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Why the public perception of risks is to be taken seriously: The special case of nanotechnology

Daniela Fuchs*,
André Gazsó

Summary

Considering the public perception of risks with regard to technology controversies has increasingly become important since the debates on genetically modified organisms (GMOs) in Europe. The perception of risks by the population is not comparable with assessments by experts as the concerns stem from a possible direct effect on citizens' lives, thus subject to different dynamics. This dossier focusses on factors which influence the public perception of risks and elaborates on their relevance for regulatory policies. Moreover, it introduces several European studies on familiarity and risk perception of nanotechnology. The studies' results are similar: While citizens know comparatively little about nanotechnology, the questioned subjects also perceived it as having a relatively low risk potential. There are several possible explanations: Alongside a general technology-friendly attitude, positive media reporting and the broad range of the technology – which makes it difficult to scandalize it as a whole -, a basic trust in institutions concerned with risks and an accurate, proactive regulatory policy could play an important role.

* *Corresponding author*

Introduction

Due to the multiple fields of application of nanotechnology – ranging from every-day products such as cosmetics or electronic devices to industrial usage – there are manifold advantages but also risks in different fields.

The risk potential of protected goods is evaluated diversely in different contexts. Risk perception and assessment by experts and laymen can show considerable differences. Thus, in a wider regulatory context, a sole focus on the opinions of experts is insufficient.

This dossier compares several European studies on public risk perception of nanotechnology. These concerned, on the one hand, the level of knowledge of citizens and, on the other hand, their fears and hopes, providing an overview of the general position of the population towards these new technologies.

The relevance of the population's risk perception for regulation

It has been debated in science for quite some time whether, and if so in which way, more information has an influence on public perception and evaluation. The so-called 'deficit-model' implies that more information automatically leads to a lesser risk perception and to a greater acceptance of technology. Thus, it would merely be lack of knowledge which is responsible for 'faulty' risk assessment.[1] This model is not empirically proven: Even though a certain influence of information can be measured, it is not possible to predict the type of reaction (acceptance, rejection, ambivalence).[2] The difference between technocratic evaluation and the public perception of risks is therefore not able to be traced back to an 'irrational' assessment by the population, but is simply a consequence of diverse dynamics and evaluation procedures.

The current political climate shows a general shift of decision authority from a centralized power to netlike structures, with a majority of privatized institutions. The tendency to include as many different perspectives and opinions is thereby increased.[3] If one takes public participation seriously, the perception of citizens has a legitimate significance. Hence, studies on the public risk perception fulfil a function which is not accessible to 'classical' risk analysis (the evaluation, management, and communication of risks[4]): They reflect personal experiences and give indications of fears, values and preferences on disputed issues. They put a spotlight on alternative options for action and generate additional knowledge and normative criteria for the assessment of facts. These studies can choose either qualitative or quantitative approaches. However, particularly the results of the former approach can only be transferred to a limited extent onto the general public due to their primary focus on individual experiences.[5]

Public risk perception and the development of technology

The focus of new technologies on societal benefits is increasingly growing in relevance. The idea to aim technological developments at social objectives also includes an analysis of possible effects of these technologies. In this context, the avoidance of risks is a constant aim, also finding legal affirmation in the codification

of risk avoidance as a due diligence obligation of the state. The discussion of (public) risk perception and assessment is thus not only a question whether risks should be avoided, but also which risks are still deemed to be acceptable and which not.

This debate roots in unintended side effects[6] of the development of technologies, prompting criticism by the personally affected population on experts.[7] The integration of the perceptions and opinions of potentially affected persons into specific policy fields such as regulation therefore has a legitimate status.[8]

Factors of individual risk perception

The public risk perception has been of concern to science for decades (for basic literature see[9]). The following concise overview cannot do justice to this discussion, but merely aims at presenting a few important factors on different levels.

The classification by the BfR

In its study on public risk perception of nanotechnology, the German Federal Institute for Risk Assessment (Bundesinstitut für Risikobewertung, BfR) distinguishes relevant factors into four groups.[10]

Object-related factors

Even though participants of studies are frequently asked for a self-assessment of their personal knowledge, the results do not show any clear trend. However, it can be noticed that familiarity with the issue has a positive effect on the acceptance of nanotechnology. If specific fields of application and usages or risks are listed in the studies, the risk perception in these fields is also more refined.

Socio-demographic factors

Here, personal attitudes are linked to individual or milieu-specific characteristics. Particularly widespread are the variables of gender, level of education, and age. Especially the first two of these factors are strongly dependent on the public attitude.

Psycho-social factors

Psycho-social factors give information on associations and internalized patterns. They refer to fundamental aspects of social and cultural embedding and subjective intuition, such as, *e.g.*, the extent of trust in representatives of science and institutions.[11]

Other factors

The BfR mentions under this point primarily the reception of scientific media which corresponds both with the acceptance and perceived benefits of nanotechnology.[12]

Other possibilities of classification and further aspects

Other authors suggest partly diverging classifications and supplement the BfR's system with further aspects.

For example, Renn (2014) argues that persons are dependent on information by third parties particularly in the context of invisible or non-evident risks. Trust plays a big role as diverse and partly contradictory sources have to be assessed according to their credibility.[13, 14] The use of media can be interpreted as a need of social acceptance: Not only the immediate surroundings exert influence on the individual opinion-building, but also the wider societal context – mainly through the media. These have an own dynamic as in addition to their important role as an information carrier, they have a primary focus on diversity, plurality and arbitrariness, portraying different opinions next to one another and not sorting these according to relevance. This raises the impression that scientific facts are watered down.[15]

The BfR's study refers to the fact that in order to avoid emerging internal conflicts with existing criteria or positions, knowledge gaps in risks assessments are often filled with emotional basic attitudes.[16]

Consequently, further studies have looked at factors such as religion, opinion on the relationship between technology and nature, or political opinions. The risk assessment is often dissimilar between different social and cultural groups even if the participants have received the same preliminary information. This infers an internalized selection of information[17] and diverse cultural values of individuals which play a role in risk assessment.[18]

Characteristic features of influencing public risk perception

Laymen and experts rate risks in diverse fields of application differently: Generally, laymen estimate risks higher than experts[19] and also put more focus on the severity of damage rather than on the probability of occurrence[20]. In addition, there are a number of further features which influence the risk assessment of laymen. (Table 1)

Table 1: Overview of features which influence public risk perception[21]

Qualitative features	Situational patterns
People are more inclined to take risks if ...	People are more inclined to take risks if ...
... they are familiar with the source of risk/risk situation..	... they personally control the degree of risk (personal responsibility).
... they consider the vulnerability of the source of risk to catastrophes as low (low vulnerability).	... they enter risks voluntarily (voluntariness).
... they assess fatal consequences in the case of emergency as limited (horror of damage).	... they have the impression that benefits and risks are distributed fairly (fairness).
... they do not observe any unwanted consequences for future generations (short-term impact).	... beneficiaries are also risk bearers (congruence).
... hazards are perceptible to the senses (sensual perceptibility).	... they trust public control to handle risk (institutional trust).
... sources of risk are classified as natural (naturalness).	... they perceive the sources of information as trustworthy (trust in Information).
... consequences of risk can be made reversible (reversibility).	... available information gives clear information on dangers (clarity of information).

Empirical measurement of perception

There are different possibilities to measure the population's risk perception. Quantitative studies focus on the gathering of broad empirical data in order to obtain statistical information on frequencies of occurrence and distribution. Qualitative approaches analyse individual opinions and details of personal experiences. It is not possible to categorically decide which research approach is 'better' as this is dependent on the research question.[22] Table 2 provides an overview which indicators can been used to determine public risk perception.

Publicity ("awareness"): e.g. "Have you heard about nanotechnology?" Publicity constitutes the most common used measurement of perception, including answer options ranging from yes/no to differentiated details, e.g., on information behaviour or level of information.
Level of knowledge "nano literacy": Testing of factual knowledge (true/false) or self-assessment on a scale or answering of open questions (e.g. on fields of application or definition)
"Risk/benefit trade-off": Entry into scales, assessment through attributes (larger/smaller than) or compilation of several blocks of questions
Attitude towards nanotechnology Entry into scales, questioning on acceptance of certain product groups or fields of application or the acceptance/rejection of specific statements as forms of measurement of individual opinion
Questions on the contribution of nanotechnology to an **improvement of life style**
Determination of **affective reactions**
Determination of **purchase and payment willingness** of specific applications (especially more recent studies)

Table 2: Indicators for risk perception of nanotechnology[23]

Public risk perception in past controversies

The analysis of public risk perception stems from past controversies where the risk assessment diverged between experts and laymen. An example often mentioned in this context is genetic engineering (see the following studies). In Europe (in contrast to in the United States), the possibility to use genetically modified organisms (GMOs) in agriculture has been met with massive resistance by the population. While science generally tried to weigh benefits and disadvantages against each other, laymen did not see the advantages as directly relevant, but instead concentrated on a number of risks (e.g. genetic drift, the unforeseeable long-term consequences for biodiversity, ethical concerns, or possible health effects through consumption). For the industries and public authorities this rejections of GMOs constituted an example of public irrationality. Nevertheless, the rejection of the public to accept GMOs became a political factor in the food industry.[24]

Thus, the fear of rejection of possibly controversial technological developments once again by the public stems from the authorities, but also from technology developers and scientists. The fear of the fear of nanotechnology ("nanophobia phobia") therefore is a projection of other technology conflicts onto nanotechnology.[25] By analogy, similar negative reactions were feared for nanotechnology, prompting a proactive approach in seeking a public dialogue.

Overview of European risk perception studies

The topic of public perception of risks of nanotechnology has been studied by multiple institutions in the European region. Table 3 shows studies which were undertaken from 2010 to 2014. The overview is not to be understood as a complete listing but merely has explorative character. It includes both quantitative and qualitative approaches. Thus, a systematic comparability of these studies is only available to a limited extent. Nevertheless, the compilation can provide a good overview of level of knowledge, fears and hopes of the population in the context of nanotechnology.

A focus in the selection of studies was on the representative character of the sample for the respective geographic regions. Studies focussing on a certain age groups (cf. project Nanoyou[26]) were not considered. In addition, studies with a focus on a certain issue such as nanomaterials in foods and packaging or in workers' protection[27] were also not included. In the course of the discussion on the amendment of the novel food regulation of the European Union[28] several national studies have been conducted (see *inter alia* Bieberstein et al. 2013[29], FSA Citizen Forums 2011[30], Stampfli et al. 2010[31]). Broad interactive monitoring projects were not selected due to their random participations of the test persons. For the currently running project NanOpinion[32] there is no extensive description of the methodology yet (status as of December 2014).

Table 3 shows the names of the studies, the executing institutions, time of execution, methodology and geographic connection. The studies will be analysed in more detail below.

Area	Title/ Name of project	Authors/ Publishing organisation	Time/ Period	Methodology
EU 27	Eurobarometer 73.1: Biotechnology[33]	TNS Opinion & Social (Brussels) on behalf of the European Commission	2010	Quantitative
GER, CH	Nanotechnology from the perspective of consumers[34]	Eidgenössisches Department des Inneren (EDI), Bundesamt für Gesundheit (BAG), Stiftung Risikodialog	2012	103 qualitative individual interviews
GER	Nanoview[35]	Bundesinstitut für Risikobewertung (BfR)	2013	Quantitative

Table 3: European studies on risk perception (2010-2014)

Results of European studies on the risk perception of nanotechnology

Eurobarometer 73.1: Biotechnology (European Commission)

Eurobarometer is an instrument to measure public opinion in Europe. In regular intervals surveys are conducted in all EU member states on relevant EU topics such as EU enlargement, social situation, health and culture as well as other specific topics. The 2010 edition, under the topic of "biotechnology", was *inter alia* concerned with nanotechnologies as one of several investigated "new" technologies.[36] More than 26.600 personal interviews were carried out in all 27 EU member states, on a representative scale according to the respective populations.[37]

The study showed that the topic of nanotechnology was largely unknown to the population. Nanotechnology was generally significantly less known than genetic engineering, however, with large differences with regard to nationality, gender, level of education and level of information among the questioned persons.

The assessments of nanotechnology and its consequences were quite unspecific. Some questions and statements were met with clear positions by the test persons: For example, they agreed that nanotechnology was "unnatural", but also that it was "good for the national economy". They quite clearly rejected that "nanotechnology makes you uneasy". With regard to other questions, the responses are less clear and are more evenly distributed among "Agree", "Disagree" and "Don't know" (*e.g.* with regard to nanotechnology helping people in developing countries, being safe for future generations, benefitting some peoples but putting others at a risk or constituting a harm to the environment). The majority views nanotechnology as good for the economy, but there are large country differences (20%-60%), whereby the level of knowledge plays a decisive role (where the topic is better known, the agreement that it is good for the economy is double as high).

The country comparison is marked by a relatively high variability of answers indicating ignorance with regard to a number of questions. For example, on the question whether nanotechnology is good for you it ranges between 17% in Finland and 60% in Ireland; on the question whether nanotechnology is good for people in developing countries, "Don't know" is the most frequent response with an European average of 37%, with the lack in some states being above 50%. These results indicate that the process of opinion forming among the population is so far not concluded. Overall, 40% support the encouragement of nanotechnology, whereas only 25% reject it. This also shows that it is less critically seen than GMOs. Regarding risk perception, there are clear differences with regard to gender: Women tend to more often feel uneasy than men (34% vs. 28%).

Eurobarometer 73.1: Biotechnology (EC) – Main statements on nanotechnology

- Generally: unawareness and large insecurities concerning the handling of nanotechnology
- Relatively high percentage of "Don't know" answers
- Less critical than with regard to GMOs
- Level of knowledge and distribution of gender play a significant role

Nanotechnology from the perspective of consumers (EDI, BAG, Risikodialog)

The study "Nanotechnology from the perspective of consumers" was conducted in 2010 in cooperation between the Swiss Federal Department of Home Affairs (Eidgenössisches Department des Innern, EDI), the Swiss Federal Office of Public Health (Bundesamt für Gesundheit, BAG) and the Risk Dialogue Foundation (Stiftung Risiko-Dialog). The Risk Dialogue Foundation perceives it as its task to consolidate at an early stage the diverse perspectives of various actors in manifold areas on questions of risk (economy, science, politics, authorities etc.).[38] The study analysed 103 qualitative, open and personally conducted interviews in Baden-Württemberg (53) and in German-speaking Switzerland (50). The same contained a carefully selected and near-representative selection of tests person with regard to gender, age and level of education.[39]

The study confirmed the above mentioned generally low level of awareness of nanotechnology. Knowledge on specific fields of application and possible usage decreases – with the exception of cancer treatments, paints/ polishes, textiles and cleaning agents. Generally, while the population does not have a clearly more negative attitude than 2008[40], the topic's ambivalence has increased (49%), including the expectance of risks (67% expect health risks, 40% expect environmental risks). Overall, nanotechnology does not play a role in their perception (40%). The study draws the conclusion that the question of regulation recedes into the background in light of the irrelevance of the technology field (25% mention the topic of regulation). The study also addresses the question of social trust: With regard to actors, science and authorities enjoy the largest trust.

Nanotechnology from the perspective of consumers (EDI, BAG, Risikodialog) – Main statements

- Generally: little knowledge about nanotechnology
- Awareness of fields of application has decreased, thus also decreasing knowledge of benefits
- Ambivalence in attitudes has increased (to 49%)
- Expectance of risks has increased (67% expect health risks, 40% environmental risks)
- Question of regulation is relevant for 25%
- Trust in science and authorities is largest

Nanoview (BfR)

The German Federal Institute for Risk Assessment (Bundesinstitut für Risikobewertung, BfR) is responsible on behalf of the German Federal Ministry of Food and Agriculture (Ministerium für Ernährung und Landwirtschaft, BMEL) for the scientific risk assessment of substances, products, and food, as well as for risk communication. For these reasons, BfR conducted *inter alia* a study on the public opinion of nanotechnology in the project "Nanoview" (2013) and on possible communication strategies.[41] This study analysed a representative sample of the German population, consisting of 1200 persons. 200 of these test persons received detailed information on nanotechnology in advance in order to determine the influence of information material on risk perception.[42]

The study shows – similar to the Eurobarometer – that the unawareness of nanotechnology as well as its assessment as increasingly important. While the test persons are more critical in their weighing of risks and benefits than in an earlier study in 2008[43], the majority of the population still remains

positive. The acceptance of nanotechnology depends on its field of application: Distant from the body application, environmental and medicinal application generally are seen more positive.

According to the survey, chances lie *inter alia* in strengthening the economy, the further evolvement of technological developments, as well as the use of nanotechnology as an instrument for the diagnosis of diseases and healing. Just over half of the population is in favour of public financial engagement for the promotion of this technology. However, the test persons were sceptical as to health or ecological risks (approx. 2/3 of the population remain critical in this regard).

The level of information is generally lower than with regard to other technologies; this confirms the results of Eurobarometer. The study of the BfR is also concerned with the question of social trust: Scientists, doctors, health and workers' protection authorities, environmental and consumer protection organisation are at the forefront here. There is a clear claim directed at public authorities to provide information and education (equitable, objective, honest, independent and comprehensible) on specific fields of application. However, with the level of information on risks the sceptical stance towards the risk-benefit relationship also increases.

With regard to social factors, the most important variables of the study are gender and age: Men tend to be better informed and more positive than women, young people better than older people. Education, household size, income or migration background were not found to have an influence on the attitude of the test persons.

Nanoview (BfR) – Main statements

- Level of awareness is relatively low, acceptance is dependent on field of application
- Chances: strengthening of economy, instrument for the diagnosis of diseases and healing, fostering of technological development and societal benefits
- Ambivalence: in favour of public funding but sceptical towards health and ecological risks
- Demands directed at public authorities: information and education (equitable, objective, honest, independent and comprehensible) on specific fields of application
- Most important social variables with regard to risk perception: gender and age

The relationship of the public to nanotechnology

In light of previous technology conflicts, a proactive inclusion of the public into the regulatory debate is unavoidable in fields such as nanotechnology. Partly parallels are drawn to the difficulties of the involvement of the public into the debate on GMOs. Overall, a lower level of awareness is found in the case of nanotechnology. With regard to the assessment of risk potential, it is distinguished among specific fields of application, with applications close to the body (e.g. food) being seen as more problematic. Important social factors are gender, in addition to age, level of education and information. With a higher degree of information, the public risk perception becomes more diametric and ambivalent, which can be traced to a more differentiated analysis of risks.

Altogether, it can be noticed that the positive assessment of nanotechnology is slightly decreasing. Regarding the level of awareness, different studies come to diverging outcomes: While the study by BAG shows that a lower level of knowledge exists with regard to the fields of application, the study by BfR indicates that the general knowledge is decreasing, but that the specific fields of application are better known than in 2007. These changes could be potentially linked to decreasing product advertisements as their developments have so far fallen short of expectations, or could be connected with a generally perceived lack of relevance of the issue for everyday life.

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Conclusions

Overall, nanotechnology is little known and hardly classified as risky. This generally positive attitude can be interpreted, on the one hand, as a general technology-friendly attitude of the population (without knowledge of the specific technology) or as a consequence of predominantly positive media reporting. Moreover, nanotechnology shows a certain diffusivity and broadness, which protect it from being universally scandalized.

Additionally, previous successful and proactive risk regulation in similar fields of technology played a contributing element. The social trust and high ranking of science and authorities, which was asked in some studies, implies a general acceptance of these institutions in the context of risk. The high standard of an established precautionary regulation on a broader basis can therefore have a positive effect on the public risk perception. However, this is only the case as long as the regulation is seriously concerned with the fears of the population, takes their fears into consideration during decision-making, and there is no current case of damage.

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- Social risk modifiers
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