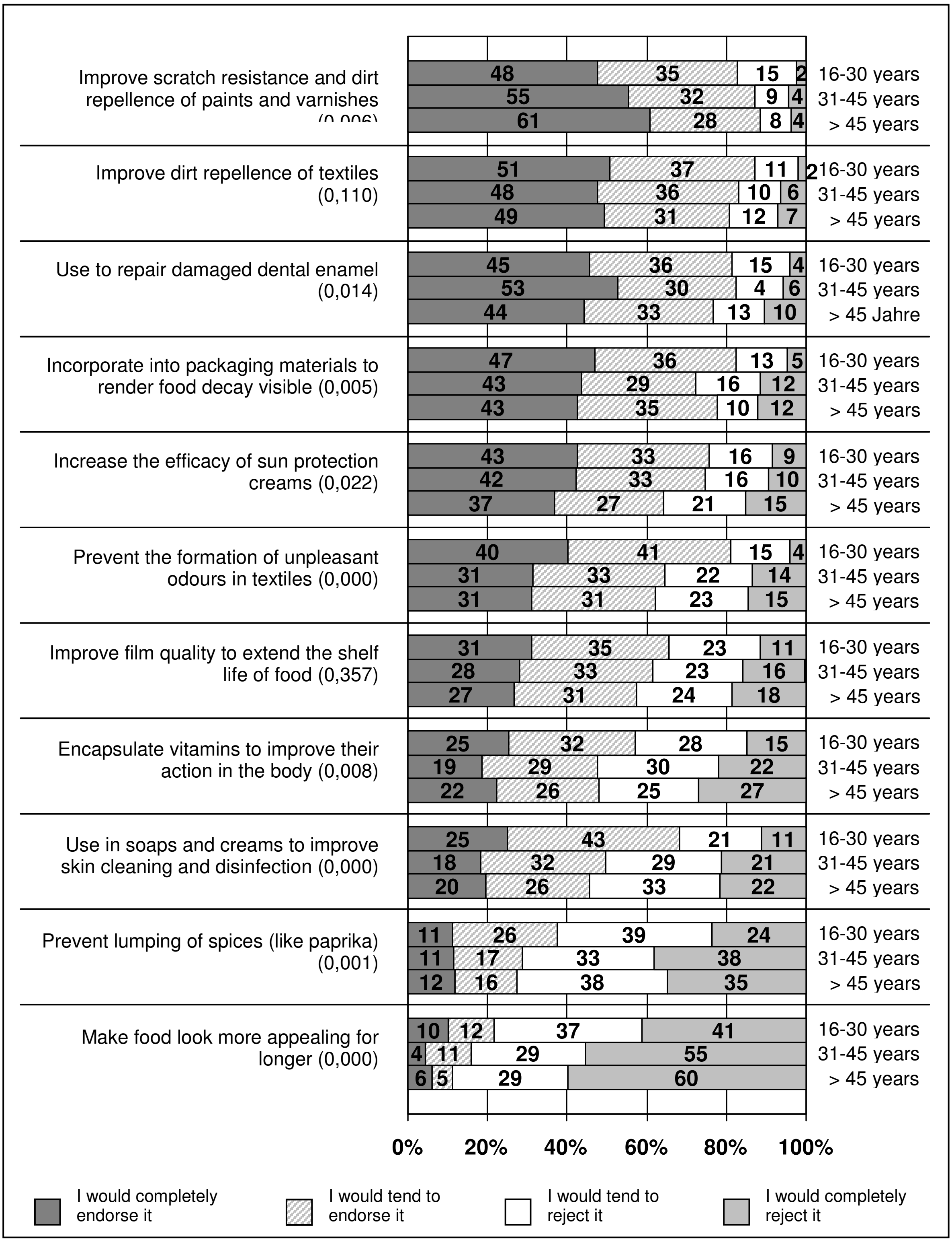
Fig. 37: Acceptance of the use of nanotechnology in different products (Question 7) by gender



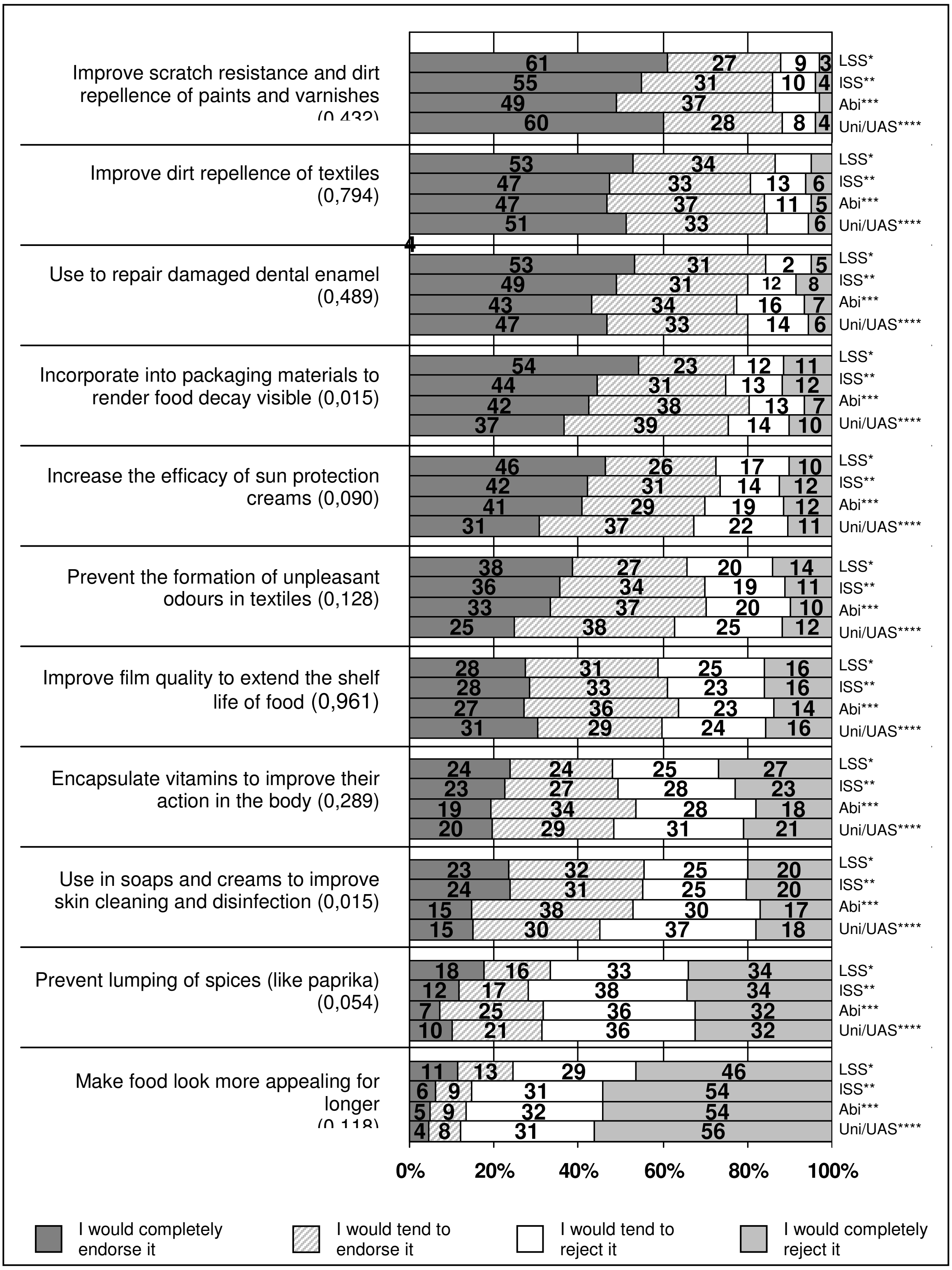
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 38: Acceptance of the use of nanotechnology in different products (Question 7) by age



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 39: Acceptance of the use of nanotechnology in different products (Question 7) by education level



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

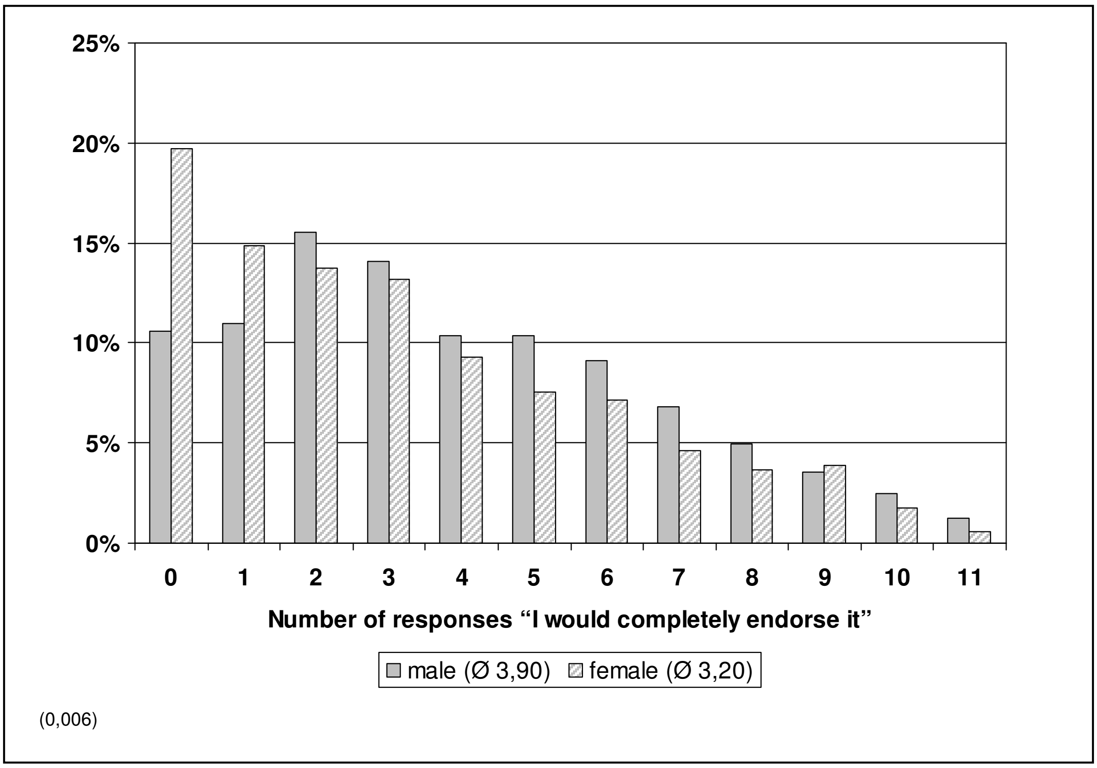
* Lower secondary school (LSS

** Intermediate secondary school (ISS)

*** (Spezialist) school-leaving certificate (Abi)

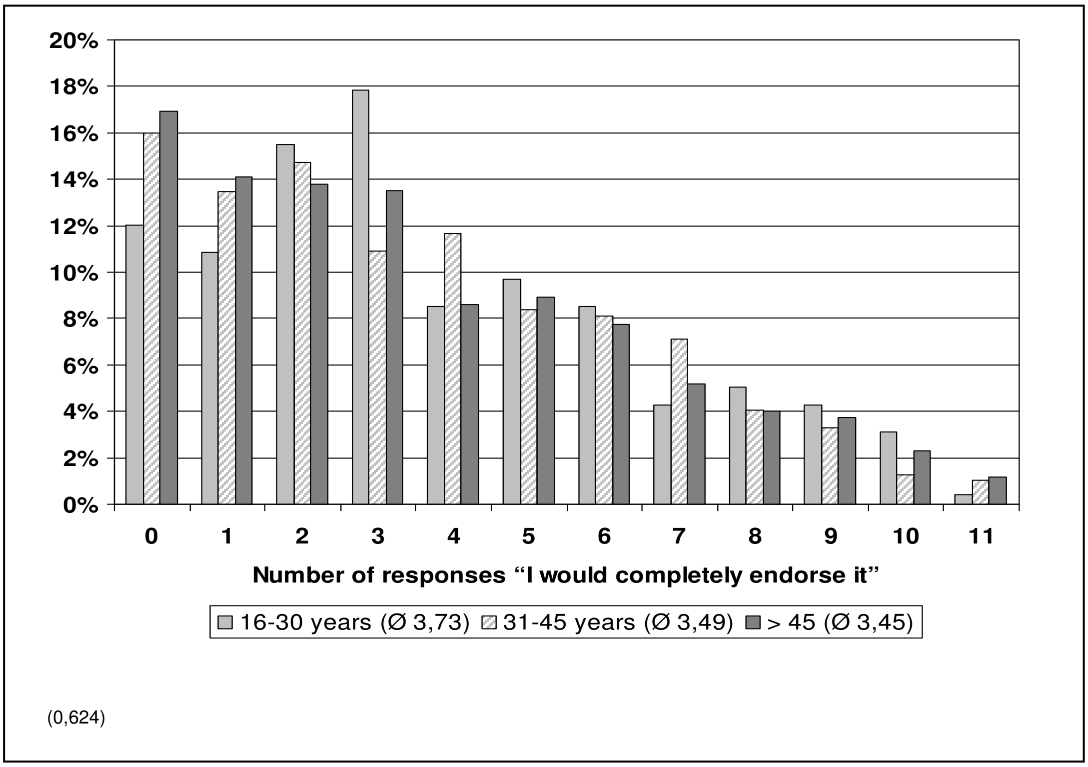
**** University/university of the applied sciences (Uni/UAS)

Fig. 40: Participant-related frequency of response "I would completely endorse it" in response to the question about the acceptance of the use of nanotechnology in different products (Question 7) by gender



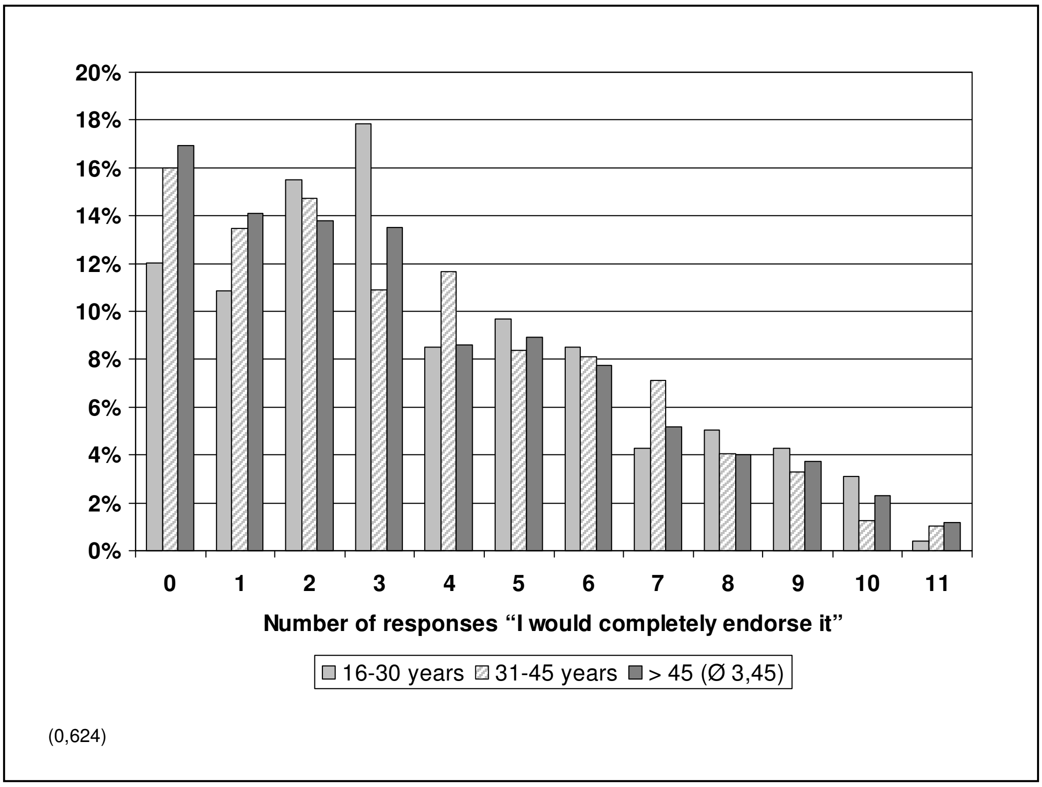
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 41: Participant-related frequency of the response "I would completely endorse it" in response to the question about the acceptance of the use of nanotechnology in different products (Question 7) by age



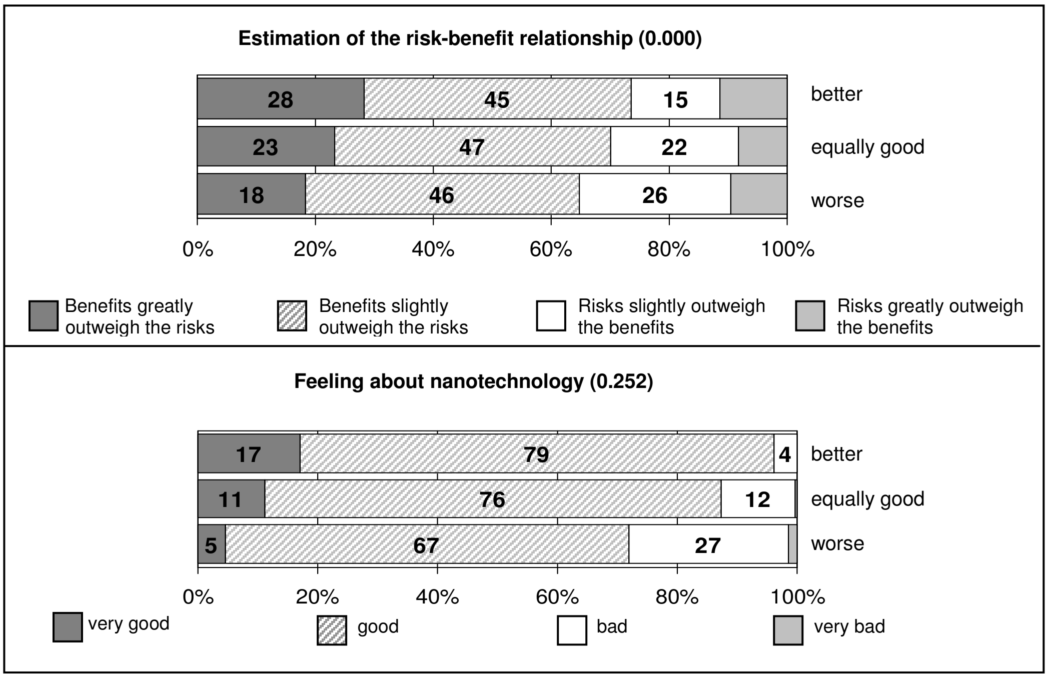
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 42: Participant-related frequency of the response "I would completely endorse it" in response to the question about the acceptance of the use of nanotechnology in different products (Question 7) by education level



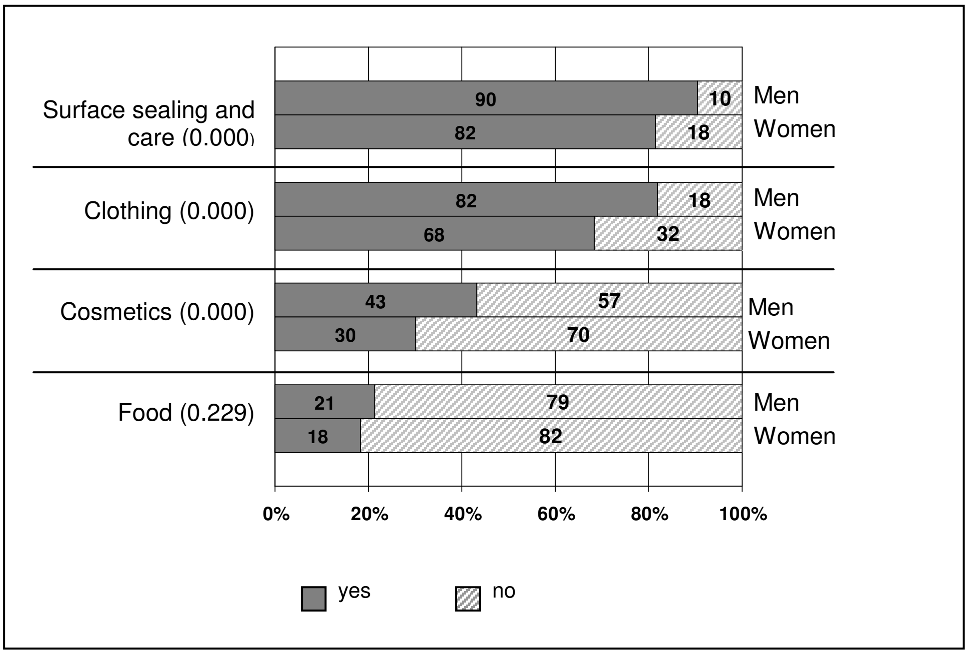
Values in brackets: 2-sided asymptotic significance (p-values) of the Chi square test according to Pearson

Fig. 43: Estimation of the risk-benefit relationship of nanotechnology (Question 8) and overall feeling on nanotechnology (Question 15) depending on the level of information compared with other technologies (Question 11)



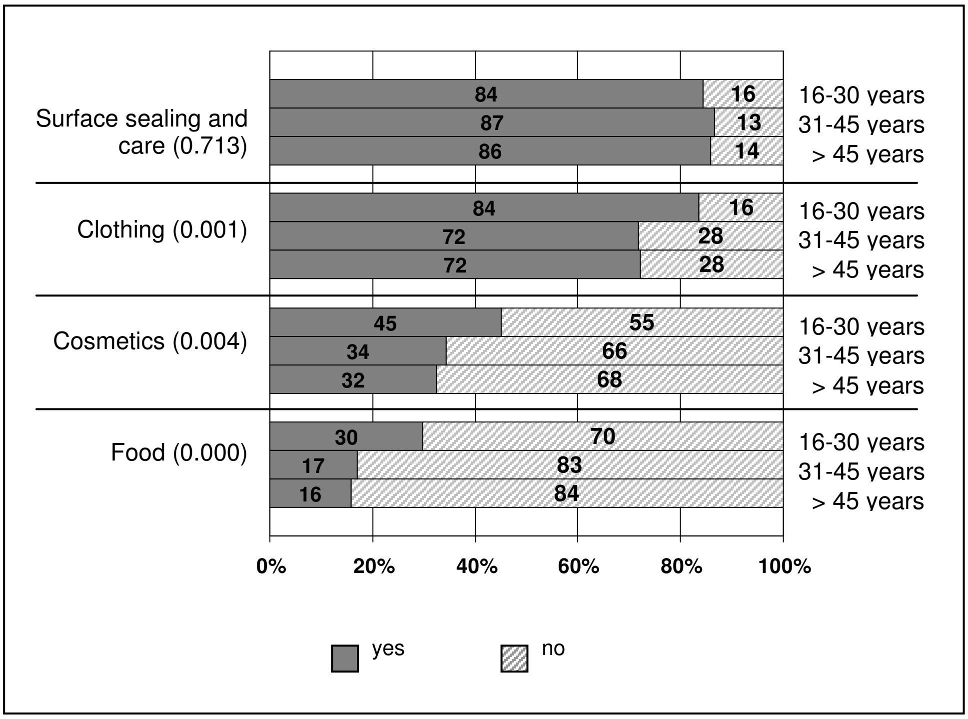
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 44: Willingness to buy nanoproducts in the different product groups (Question 10) by gender



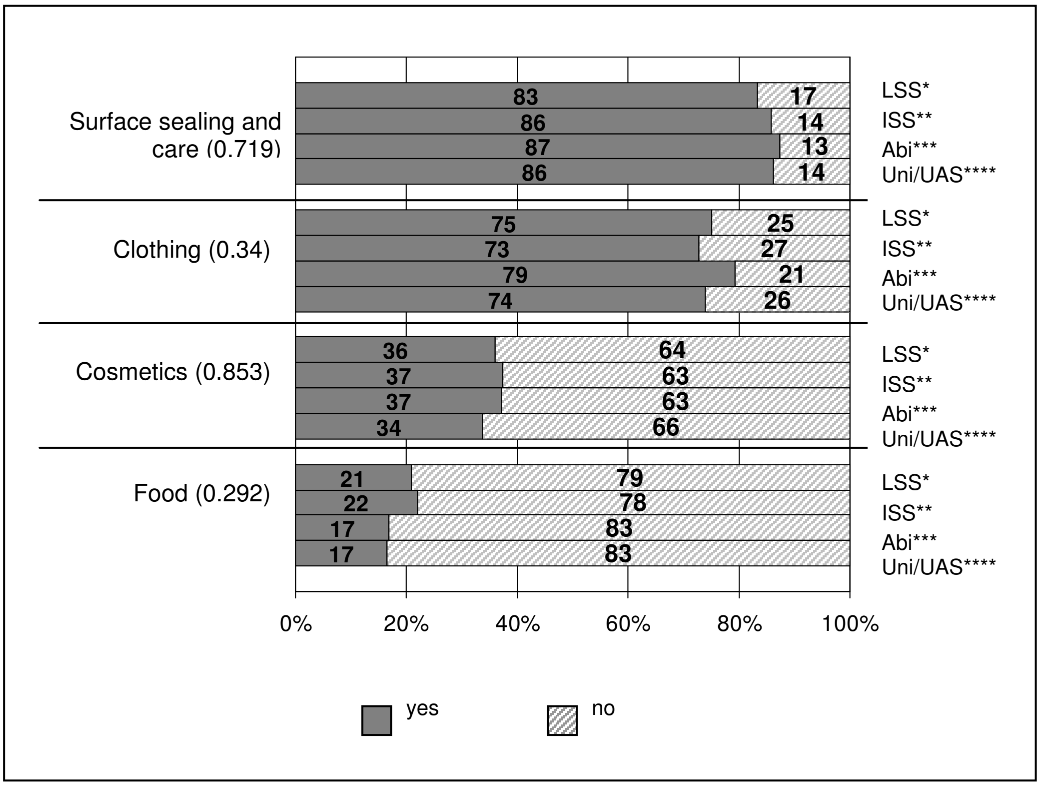
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 45: Willingness to buy nanoproducts in different product groups (Question 10) by age



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

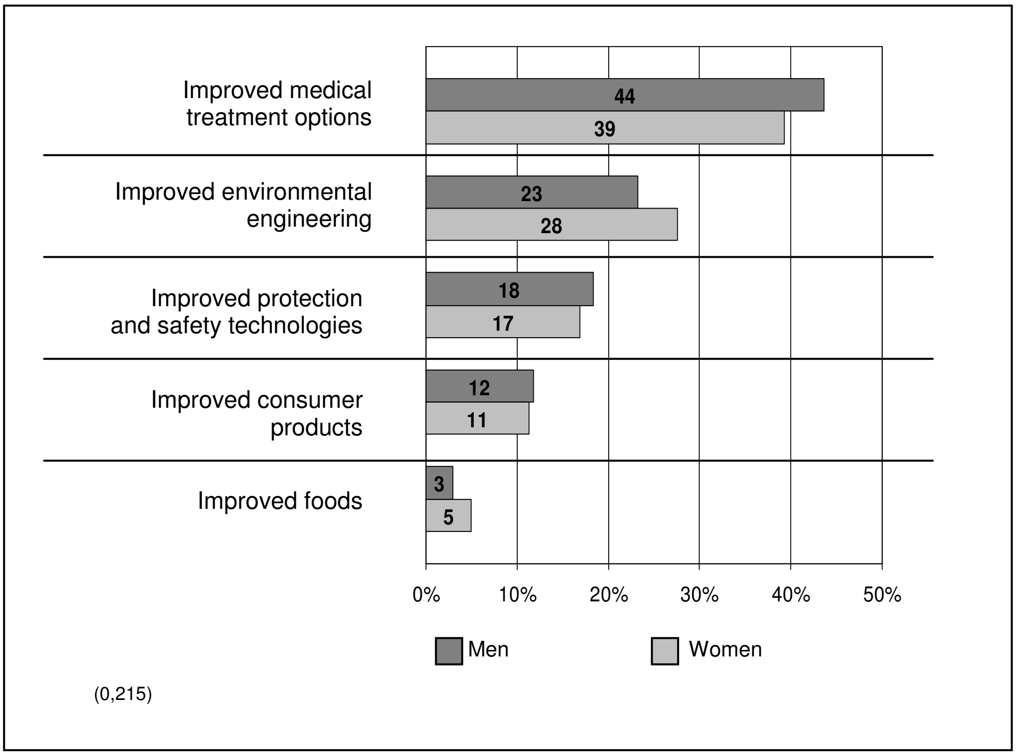
Fig. 46: Willingness to buy nanoproducts in various product groups (Question 10) by education level



Values in brackets: 2-sided asymptotic significance (p-values) of the Chi square test according to Pearson

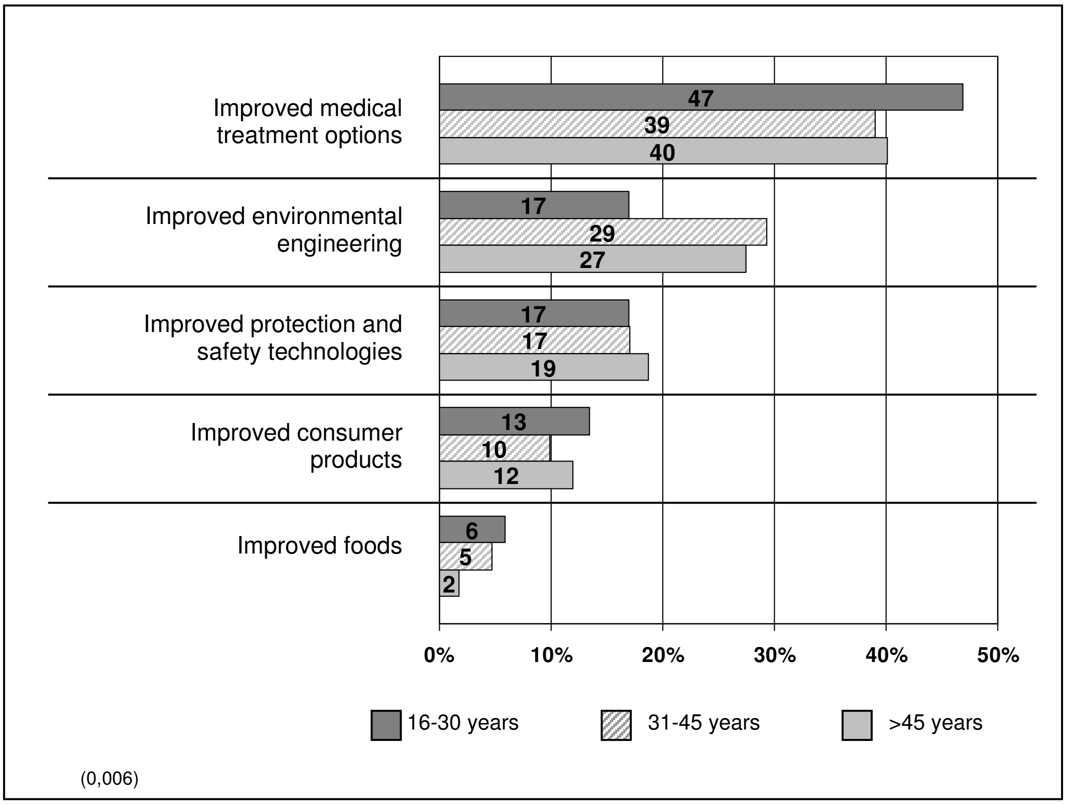
* Lower secondary school (LSS
** Intermediate secondary school (ISS)
*** (Spezialist) school-leaving certificate (Abi)
**** University/university of the applied sciences (Uni/UAS)

Fig. 47: Estimation of the benefits of nanotechnology for various applications (Question 9) by gender



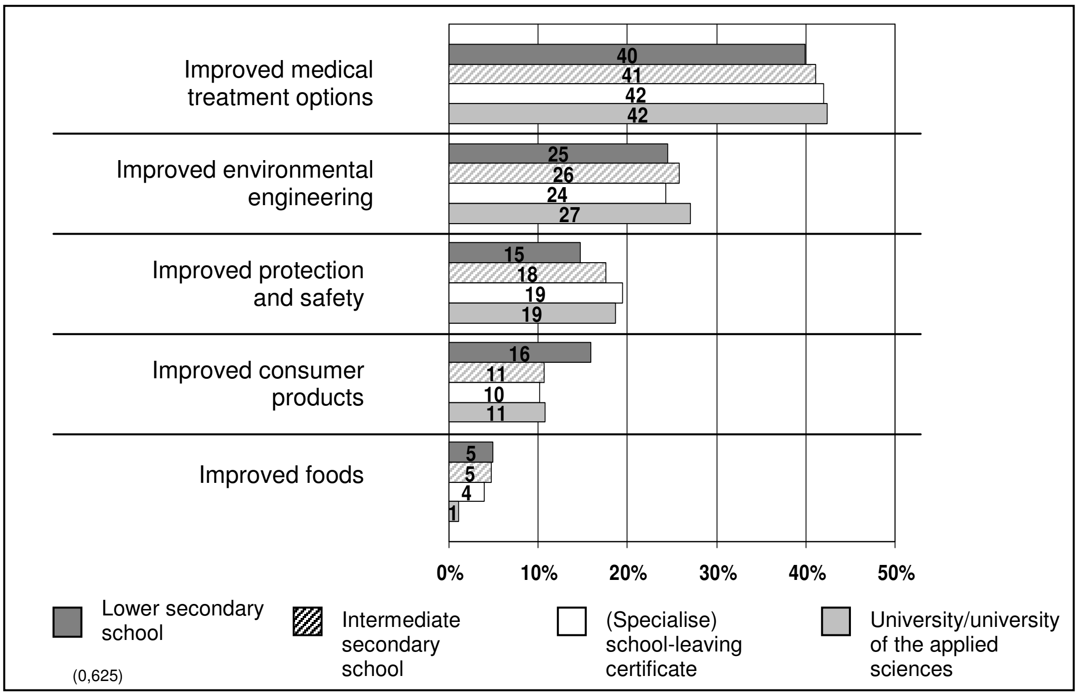
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 48: Estimation of the benefits of nanotechnology for various applications (Question 9) by age



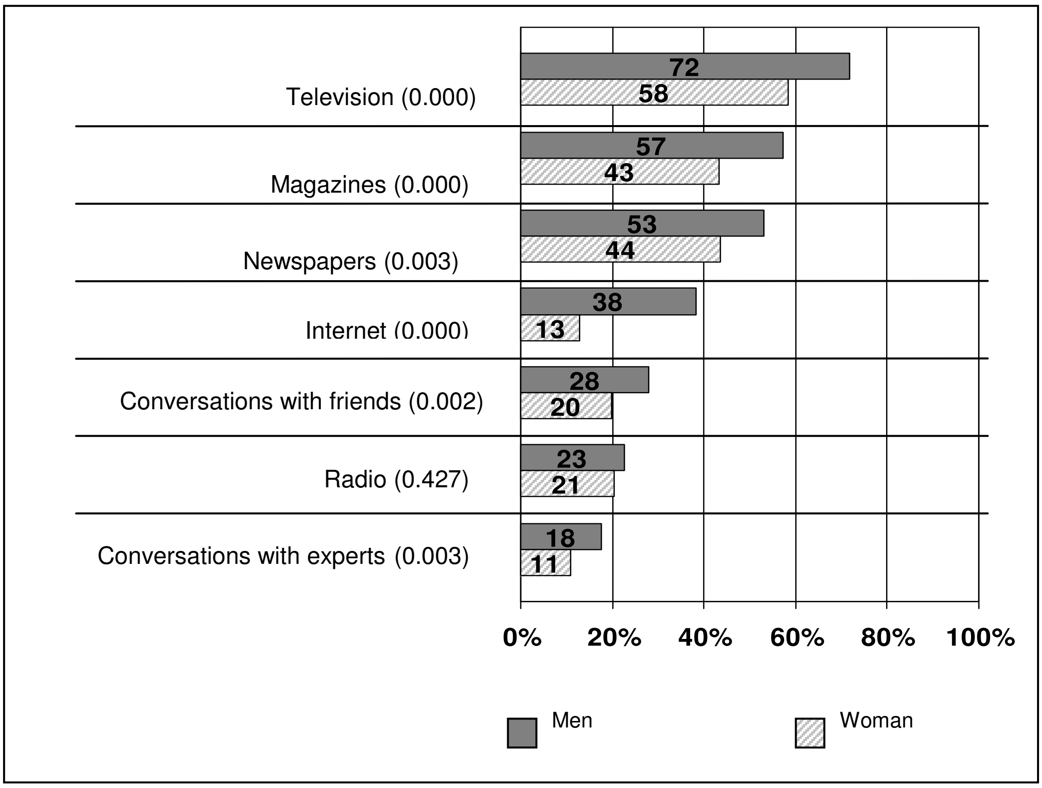
Values in brackets: 2-sided asymptotic significance (p-values) of the Chi square test according to Pearson

Fig. 49: Estimation of the benefits of nanotechnology for various applications (Question 9) by education level



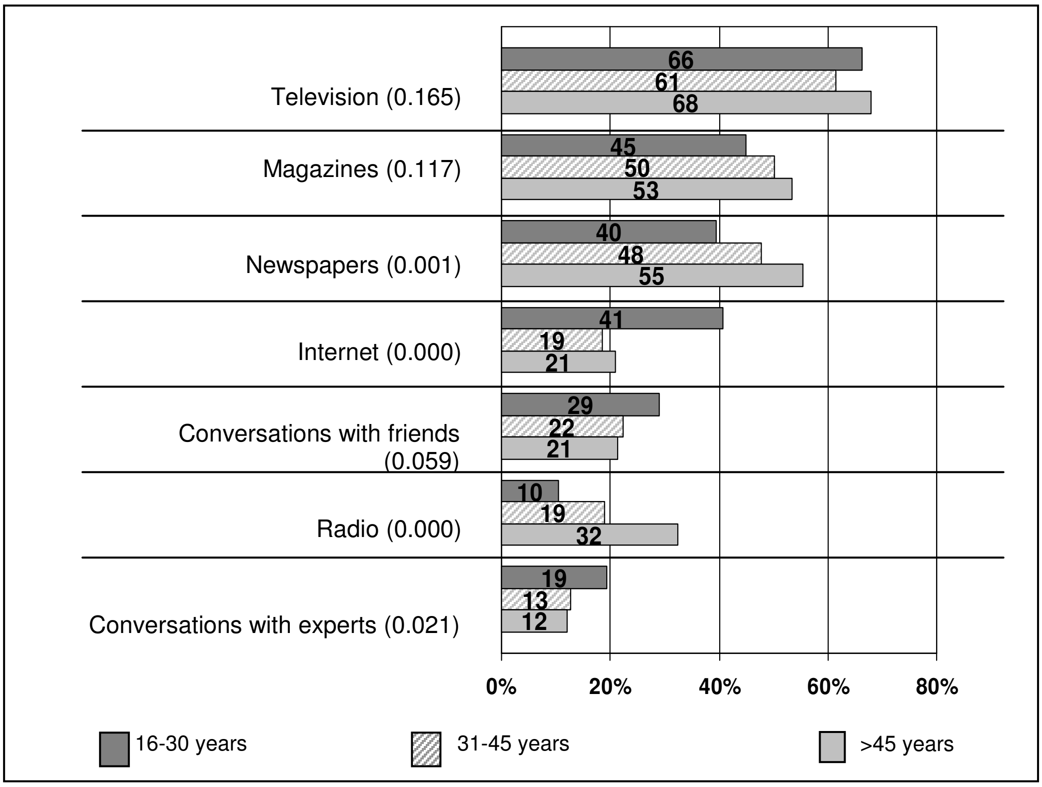
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 50: Importance of different media for the previous dissemination of information on nanotechnology (Question 12) by gender



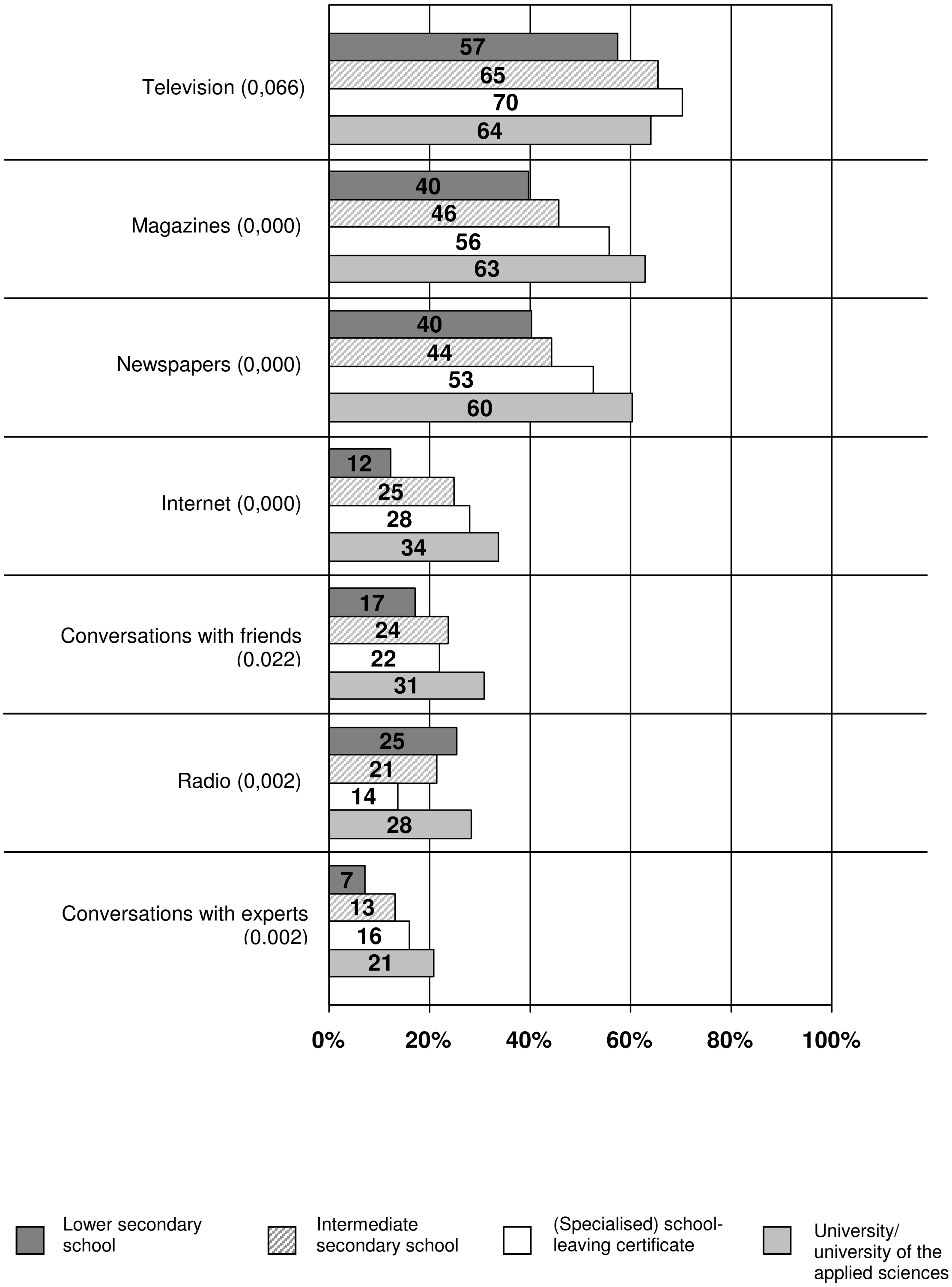
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 51: Importance of different media for the previous dissemination of information on nanotechnology (Question 12) by age



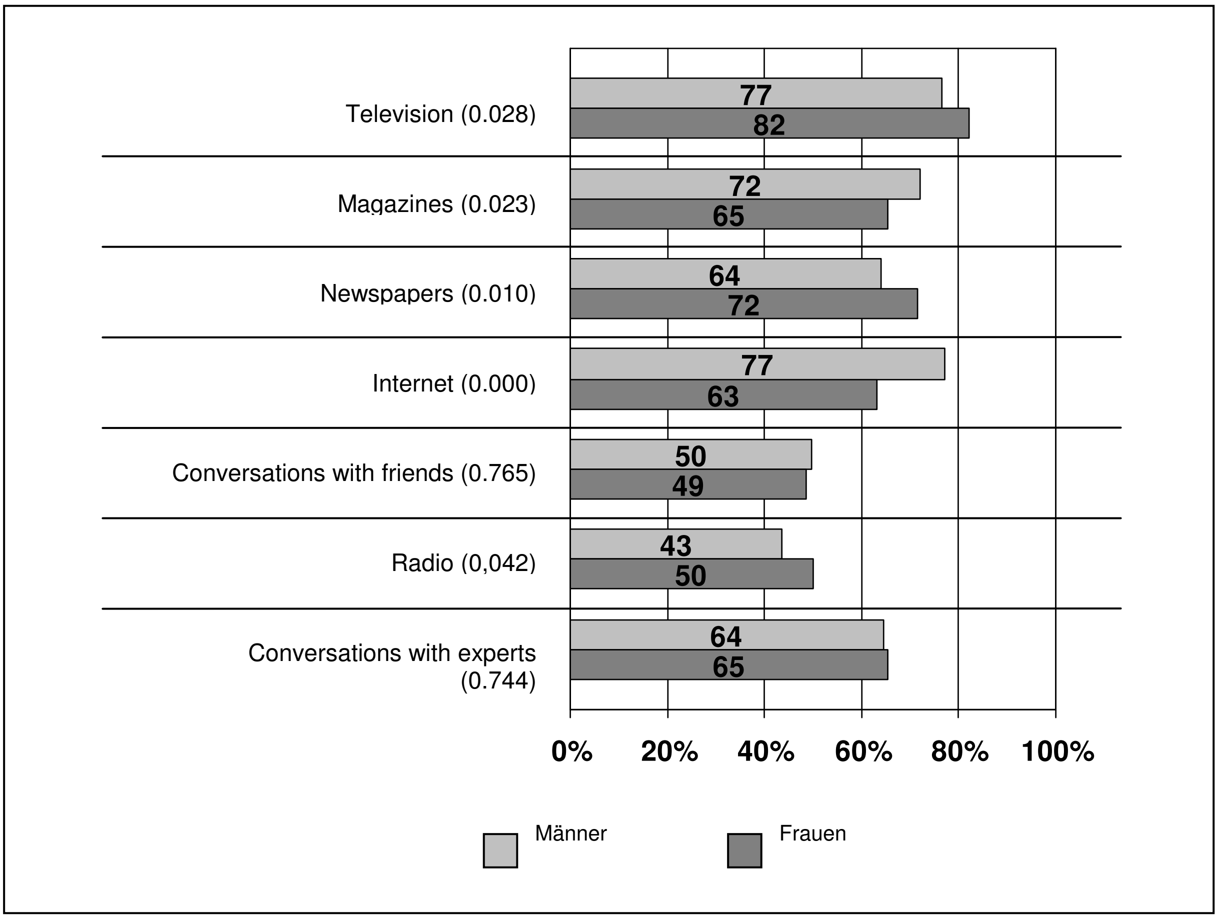
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 52: Importance of different media for the previous dissemination of information on nanotechnology (Question 12) by education level



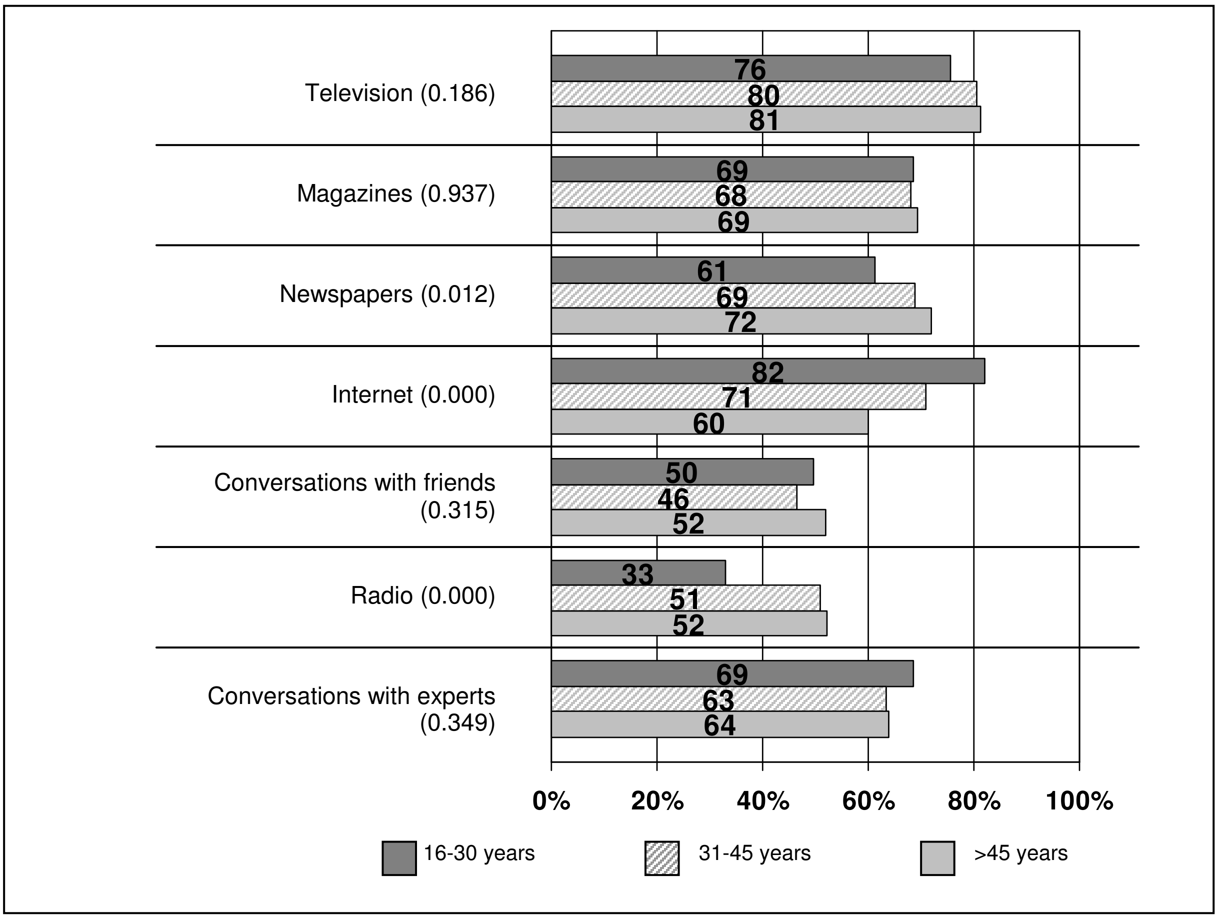
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 53: Importance of different media for the search for information on nanotechnology (Question 13) by gender



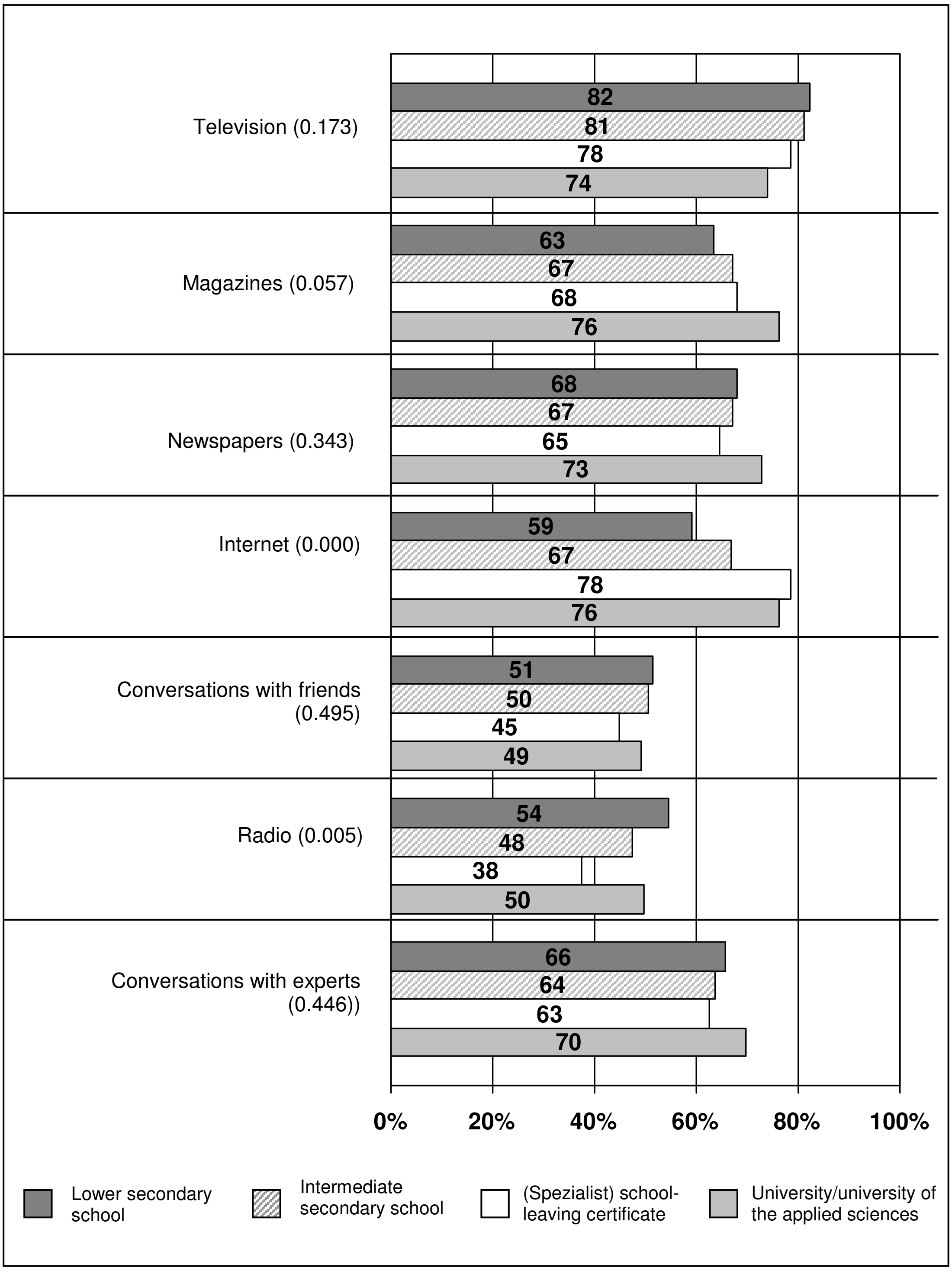
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 54: Importance of different media for the search for information on nanotechnology (Question 13) by age



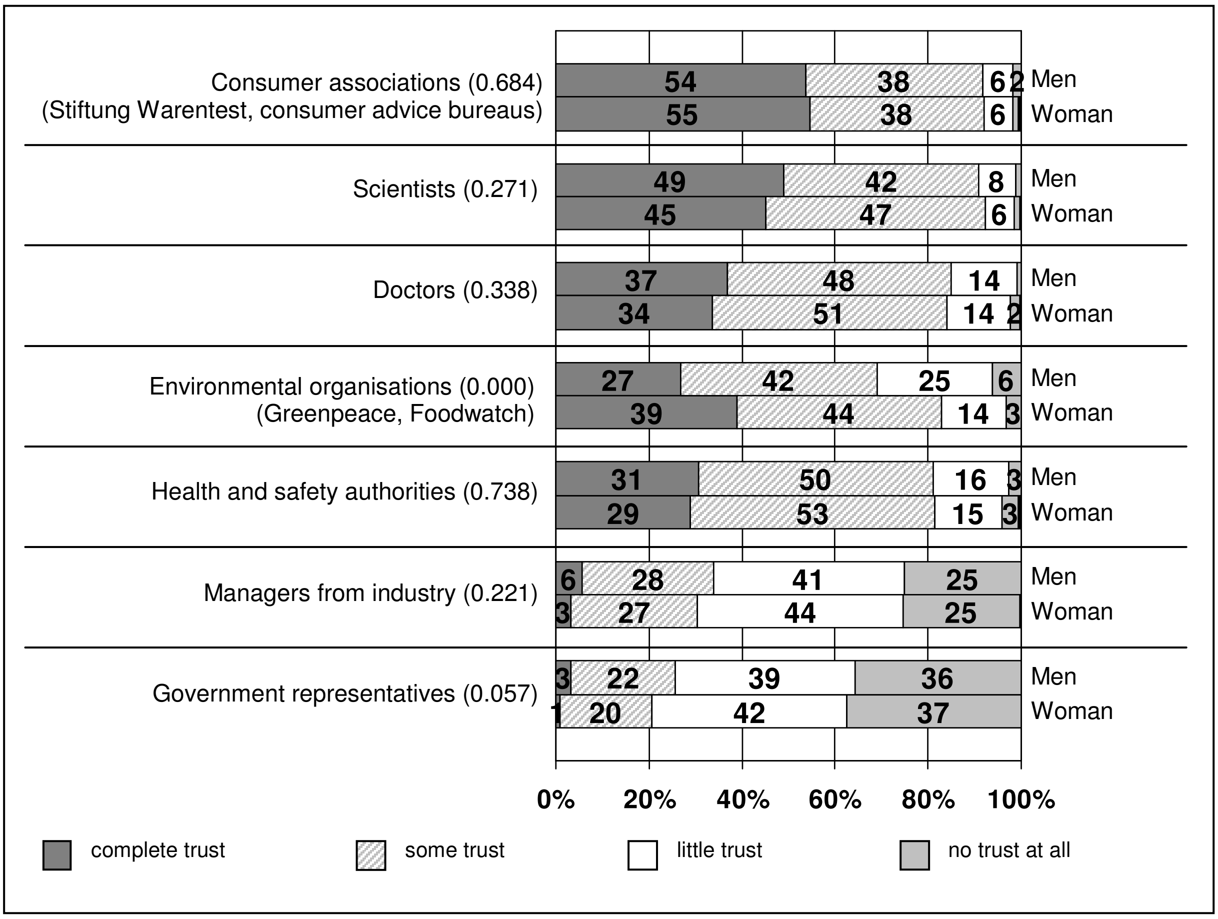
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 55: Importance of different media for the search for information on nanotechnology (Question 13) by education level



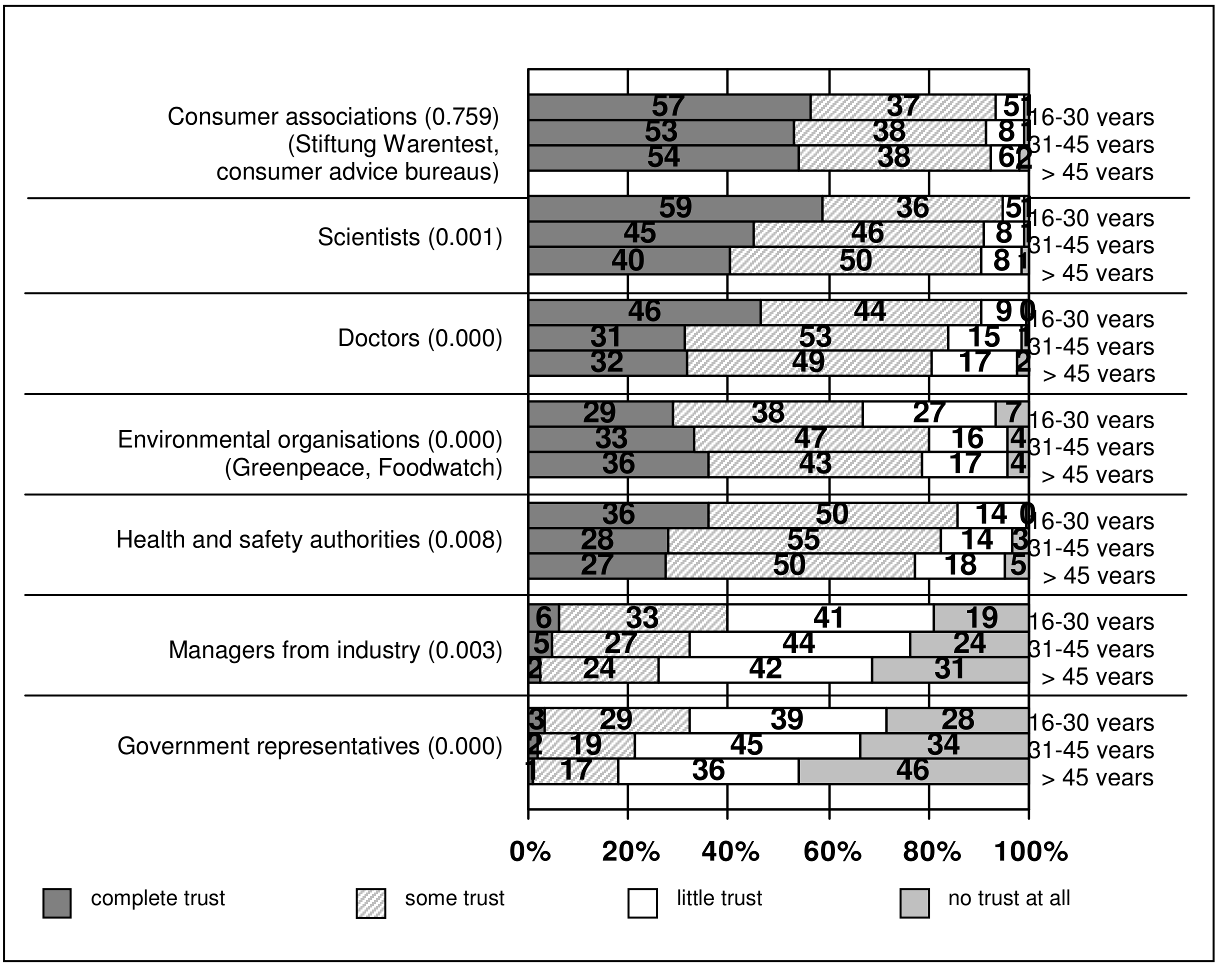
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 56: Trustworthiness of groups of individuals and institutions concerning the dissemination of information on nanotechnology (Question 14) by gender



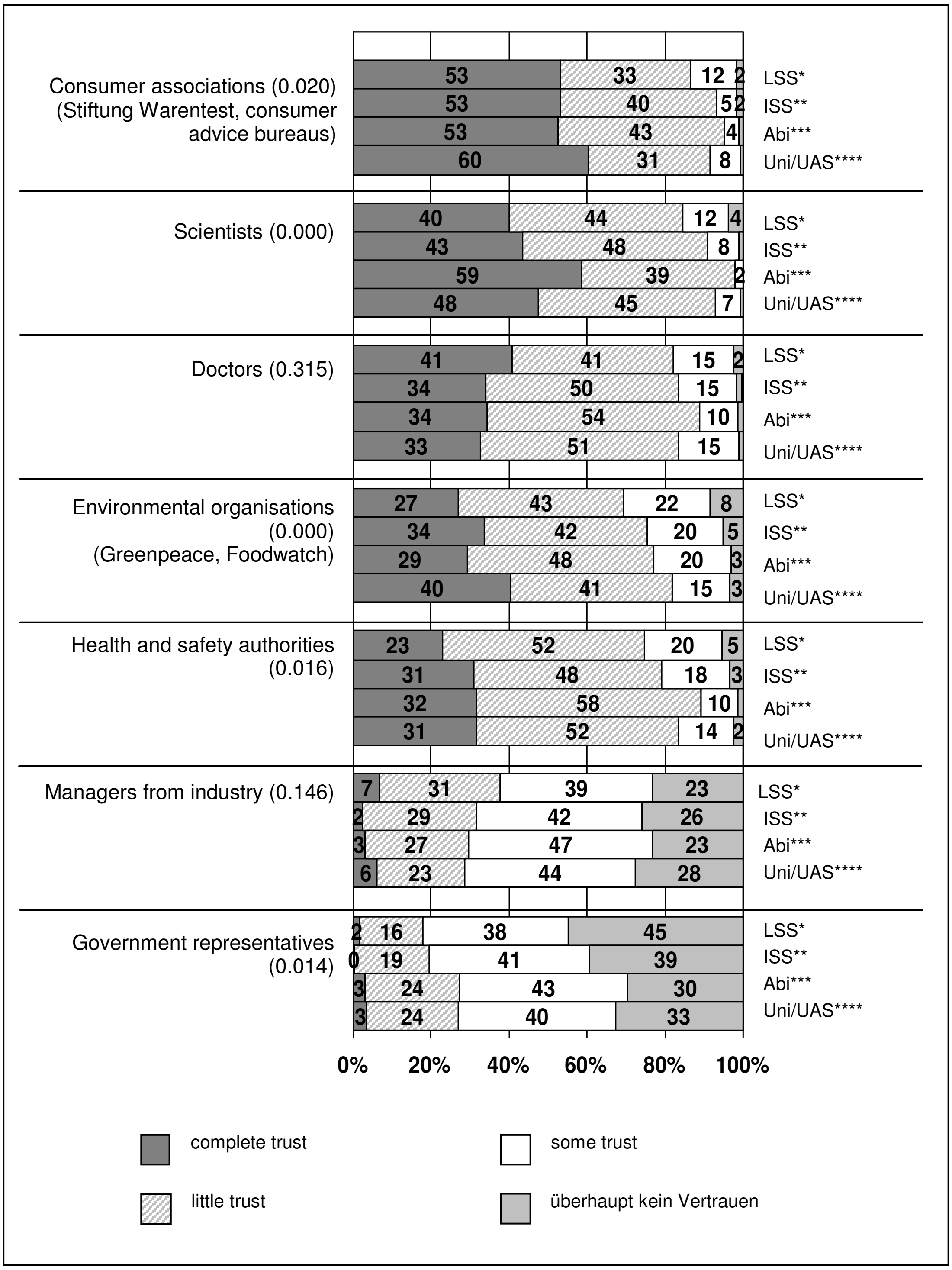
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 57: Trustworthiness of groups of individuals and institutions concerning the dissemination of information on nanotechnology (Question 14) by age



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 58: Trustworthiness of groups of individuals and institutions concerning the dissemination of information on nanotechnology (Question 14) by education level



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

* Lower secondary school (LSS

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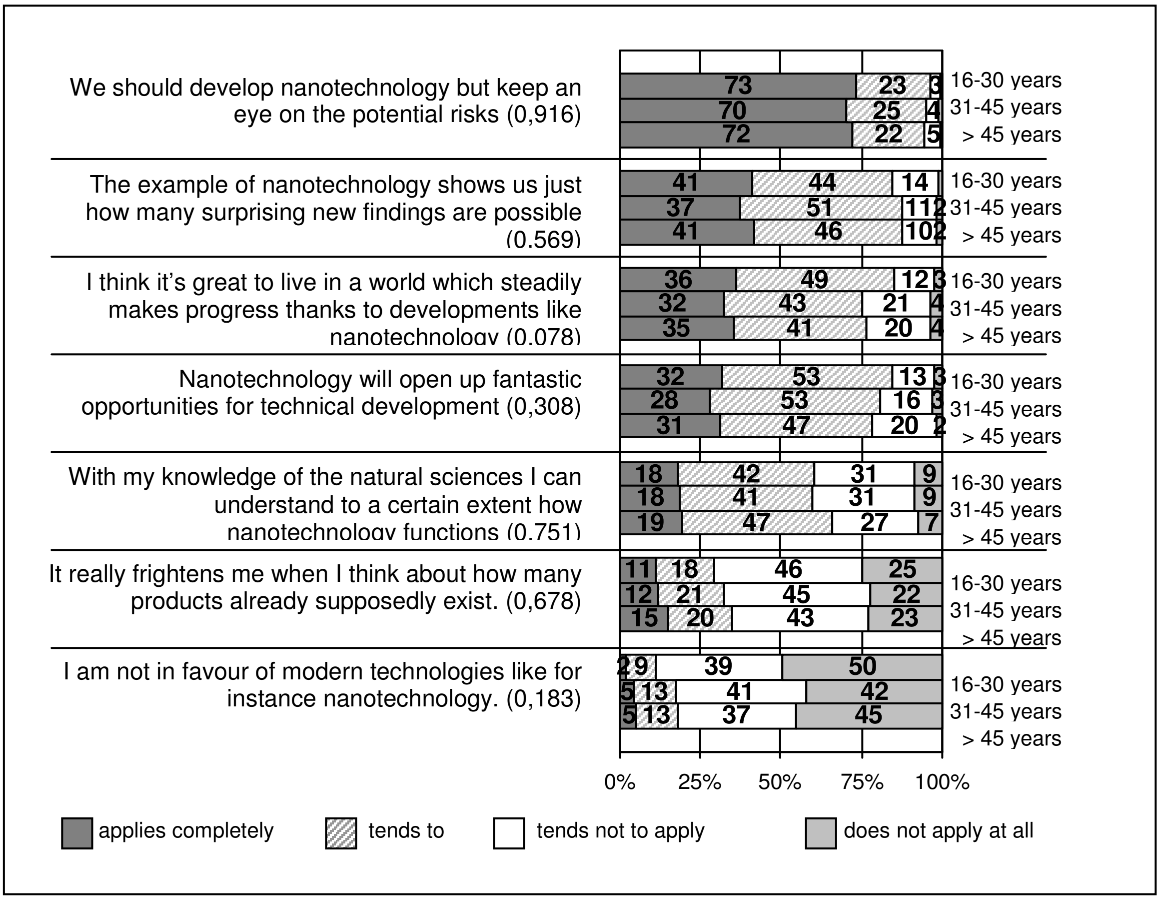
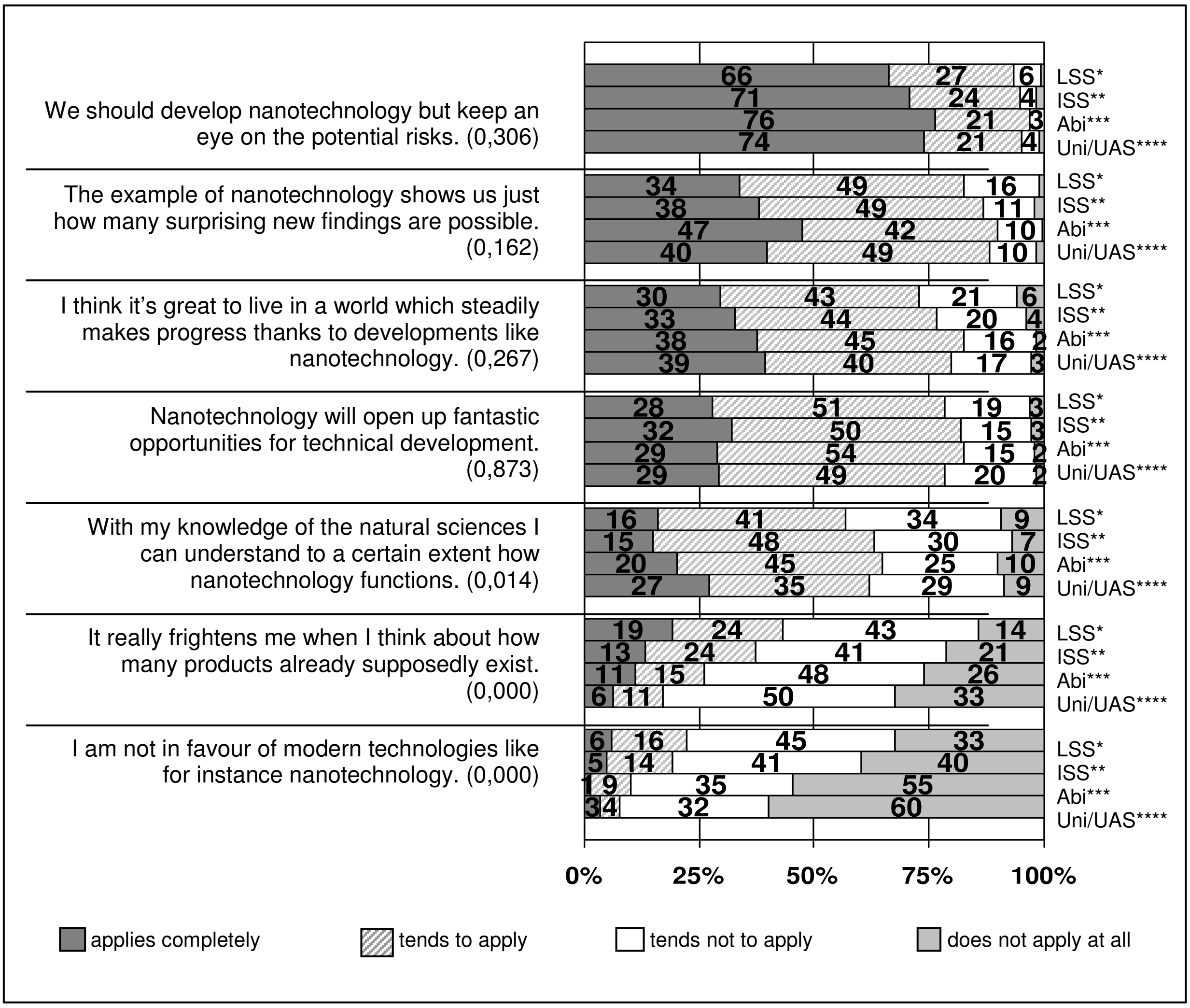
Fig. 59: Assessment of the statements on dealing with nanotechnology (Question 19) by age



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

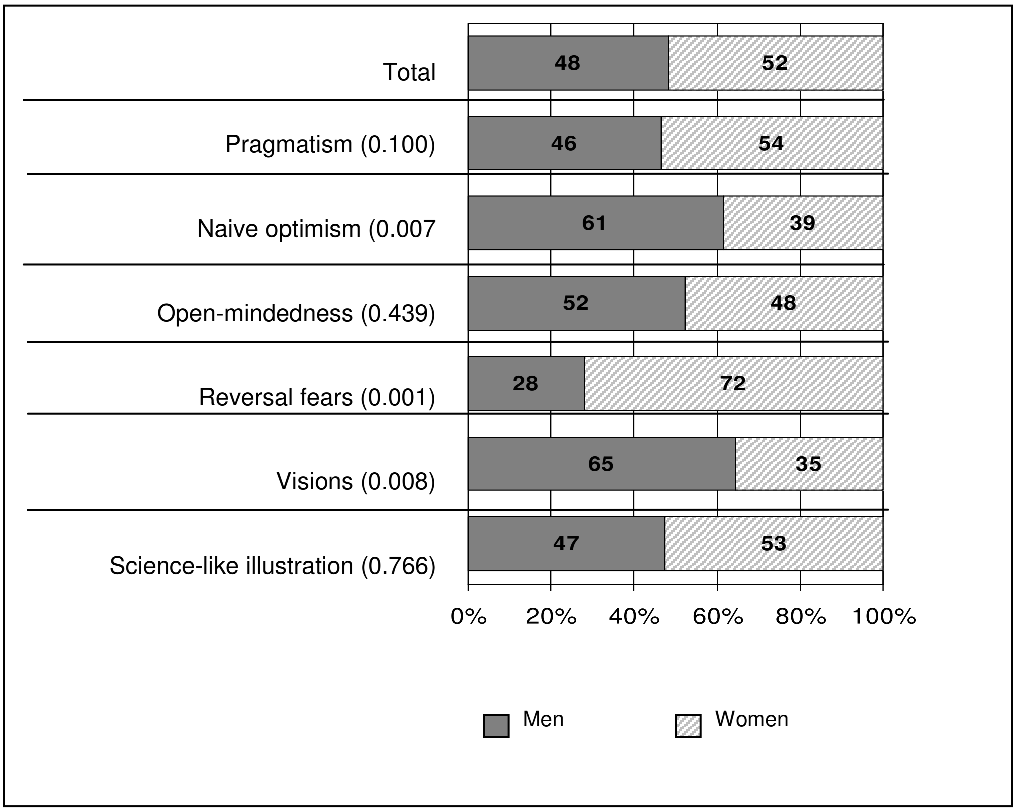
Fig. 60: Assessment of statements on dealing with nanotechnology (Question 19) by education level



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

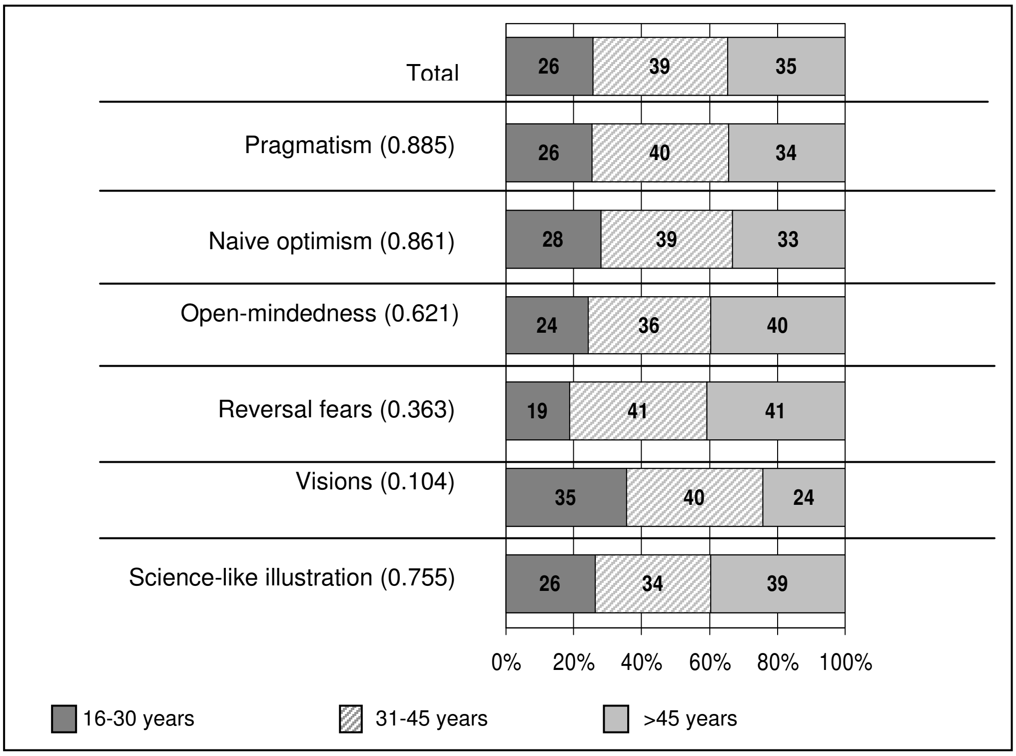
* Lower secondary school (LSS
** Intermediate secondary school (ISS)
*** (Spezialist) school-leaving certificate (Abi)
**** University/university of the applied sciences (Uni/UAS)

Fig. 61: Dominant, typical forms of behaviour when dealing with nanotechnology (Question 20) by gender



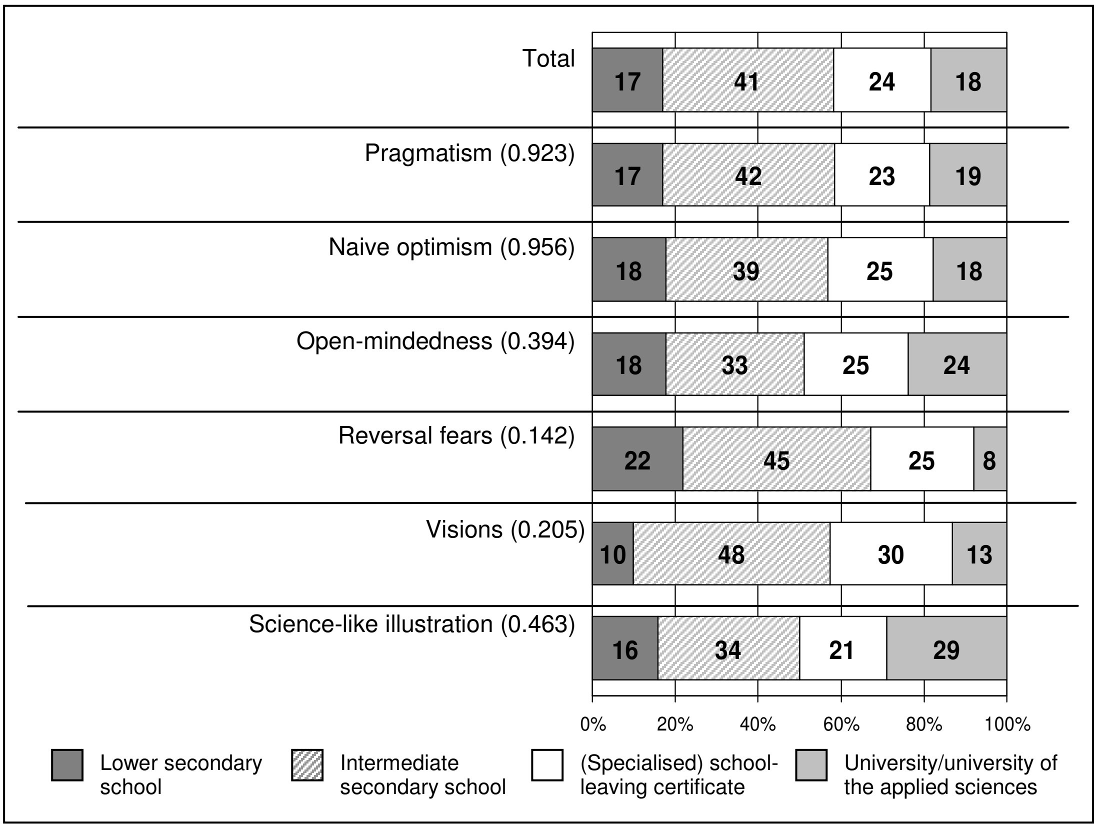
Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 62: Dominant, typical forms of behaviour when dealing with nanotechnology (Question 20) by age



Values in brackets: 2-sided asymptotic significance (p-values) of the chi-square test according to Pearson

Fig. 63: Dominant, typical forms of behaviour when dealing with nanotechnology (Question 20) by education level



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