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Anna Leinonen & Sirkku Kivisaari

Nanotechnology perceptions

Literature review on media coverage, public opinion and NGO perspectives

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Abstract

Nanotechnology development is in its early phase and there is a growing debate on its potential benefits and risks. This report reviews literature on public opinion and NGO perspectives concerning nanotechnology. It starts with a discussion on the position of public in the context of nanotechnology development. Different constructions of public (citizens, consumers, human beings, populations, patients) contain different understandings of the possibilities for action, responsibilities and needs for information.

The report discusses the role of news media in nanotechnology communication. One central issue is message framing which refers to the context in which an issue is presented. Framing of nanotechnology in newspapers has changed in time. In the late 1990s scientific framing was common but currently more varied frames are used, e.g. societal implications of nanotechnology.

The report reveals that general knowledge of nanotechnology among lay people is currently very low. However, various studies suggest that lay people are able to consider complicated technological and scientific developments from wide perspectives, if they are provided with proper possibilities for that.

The analysis indicated that NGOs view nanotechnology not only from the perspective of health and safety, but also from the perspective of its societal implications. The NGOs point out the importance of public transparency and societal relevance of nanotechnology research and development.

The lack of knowledge of nanotechnology among lay people creates challenges for communication. Making information available is important. However, various studies have indicated that feelings and values have an important role to play in the formation of nanotechnology perceptions. This is why an interactive and dialogical approach may be more effective than one-way information in communicating a message about nanotechnology to the public.

Preface

Literature review on media coverage, public opinion and NGO perspective for nanotechnology was carried out in 2009–2010 as a part of the SACOP-project (Safety Assessment Concept of Paper and Board), which was funded by M-real, UPM-Kymmene and Stora Enso.

Safety and risks may raise various opinions, discussions, even mass movements before the products based on new technologies, such as nanotechnology will be approved as a part of daily human life. Obviously, there are nanotechnological opportunities even for the forest industry, to improve properties of existing products or to develop totally new products. However, it is self-evident that the debate on risks and safety does not wait until the launch of new products, but rather, it follows its own rules by using internet and other rapid, global media.

The aim of this review was to study what different stakeholders, such as consumers and NGOs, think about safety of nanotechnology and its applications at this stage. Our objective was to understand their views, and thus enabling the companies to succeed in their safety communication.

Eija Saski
Chairman of the Industry Contact Group

Foreword

This publication is part of a larger SACOP research project. The goal of the SACOP project was to provide the paper and board industry with tools to assess the safety of new materials including nanomaterials and products.

This report reviews literature dealing with societal and communication issues concerning nanotechnology. Its objective is to deepen the understanding of consumers' and NGOs' attitudes concerning nanotechnology and to formulate guidelines for communication about nanotechnology related issues. The main part of the report has been written by Anna Leinonen. Sirkku Kivisaari has contributed by analysing NGO reports.

We gratefully acknowledge the funding of this project from UPM-Kymmene, Stora Enso and M-real. Our warm thanks are also due to the contact group members Eija Saski from Metsäliitto, Päivi Korhonen from UPM-Kymmene, Kirsi Partti-Pellinen from Stora-Enso and Sirpa Eskelinen from M-Real.

Contents

1. Introduction

Nanotechnology is a new emerging branch of technology, which bears high expectations of its potential to change the world fundamentally. Some policy makers and technology developers even speak about "the Next Industrial Revolution", which advancing nanotechnology is supposed to bring along (Schummer 2004). However, the development of nanotechnology is in such an early state that there is not even complete consensus about the definition of nanotechnology and its essence. Some claim that nanotechnology is a specific area of research and it can be defined as a *general purpose technology* (GPT). GPT refers to technologies that have the following three characteristics: pervasiveness (has some function that is vital to the functioning of a large segment of existing or potential products and production systems), innovation spawning (fosters new innovations that directly or indirectly result from the early major invention) and scope for improvement (technology improves substantially over time) (Youtie et al. 2008). Others argue that nanotechnology is just a new label put on research projects in conventional fields of science – such as chemistry, physics, biomedical engineering, materials science and electrical engineering – to gain more research funding (Schummer 2004). However, there have been also efforts to define various terms in the field of nanotechnology, and thus build common understanding about the issue. Table 1 shows definitions found in a publicly available specification by British Standards (PAS71:2005).

Table 1. Definitions of general nanotechnology-related terms (PAS71:2005).

Term	Definition
1 nanomaterial	Material with one or more external dimensions, or an internal structure, on the **nanoscale**, which could exhibit novel characteristics compared to the same material without **nanoscale** features NOTE Novel characteristics might include increased strength, chemical reactivity or conductivity.
2 nanoparticle	Particle with one or more dimensions at the **nanoscale** NOTE 1 Also referred to as nanoparticulate, although this term is more often used adjectivally. NOTE 2 Novel properties that differentiate **nanoparticles** from the bulk material are typically developed at a critical length scale of under 100 nm.
3 nanoscale	Having one or more dimensions of the order of 100 nm or less NOTE Also referred to as nanosize.
4 nanoscience	Study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale
5 nanostructured	Having a structure at the **nanoscale** NOTE **Agglomerate**s and **aggregate**s of **nanoparticle**s are examples of nanostructured particles.
6 nanotechnology	Design, characterization, production and application of structures, devices and systems by controlling shape and size at the **nanoscale**

Table 2 shows a timeline for nanotechnology development (Renn & Roco 2006). In the period 2000–2020 nanotechnology is expected to develop in four overlapping generations. The first generation of nanotechnology products, which is already on the market, is passive nanostructures. These materials are relatively simple with passive or merely reactive behavior, and have steady or quasi-steady structures and functions during their use. The second generation is active nanostructures. An active nanostructure changes its state during operation. The third generation consists of integrated nanosystems, or in other words, systems of nanosystems. These systems are generated, for example, by using various synthesis and assembling techniques and they can be applied, for example, in the fields of nanomedicine or nanoelectronics. The fourth generation of nanoproducts is heterogeneous molecular nanosystems. In this generation each molecule in the nanosystem has a specific structure and plays a different role. Molecules will be used as devices, and fundamentally new functions will emerge from their engineered structures and architectures.

Table 2. Timeline for beginning of industrial prototyping and nanotechnology commercialization: four generations of products and production processes (Renn & Roco 2006).

~2000	***1st Passive nanostructures (1st generation products)***	
	a. Dispersed and contact nanostructures	e.g. aerosols, colloids
	b. Products incorporating nanostructures	e.g. coatings; nanoparticle reinforced composites; nanostructured metals, polymers, ceramics
~2005	***2nd Active nanostructures***	
	a. Bio-active, health effects	e.g. targeted drugs, biodevices
	b. Physico-chemical active	e.g. 3D transistors, amplifiers, actuators, adaptive structures
~2010	***3rd Systems of nanosystems***	
	e.g. guided assembling; 3D networking and new hierarchical architectures, robotics, evolutionary biosystems	
~2015–2020	***4th Molecular nanosystems***	
	e.g. molecular devices 'by design', atomic design, emerging functions	

As the development of nanotechnology is still in early phase, there are many questions about its benefits and risks. There are high expectations that nanotechnology solves a bunch of social problems from the collapse of birth rate in advanced nations to global warming, and currently incurable illnesses, such as cancer or AIDS (see table 3). On the other hand, the obscurity of the form of future nanotechnology has bred some end-of-the-world scenarios. The most famous one is known as "Grey goo". Wikipedia describes Grey goo as follows (http://en.wikipedia.org/wiki/Grey_goo):

> **Grey goo** (alternatively spelled gray goo) is a hypothetical end-of-the-world scenario involving molecular nanotechnology in which out-of-control self-replicating robots consume all matter on Earth while building more of themselves, a scenario known as ecophagy ("eating the environment").
>
> Self-replicating machines of the macroscopic variety were originally described by mathematician John von Neumann, and are sometimes referred to as von Neumann machines. The term grey goo was coined by nanotechnology pioneer Eric Drexler in his 1986 book Engines of Creation, stating that "we cannot afford certain types of accidents." He later changed his position, in 2004 stating "I wish I had never used the term 'grey goo'."

In an opinion writing, Eric Drexler together with Chris Phoenix (Phoenix & Drexler 2004) argues that self-replicating molecular systems are not only undesirable, but also inefficient and unnecessary, and therefore it is unlikely that such systems would ever be developed. Instead, they think that the most dangerous outcome of molecular nanotechnology would be non-replicating weapons. Since non-replicating weapon systems will be both easier to build and more likely to draw investment than any self-replicating nanodevices, these generate a greater risk than the Grey goo scenario.

Table 3. Problematic societal trends and ways nanotechnology could contribute to solutions, according to Roco and Bainbridge (2005).

Social problem	**Nanotechnology contribution to solution**
Healthcare and working capacity of aging population	Convergence of nanotechnology with biotechnology, information technology and neurotechnology would address chronic illnesses, losing sensorial capacity, and maintaining work capacity
Collapse of birth rate in most advanced nations, below level required for population stability	Convergence of nanotechnology with biotechnology to overcome infertility
Poverty and inequality, most urgently in under developed nations	Economic progress, fueled by technological developments requiring systematic control of nanoscale processes and materials
Loss of jobs in advanced nations, as work goes to nations with lower wages, weaker worker benefits, and worse workplace safety	Progress in nanoscience will allow industrial nations to maintain quality of life, generating new domestic industries with high-quality jobs, even as poor nations benefit from globalization
Threatened exhaustion of natural resources	Nano-enabled technologies for improved efficiency in use of non-renewable resources, including energy production, water filtration, and invention of many high-quality nano-fabricated substitute materials
Environmental degradation, including global warming	Reduced pollution from more efficient use of materials; specific new pollution remediation nanotechnologies; improved environmental monitoring by means of nano-enabled sensor nets
World political instability threatens the gains achieved by newly democratic nations	Stability will require technology that can offer abundance to a majority of people in all societies with existing natural resources

Security issues within industrial nations	Numerous specific nanotechnology-based solutions, such as: sensors to detect bioterrorism substances; inexpensive ‘‘smart labels’’ to deter theft of valuable goods; armor and vehicle components from nano-structured materials
Cultural chaos in post-industrial, post-modern, pluralist society	Nanotechnology will permit rapid progress in technologies of computation, communication, and creativity to sustain a culture of connectivity, equal access to information and a myriad subcultures simultaneously
Medical: diminishing returns from research; rising cost of health care	Fresh approaches to disease diagnosis and treatment from nanotechnology; prevention of disease from better nutrition and from quick detection and treatment of conditions predisposing to disease
Medical: currently incurable illnesses, including cancer and AIDS	Molecular and nanobiosystems solutions for detection and treatment at the subcellular level
Possible slowing of progress in many fields of science and engineering (e.g., aviation and space, nuclear power; computers)	Fresh ideas, research methods, and design approaches generated by convergence and combination of many fields, made possible by the nanoscale science and technology platforms. It will support rapid advancements in biotechnology and information technology.

As the examples above show, the future nanotechnology raises many open questions and contradictions. The development of nanotechnology is also evaluated in the context of previous experiences on emerging technologies and scientific developments. One topic that appears in the articles (e.g. Friedman & Egolf 2005; Throne-Holst et al. 2007; Pidgeon & Rogers-Hayden 2007) is the possible analogy between nanotechnology and genetically modified (GM) food or genetically modified organisms (GMO). It is feared that some members of the public would react to nanotechnology in the same way many reacted to GMOs, and the change of general opinion towards negative direction would be a serious obstacle for the further development of nanotechnology. This kind of sudden change of opinion in which the potential of a technology becomes tainted by discourses of risk can be called stigmatization (Wilkinson et al. 2007). Stigma is remarkably difficult to overcome once it takes root. According to Wilkinson and others, the possible impetus for stigmatization is obvious in the case of nanotechnology, because of its characteristics and scale. Nanoparticles are unbounded, and therefore involve involuntary exposure to natural environment and people. The scale

of nanotechnology means that the risk is “invisible” in the sense that any possible contamination is indeterminable to human sensory capacities. The possibility of bodily entry and harm through digestion or other promiscuous routes further advances the potential perception of threat. Because nanotechnology involves a serious threat of stigmatization, some writers consider it essential that policy makers and the developers of nanotechnology learn a lesson from the past, and actively engage general public in dialogue about the development of nanotechnology. As the development is in early state, public participation is possible before significant research and development has taken place and before any firm public attitudes or social representations have been established. This kind of approach is called “upstream” engagement (Pidgeon & Rogers-Hayden 2007).

This report is a literature review about societal and communication issues concerning nanotechnology. The objective of the review was to gain understanding of consumers’ and NGOs’ attitudes to nanotechnology. The ultimate goal was to formulate guidelines for communication about nanotechnology related issues based on the literature. The report starts with discussion on the position of public in the context of nanotechnology development. Does the public have any role in the development? The third chapter discusses the role of news media in nanotechnology communication. The topic of the fourth chapter is public opinion on nanotechnology, and the fifth chapter covers the NGO (non-governmental organization) perspective. Finally, the findings are summarized and the objective of this review is addressed in the conclusion.

2. Consumer or citizens – public in the context of nanotechnology development

The development of new technologies is a complicated issue requiring special competences. Could general public have any role in the development? The answer to this question depends on the interpretation that we give to the concept of public. To elaborate this question, I use the analysis by Karoliina Snell (2009) as a starting point. Snell analyzed Finnish policy documents and strategies on biotechnology and interviews with Finnish experts on biotechnological research and policymaking. The aim of the analysis is to provide a picture of the way lay people are portrayed in these texts. In other words, how publics are constructed in the policy documents, what is the "imagined" picture of public that is written in the texts. This kind of analysis is necessary to reveal the boundaries of power and opportunities for action that is thought to belong to ordinary people in relation to development and governance of emerging technologies, such as biotechnology. The analysis by Karoliina Snell (2009, 129–164) resulted in five analytical classes, which are *citizens*, *consumers*, *human beings*, *populations* and *patients*. These constructions of public contain different understandings of the possibilities for action, responsibilities and needs for information. It is important to note that the classes are not real in the sense that it would be possible to divide people into them, or they would represent people in some other context than the context of the analyzed texts.

According to Snell, citizens are political and active members of society who play an important part in decision-making and who have social responsibilities. However, the level of activity varies in different documents. The documents by European Commission presented citizens in a more active role than Finnish documents. Characteristic to the Finnish documents is to see citizens as passive audience, whose opinion can be constructed through surveys rather than achieved through active participation. Also, NGOs (non-governmental organiza-

tions) can be preferred as representatives of public opinion in public discussion or in decision making. Consumers are also active, but their activity is restricted only to decisions concerning their personal consumption patterns. Citizens and consumers have different rights. The class of citizens is based on procedural rights: the possibilities of participating in decision-making or bringing about changes in society.

Consumers, in turn, have personal rights to choose from various alternatives on the market. These choices are expected to be based on rational arguments and therefore consumers need to be informed on the products and choices that are available.

The three other classes – human beings, populations and patients – appeared mainly in relation to medical biotechnology. Also, these classes differ from each other based on opportunities for activity. Human beings are ethical subjects, worthy as such, and active and responsible in relation to their own bodies. An important concept in this category are human rights, which means that these rights need to be respected and human beings cannot be targets of action without their own consent. In contrast to the category of citizens, the rights of human beings are personal, not procedural, and therefore human beings are not political actors in the same way as citizens. Populations are only targets of action and they do not have active or responsible roles. Population is an object for analysis and health measures, but it is also a resource for biotechnology, for example as a source of tissue samples and medical information. Where populations are impersonal, patients are seen as individuals who need treatment. They can be active also, but only in finding information on their illness and demanding the latest methods and tools for themselves. Table 4 summarizes the classification of public.

Table 4. Different types of publics in (mainly) Finnish texts on biotechnology. These classes represent the "imagined" pictures of publics as subjects and instances of responsibility. (Modified from Snell 2009, 161.)

Type of public		**As subject of responsibility**	**As instance of responsibility**
Citizens	Active (in the EU)	Active participants in decision-making	One group of stakeholders dealing with a common future
	Passive audience (in Finland)	Passive, opinions gathered through surveys	Important actors with rights and opinions to be respected
Consumers		Active in the market, personal rights and informed choices	Need to be provided with product safety, information and possibilities for choices
Population		Passive objects	Beneficiaries of well-being created by biotechnology and source of resources (such as tissue samples)
Human beings		Active in relation to self, passive in relation to development of bio-technology	Rights and integrity to be respected
Patients		Active in issues of own health and illness	Treatment and choices need to be offered

How does the discussion above relate to nanotechnology? One can assume that nanotechnology is, at least to some extent, comparable to biotechnology as another branch of emerging technology. Therefore, similar constructions of publics could be found in various strategies of policy documents on nanotechnology. Also, the classes can help to consider the position of public in development of nanotechnology. From this perspective, the classes of citizens and consumers are the most interesting. If we understand public as citizens, we think that they have also political power in its procedural form and rights to participate in decision-making. Therefore, general opinion becomes an important factor when new technologies are developed. On the other hand, if we consider public as consumers, it is enough to provide them an opportunity to decide which products have success on market and which do not. Because both groups are active and have a certain amount of power, information and communication become important aspects. However, the reasons for the importance are different. Citizens need information on the developed technology in order to realize their responsibilities

as active members of society. On the other hand, the developers of technology are obligated to know the opinion of citizens in order to respect their rights to participate in the society. Consumers need information about products so that they can make rationalized decisions on their consumption. Difficulty in this is that consumers can express their opinion only when products are already developed and placed to market. If their opinion is disapproving and they decide not to buy the product, all the development investments have been lost. Therefore, it may be in the producers' interest to collect information about consumers' wishes and needs already in the beginning of the production development process.

To illustrate the presentations of public in the context of nanotechnology, I will next show a few examples from literature. The first example is from an article (Roco & Bainbridge 2004) which summarizes opinions presented in a workshop organized by U.S. National Nanotechnology Initiative in late 2003. The article describes the agenda of the workshop as follows: "leading representatives of industry, government, and a wide range of scientific and engineering disciplines shared information and analyzed the increasing societal importance of nanotechnology". The next quote is a section of the article titled *Interaction with the public.*

> The National Nanotechnology Initiative can play an important role as an honest broker in coordinating research and development in nanotechnology with public hopes and fears, and it should embrace the goal of building capacity for public dialog. It is imperative that genuine risks be dealt with in an expeditious, open and honest manner. Negative public attitudes toward nanotechnology could impede research and development, leaving the benefits of nanotechnology unrealized and the economic potential, untapped, or worse, leaving the development of nanotechnology to countries and researchers who are not constrained by regulations and ethical norms held by most scientists worldwide. Research on how to achieve an informed population will be important for establishing best practices for educating, communicating and engaging diverse publics about nanotechnology. We need to develop survey data about audience response to various media products, and effective training method to prepare scientists and engineers to engage in public dialog about nanotechnology. (Roco & Bainbridge 2004, 7).

The conception of public is extremely passive in this quote. It appears already in the selection of words describing the publics. Public is only a target for actions, such as education and information, not an active participant in a dialogue. The ultimate goal of the action is to achieve an *informed population* so that it would not impede research and development of nanotechnology with its negative attitude. Public is *audience* which *responses* to various products, not a group of

active participants who would formulate their own opinions and use procedural power in the society. The quote suggests that the developers of nanotechnology in the U.S. consider themselves eligible to develop nanotechnology regardless the public opinion or other external factors, as they follow the high moral standards of the research community. The public appears in the text only in a position of potential threat to the development of nanotechnology, and scientists and engineers need special training to meet this threat. To this threatening population it is obligatory to communicate only the *genuine risks* of the developed technology, not potential or possible risks in general – or even less necessary is to know how the population perceives the risks.

Next example is from an article on methodologies of participation:

> The special properties that have already led nanomaterials to be used in sunscreens, tennis rackets, clothing treatments and other uses may pose new risks that deserve special regulatory attention. Future applications of nanotechnologies are expected to have much more dramatic impacts. The public is involved as current, and more importantly, possible future users of products employing nanotechnology, as well as citizens of countries that are investing heavily in nanotechnology research and development. Emerging technologies such as nanotechnology offer new opportunities and new dangers, posing questions for researchers, ordinary citizens, government officials, and others about what roles they may play in promoting safe and socially beneficial development and application of new technological capabilities. (Bruns 2003, 1).

This quote involves a conception of public as consumers, in other words *users of products employing nanotechnology*, and citizens. The quote represents citizens as an equal stakeholder group among other ones, such as researchers and government officials, who have their responsibilities in *promoting safe and socially beneficial* nanotechnologies. The question about how public, or *ordinary citizens*, may take this responsibility, is a matter of possibilities to participate in a dialogue or decision-making on nanotechnologies. If there are not any mechanisms of public participation, lay people do not have any possibilities to affect the development in the early stages, but the only possibility that remains is some sort of outrage or backlash if any problems occur later. The concepts of public, which were discussed above, include also an idea of the possibilities for participation that need to be offered for the public. Bruns (2003) presents five levels of participation which provide different possibilities for influencing. These levels are Information, Consultation, Involvement, Collaboration, and last Empowerment. Table 5 shows examples of these and their advantages and disadvantages. Also, the corresponding conceptions of public presented above are added in the table.

As nanotechnologies are complex and their development requires professional capabilities, empowerment is not necessarily a realistic alternative for lay people participation in development of nanotechnologies. The examples of empowerment methods listed in Table 5 concern more companies and other professional stakeholders than lay people. Only labelling which makes conscious consumption choices possible refers to consumers. The difference between consultation and involvement, on one hand, and collaboration, on the other, is that the participants' contribution should affect the decisions made in the latter case. In other words, the recommendations by a citizen jury should be taken into account in decision-making equally with expert recommendations. Information as a participation method is connected to a common view that consciousness and knowledge about new technologies also improve attitudes towards them. The same view can be read in the quote above, which considered lay people as a threat for the development of nanotechnologies: *Negative public attitudes toward nanotechnology could impede research and development -- Research on how to achieve an informed population will be important for establishing best practices for educating, communicating and engaging diverse publics about nanotechnology* (Roco & Bainbridge 2004, 7).

One example of collaboration method is a citizen jury. The method was developed in the USA in the 1970s, and it is based on the model of a legal jury. A small number of lay people are selected to represent a cross-section of society. They then deliberate a specific issue selected by the organizers. The purpose of the jury is to pass judgments or make recommendations on the policy issues at hand. During the process the jury has an opportunity to question “witnesses”, typically experts on the issue. The deliberations of a citizens' jury are not legally binding, but the idea of collaboration is that the opinions of participants should be taken into account in the decision-making. In the UK, the citizens' jury method was applied to nanotechnology related issues. NanoJury UK was organized in the summer 2005. The jury formulated 13 general recommendations and 10 specific recommendations (four on ICTs, three on energy, three on health). The general recommendations dealt with issues, such as the principles of public money spending on the development of nanotechnologies and possibilities for public involvement in the development. (Pidgeon & Rogers-Hayden 2007).

Table 5. Levels of participation for public involvement in nanotechnology (modified from Bruns 2003).

Level of participation	Examples of methods	Advantages/disadvantage	Corresponding conception of public
No participation	Withhold information Deny dangers, dismiss critics Confine discussion to experts and technical issues Disregards differences between new technologies and products and old ones	-Delay in discussion and analysis -Outrage and backlash if concealed problems show up later on -Risk of losing public and investor confidence	
Information	Regulatory filings Journal articles, technical publications Public relations: press releases, FAQs, briefings, interviews, tours, websites, advertisements	+Better understanding by public and decisionmakers -Concerns about bias, selective disclosure -One-way, lack of dialogue	Population, citizens as passive audience
Consultation	Public hearing, public comment procedures, community open houses, focus groups Online forums, addresses for comments	+Facilitate diverse, well-informed public input into decision-making +Identify public concerns and ideas -Difficulty in understanding and discussing complex technical issues -Need for inclusive outreach	Citizens as passive audience, Consumers
Involvement	Participatory workshops	+Engage representative range of concerned people +More intensive interaction +Results are input to decisions	Consumers, Active citizens
Collaboration	Stakeholder panel input into plans Citizen jury recommendations Negotiated rulemaking by regulatory agencies together with stakeholders	+Stakeholders have a “seat at the table” in developing and ranking alternatives, various views included in the process +Customized adaptation to technical and economic constraints and regulatory goals -Risk of process being captured by narrow interests	Active citizens
Empowerment	Joint decisions by concerned groups and government, e.g. in standards-setting Self regulation, corporate codes of conduct, environmental audits Reputational consequences Tor law, insurance Open standards, open-source software, non-exclusive licensing Consumer choice in technologies and products, labeling	+Obtain advantages of both government authority and professional standards +Encourages voluntary initiative, flexible development of best practices +Focus on individual and corporate responsibility -Difficulties in determining liability +Facilitate collaboration, error detection, prevent monopoly abuse +Reduce concerns about invisible and involuntary risks	(Consumers)

The NanoJury UK was organized as an experiment on “upstream” engagement. Upstream engagement refers to a public participation process before significant research and development has taken place and before establishment of firm public attitudes or social representations about an issue. Nanotechnologies were seen as an interesting test case for such an experiment, because the development of nanotechnologies is still in an early phase. Based on their analysis on the NanoJury UK, Pidgeon and Rogers-Hayden (2007) argue that upstream engagement requires moving beyond conventional approaches to discussing risks in relation to new technologies. When it is a question about future technologies, there are also more scientific uncertainties involved. In such conditions, it is not reasonable to expect the members of the public to discuss risks, but to offer insight into the way they contextualize and evaluate technology issues within their lives, their values and their worldviews. Therefore, the dialogue in public engagement need to be future focused, broadly framed, and to explicitly incorporate questions of both public values and technology governance. The greatest challenge in such a dialogue is that it must be broad enough not to restrict and decontextualise debate, but on the other hand, too much flexibility means recommendations are rather abstract and thus difficult for policy makers to utilize.

A more traditional approach to public engagement is the risk communication approach. According to this view, the potential risks and benefits of technologies should be communicated to the public to gain public acceptance. One channel of communication is mass media. Next chapter discusses the role of news media in nanotechnology-related communication.

3. Nanotechnology in the news media

3.1 Article tones and framing

Characteristic to the reporting of nanotechnology in newspapers and other print media, especially in the United States, has been to highlight its benefits. For example, Figure 1 shows results of an analysis of U.S. and non-U.S. articles about nano science and technology from 1992–2004 (Stephens 2005). As can be seen in the figure, discussion of benefits and risks have been more common in the non-U.S. newspapers, as more than half of the articles in the U.S. did not contain discernible tone regarding benefits or risks, while this share in the other group was only 30 %. In both groups, a more common tone was that benefits outweigh risks than the opposing tone.

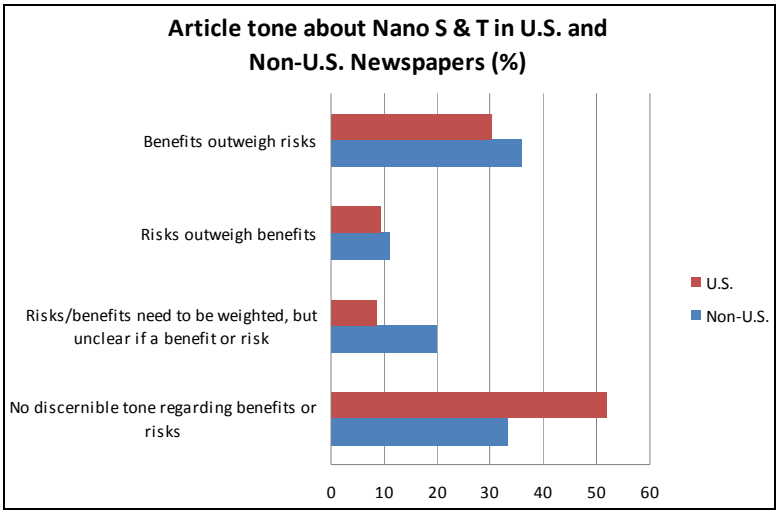

Figure 1. Article tone about the benefits vs. risks of nano science and technology in U.S. and non-U.S. newspapers. Data sample covers years 1992-2004. Total number of the articles in the sample is 350, of which 76 % are U.S. articles. (Data from Stephens 2005.)

Also another analysis of the U.S. print media (Fitzgerald 2006) showed that the benefits of nanotechnology were reported much more frequently than the risks. The data covered 570 print media articles from years 1998–2005. In the sample, there were 479 benefits mentioned, and in contrast, only 121 risks or costs. (A single article could include more than one topic of benefits or risks.) The most frequently cited current or future benefits were related to enhanced quality of goods and services and disease prevention and cures. The most frequently mentioned risks or costs were new health problems and environmental degradation. It was also found out that there were not differences in the emphasis of benefits in comparison to risks between popular press, trade journals and general science publications but in all the media types the benefits outweighed risks. However, Te Kulve (2006) states based on his analysis of the Dutch newspaper reporting on nanotechnology that similar emphasis on the benefits of nanotechnology was not found in the Netherlands, but already from the early years of reporting on the topic there was a dual pattern of high expectations and more modest expectations present in the reporting.

Another topic that appears in the nanotechnology-related communication studies is news framing. These studies analyze the context in which nanotechnology is presented in newspapers. The concept of frame refers to an idea that information becomes meaningful only when it is placed in a context of other information. In other words, frames help to identify what is essential in the flow of information, why an issue matters, who might be responsible, and what should be done, etc. Framing is important both from the perspectives of news production and reception. On one hand, news frames indicate journalists' interpretation of a news event's significance; why an event or issue is worth of reporting. On the other hand, reception studies have shown that readers often rely on interpretative frames which are derived largely from personal experience, and differ from the frames that are offered by the news media (Jensen 2002, 150).

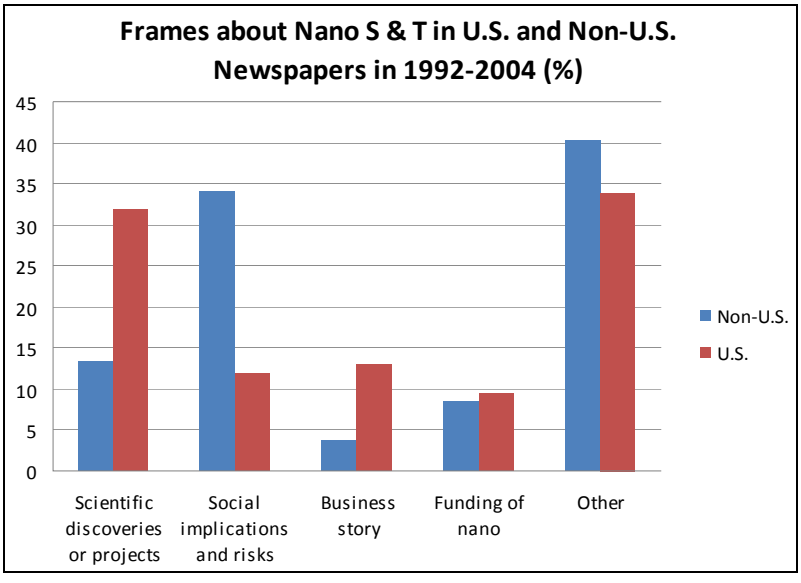

Figure 2. News frames in U.S. and non-U.S. newspapers. Data sample covers years 1992–2004. Total number of the articles in the sample is 350, of which 76 % are U.S. articles. (Data from Stephens 2005.)

Figures 2 and 3 show results of a study (Stephens 2005) analyzing news frames about nano science and technology related reporting. Data is collected as a database search and it covers years 1992–2004. The sample contains U.S. newspapers and non-U.S. newspapers from undefined countries. As can be seen in the Figure 2, scientific discoveries or projects have been the most dominant context for nano science and technology reporting in the U.S. while social implications and risks were more common in the non-U.S. press. Another difference between the U.S. and non-U.S. publicity about nanotechnology is that business stories are more common in the U.S. The category *other* covers 12 additional themes, such as celebratory; finance, intellectual property, PR, military applications, and science fiction and popular culture. Figure 3 shows that there have been clear changes in the reporting over time; as the frequency of reporting has increased the themes have also become more diverse. This tendency can be seen in the dramatic decrease of the *scientific discoveries or projects* frame, and increase of *other* frames at the same time.

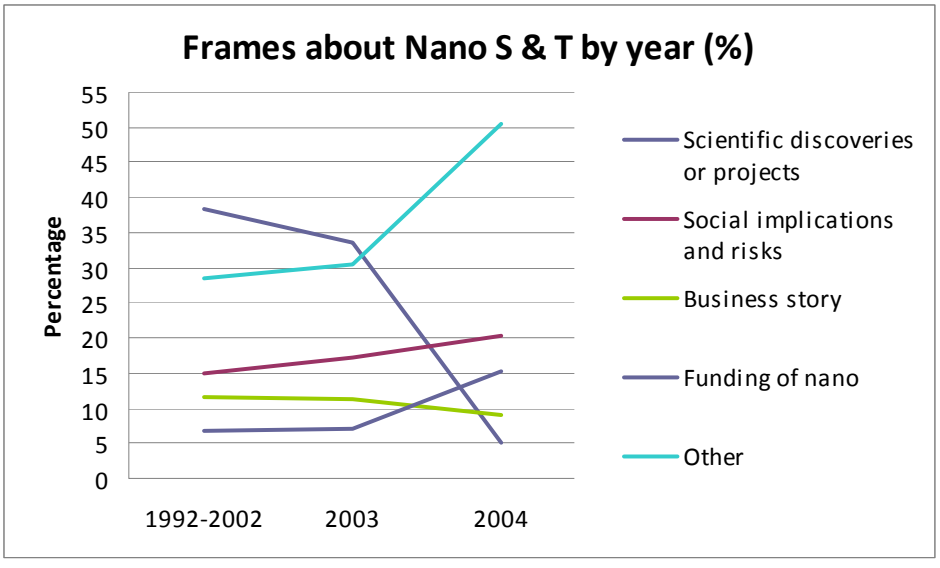

Figure 3. Changes in the dominant news frames about nano science and technology in U.S. and non-U.S. newspapers over years. Total number of the articles in the sample is 350, of which 152 are from 1992–2002, 98 from 2003 and 100 from 2004. (Data from Stephens 2005.)

Figure 4 shows results from an analysis of news frames about nanotechnologies in 18 UK-based national newspapers (Anderson et al. 2005). Data of this study covers a period from April 2003 to June 2004. As can be seen in Figure 4, it has been as common to present nanotechnology in the frame of *science fiction and popular culture* as in *scientific discoveries or project* frame in the UK newspapers. According to the writers (Anderson et al. 2005, 207) this finding seems to reflect uncertainty about whether nanotechnologies can be most adequately contextualized within the realms of science fiction or science fact. The economic implications of nanotechnologies, however, seem to gain strong interest as the *Business story* frame is almost as popular as the two above-mentioned ones. On the fourth place there is a frame called *Prince Charles interest*. This refers to stories that originated from an interview with Prince Charles that was published on late April 2003 and headlined "Charles: 'Grey Goo' Threat to the World". The story had political focus as the article stated that Prince Charles was on a 'collision course' with Prime Minister Tony Blair because the Labour government was keen to support developments in nanotechnology (Anderson et al. 2005, 221). In the coming days, other newspapers began to comment the inter-

view and speculate on Prince Charles's attitudes and stance and the inspiration for his interest, which increased the number of stories falling in this frame. What differentiates the *Prince Charles interest* frame from, for example, the *Scientific discovery* frame is that the Prince stories appeared during a short period, whereas the stories using the scientific discovery frame were relatively commonly distributed throughout the whole period. According to Anderson et al. (2005, 212) the involvement of a celebrity, such as Prince Charles, boosted the newsworthiness of nanotechnologies in the press, even if his comments were treated with skepticism by most national UK newspapers. This indicates that celebrities can play a crucial role in sustaining media attention to an issue despite a lack of policy events.

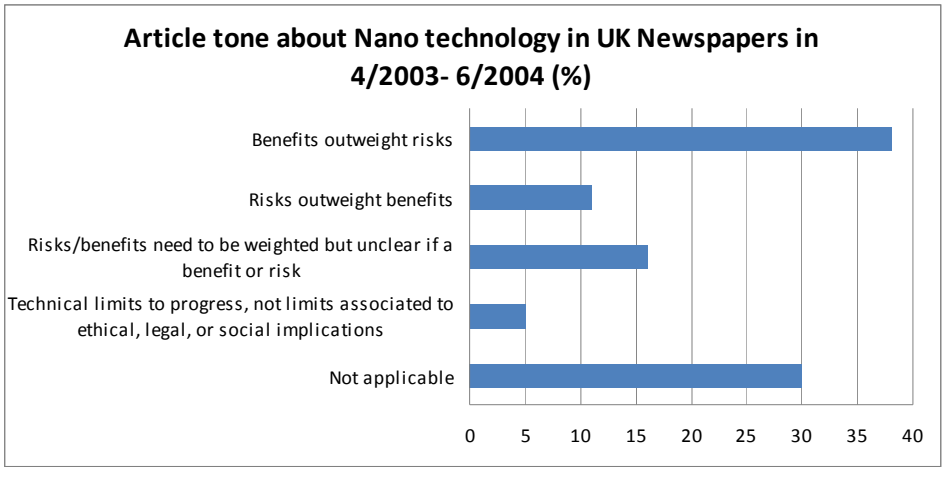

Figure 4. News frames in UK Newspapers. Data sample covers 18 UK-based national newspapers and the period from April 2003–June 2004. The number of articles is 344. (Data from Anderson et al. 2005.)

A slightly different, but related, approach to newspaper reporting on nanotechnology is in Te Kulve's article (2006). He analyzed the changes in five general Dutch newspapers in 1992–2005. Te Kulve uses the concept of repertoire instead of frame in his analysis. Repertoire can be understood as a wider concept than frame. Framing primarily deals with the relations between various issues – the context in which certain issues are presented – while repertoire includes also an idea about the patterns *how* various issues are presented. The concept of repertoire views culture as providing actors with a "tool kit" of symbols, stories,

rituals, and world-views from which they can select different elements to shape their action and solve problems. In the context of newspaper repertoire, this would mean that there are some common patterns to write on certain issues. An example of this is the antagonistic pattern of writing on debates over emerging technologies, which means that the views of proponents and opponents of the technology are contrasted in the articles.

Te Kulve recognized three periods in the Dutch newspaper reporting on nanotechnology. These were: The rising 'star' of nanotechnology (1992–1999); The consolidation of nanotechnology research (2000–2002) and The confrontation of nanotechnology and society (2003–2005). Te Kulve recognized these periods focusing on the context in which nanotechnology appears in the newspapers and analyzing the articulation of repertoires and the extent to which views were explicitly related to each other. Actually, the first point, the context in which nanotechnology appears, goes close to the concept of framing, and therefore Te Kulve's findings can be related to the ones referred above. (The concept of frame is also used here when referring to the contexts of reporting. The original source used a concept of repertoire segments in this context.) According to Te Kulve, diverging views on nanotechnology were not contrasted in the first stage, and the repertoire could be characterized as having a dual pattern of high expectations on the one hand and more modest expectations on the other. The dual pattern shifted gradually to a more antagonistic pattern at a later stage. Views about nanotechnology become increasingly contrasted, for example scientists began to refer to other actors, and provide also counter-arguments to their own views. The representation of nanotechnology did not include only scientific context anymore, but also broader sociotechnical views such as utopian and dystopian visions, views regarding the possible contributions of nanotechnology to economic growth, as well as discussions about risks inherent in the new and emerging field of science and technology. In the second stage of reporting, these views started to appear but received only limited attention. Therefore, this period can be characterized as one of further consolidation of the dual nanotechnology repertoire, which was dominant during the first period.

If we compare the findings of Te Kulve (2006, Figure 5) and Stephens (2005, Figure 3), we can identify some similar patterns: The dominant position of the scientific frame in reporting has disappeared, and new societal frames have gained more attention. According to Te Kulve (2006, 380) the diversifying range of repertoires (or frames) that emerged in newspapers improved the newspapers' potential to support their readers' engagement in public dialogue about the risks

and benefits of nanotechnology. Also, the antagonistic pattern of reporting may improve the readers' ability to appreciate the risks and benefits of nanotechnology in a more balanced way, if the arguments and counter-arguments are continuously presented in newspapers.

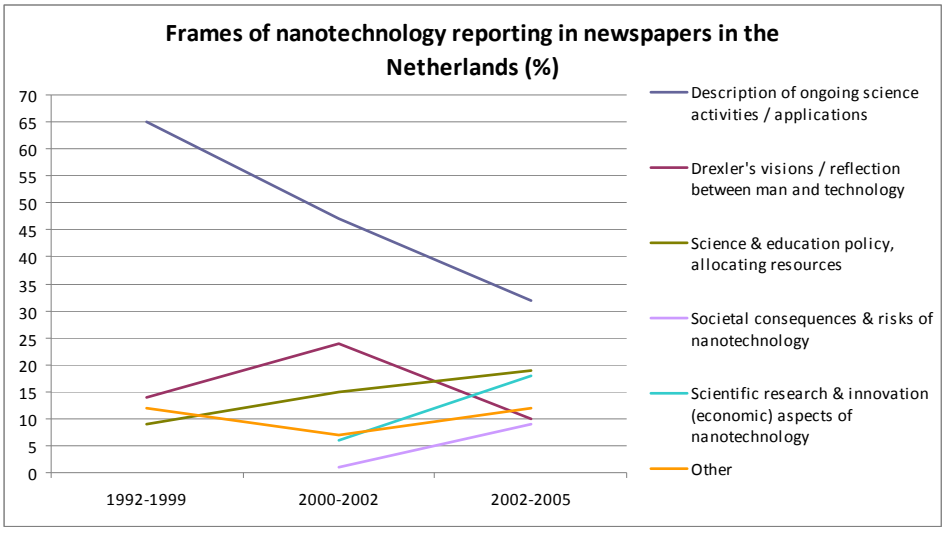

Figure 5. Changes in the news frames about nanotechnology in the Netherlands over years. Total number of the articles in the sample is 237. (Data from Te Kulve 2006.)

Kahan et al. (2009) have studied framing from the news reception's perspective. In the study, they first measured the respondents' values and formulated two value orientations: *egalitarian communitarians* and *hierarchical individualists*. After that they divided the respondent into four groups, and each group received a distinct version of a newspaper story on nanotechnology with different framing. The four articles differed in their headlines and in their first and last paragraphs, which were worded to emphasize different applications of nanotechnology. One of the stories highlighted the use of nanotechnology in commercially produced consumer goods (*Consumer goods* frame). Another one emphasized the potential of nanotechnology to make government regulation of pollution emissions more effective (*Regulation* frame). The third story described the use of nanotechnologies in creating market opportunities for firms specializing in cleaning the environment (*Cleaning environment* frame), and the fourth one emphasized the deployment of nanotechnology to thwart the use of biological or chemical weapons by terrorists (*National security* frame). After the respondents

had read the stories, they were asked to evaluate the benefits and risks of nanotechnology. The hypothesis of the study was that the different applications of nanotechnology presented in the articles would either threat or affirm the values of the respondents, and therefore the respondent of each group would evaluate the risks and benefits of nanotechnology differently based on their value orientation.

A summary of the study results is presented in the following:

- The authors hypothesized that Consumer goods frame would be identity-threatening for the respondents holding egalitarian and communitarian worldview, because they tend to associate commerce and industry with individual selfishness and unjust distributions of wealth. Therefore, the egalitarian communitarians were expected to evaluate the risks of nanotechnology higher than its benefits. On the contrary, the consumer goods frame was hypothesized to be identity-affirming for hierarchical individualists, because they tend to associate commerce and industry with individual freedom and the competence of social elites, and therefore they were expected to evaluate the benefits higher than risks. The results of the study supported these hypotheses, in other words, the respondents holding the egalitarian and communitarian worldview evaluated the risks of nanotechnology to outweigh the benefits, while the result among the hierarchical individualists was the opposite.
- In the Regulation frame the pattern of risk-benefit perceptions was hypothesized to be reverse compared to the consumer goods frame. The hierarchical individualists were expected to evaluate the risks of nanotechnology higher than benefits, because the Regulation frame implied that commerce and industry are harmful due to pollution, and therefore also worthy of restriction. On the other hand, regulation of industrial pollution is an affirmative condition to the egalitarian communitarians, and therefore they were expected to evaluate the benefits of nanotechnology higher than risks. The results of the study also supported this hypothesis.
- The Cleaning environment frame was expected to be identity-affirming for both egalitarian communitarians and hierarchical individualists, because it highlighted environmental protection in one hand, and its market potential on the other. This means that respondent with both value orientations were expected to evaluate the benefits of nanotechnology higher than risks. However, the results did not support this hypothesis, but both

> groups evaluated the risks to outweigh the benefits. The authors (Kahan et al. 2009, 18) explained this finding concluding that the non-nanotechnology risks that were featured in the article of the Cleaning environment frame, such as arsenic in groundwater, provoked serious fears among the respondents, and these fears spilled over to subjects' assessments of the risks associated with nanotechnology. The result was the same for the National security frame, which treated risks, such as biological and chemical attacks. Also, in this frame the groups with both value orientations evaluated the risks of nanotechnology to be higher than benefits, even if the frame was expected to be identity-affirming for the hierarchical individualists.

The study by Kahan et al. (2009) indicates the difficulty of framing. The results showed that framing affected the respondents' evaluations on the risks and benefits of nanotechnology, but the effects could not be fully anticipated. At this point, it is important to remember the lesson from communications studies, which were mentioned above: the interpretative frames that readers rely on are often derived from personal experience, and they can differ from the frames that are offered by the media. Therefore, we cannot assume the effect of news framing to be a straightforward psychological process, but a complicated phenomenon that is difficult to control. In this context, the finding by Kahn et al. that alarming risks unrelated to nanotechnology may create a perception that nanotechnology itself is risky.

3.2 Sources and reporters

Instead of analyzing the newspaper articles about nanotechnology, it is possible to take another approach to the topic of nanotechnology writing. This approach is to look at the practices of editorial work and the perspectives of those who do the work in practice, in other words journalists. This section briefly discusses this theme.

As was seen in the studies reviewed above, a scientific frame is relatively popular in the context of nanotechnology in newspapers. However, the popularity of this frame has decreased since the early years of reporting on the topic. In this sense, nanotechnology can be considered in a more general context of science journalism. What makes a good science story? A few criteria valued by newspaper science journalists can be listed (Anderson et al. 2009, 20–21). First of all, fascination value is important. The story should provide some fascinating and new information for readers, something that is not heard about before. The

second criterion is the size of natural audience, which refers to the number of newspaper readers who are already aware that they are interested in following a news story about a given topic. For example, the size of natural audience is greater for a story about a common disease that anyone could get than for a story about a rare disease. A natural criterion for the interest in science is the importance of the scientific findings, in other words, how much difference the findings are going to make in the real world. In addition, timeliness is also important in science stories as in any news story. It is reasonable to assume that journalists and scientists evaluate the fascination value or importance of scientific findings from different perspectives. Table 6 describes these differences.

Table 6. Differences in the perspectives of scientists and journalists (Anderson et al. 2009, 30).

Scientists	**Journalists**
Interest in details	Interest in the big picture
Disputation is part of the process of advancing understanding	Conflict is the source of drama that adds zest to a story
Continually trying to build consensus	Focus on the drama of pro and con
Peer review is an integral part of a process designed to reduce errors	To most journalists, allowing sources to review material before publication is an unacceptable ceding of editorial independence
Technical terms provide added precision and clarity to discourse	Technical terms constitute a jargon that obfuscates science and makes it incomprehensible to the general reader

According to the table 6, most journalists think that allowing sources to review material before publication is unacceptable. Behind such attitudes may be the idea of the journalistic independence and mission as a champion of democracy, but also some kind of professional pride and confidence in their own competence, as expressed by a British Science editor in the following (Anderson et al. 2009, 89):

> The press is an unconscious agent of democracy. It should be free to do what it likes – free to be wrong and to be evil. The press has a role in supporting democracy. The idea that the press has a responsibility to science is dodgier. The press has a responsibility to the citizen… We have a very large responsibility but it's not my responsibility to explain science to the public, it's to get them to read the stories. When I'm talking to scientists and they ask me to show them the article before it's published to check for accuracy I tell them it's my article and I'm responsible for it. I won't show them before it's published and if they

> don't like it then they won't talk to me again. I make sure I understand what they say (and what they mean to say) otherwise I don't write it. When it comes to it, is this good or bad? It's up to the readers to make their own minds up. [Science editor, UK-Quality Newspaper]

The previous statement does not necessarily describe the situation in Finland. The self-regulation body of the Finnish journalists and publishers has formulated ethical guidelines for journalists (http://www.journalistiliitto.fi/en/the_game_rules/ethics/). The following items of the guidelines describe the rights of the interviewees to know where their statements will be published and to review their statements prior to publication. However, also the Finnish guidelines emphasize the journalistic independence and ultimate rights to make the journalistic decisions.

> 16. The interviewee has the right to know, in advance, in which context his/her statements will be used. He/she must also be told if the interview will be used in multiple mediums. The interviewee must always be told whether the conversation is intended for publication or will be used exclusively as background material.
> 17. If the interviewee requests to read his/her statement prior to publication, it is generally wise to acquiesce as long as it is possible in terms of the editorial techniques. This right strictly concerns the personal statements of the interviewee, and the final journalistic decision cannot be surrendered to any party outside the editorial office.
> 18. The interviewee's refusal to allow the publishing of his/her statement must be complied with only if the circumstances following the interview have changed so significantly that the publication of the interview could be viewed as unjust.

A challenge in writing about such topics as emerging technologies is to find the golden mean between scientific accuracy and comprehensible expression. Bell (2006, 6) warns reporters of deleting little qualifiers usually avoided by editors and writers in the context of nanotechnology reporting. Such words as "preliminary" or "this particular material" are important in the current stage of development and manufacturing, as samples of nanoparticles from different suppliers are not standard and can have different percentages of trace impurities, different distributions of size etc. Bell even advice reporters to contact the original source about what was likely left out, if they read a story without any qualifiers. Letting the sources to review the text prior publication is a good way to avoid unintentional misunderstandings that may be caused, for example, due to missing qualifiers.

What kind of sources are reporters using in the context of nanotechnology? Anderson et al. (2005) analyzed the sources in their sample of UK newspapers from April 2003 to June 2004. The most frequently quoted or cited sources in the UK newspapers were scientists, both academic and commercially based. On the

second place were politicians and governmental representatives, while spokespersons of various stakeholder groups, such as non-governmental organizations, were relatively uncommon, only 9 % of all sources in the sample (see Figure 6).

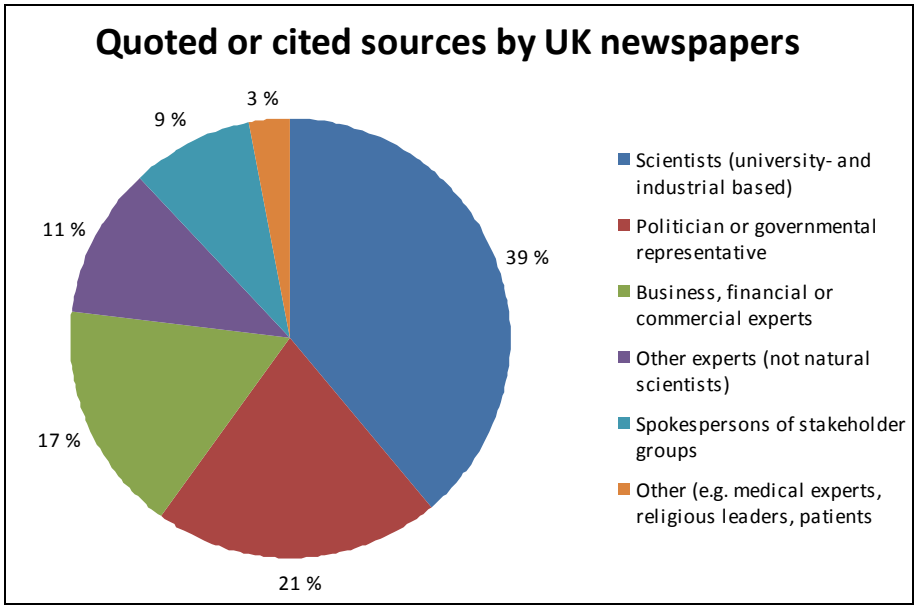

Figure 6. Quoted or cited sources in the articles on nanotechnology in the UK newspapers in 2003–2004 (Anderson et al. 2005).

The high proportion of scientists in the sources of newspaper articles may be connected to the prevalence of the scientific news frame. On the other hand, journalists may consider scientists as neutral sources, without any hidden agenda. Additional explanation may be that scientific community has learned to take care of public relations by distributing press releases, for example. References to these explanations can be found in the following quote by a science journalist (Anderson et al. 2009, 92):

> Well I mean I'd rather, you know, try and translate from what a scientist tells me what's going on than from, you know, a company or a pressure group. I think in general they tend to be a bit more sort of informed about what the reality is. But I mean when you say what role do they play I mean it's not like scientists are beating a path to my door to talk about it, but I do get a fair amount of press releases. [Science Journalist, UK-Quality Newspaper]

The statements by the journalists that Anderson et al. interviewed (2009) indicated clearly that the interest towards nanotechnology is directed by journalistic principles. Coverage is rather event-driven rather than issue-driven, meaning that nanotechnology as such is not interesting enough but some event that is evaluated journalistically interesting may be a reason to write about it. The interviewed journalists also disassociated themselves from any demands to act as a mediator between scientists and lay people or enlighten people. An example of such opinion is in the following (Anderson et al. 2009, 88–89):

> I think it's important to get things right. Equally I don't think anybody should ever take the media for granted as explainers of science as it were. I think the scientists have to explain things to the media to make sure that we get it right. I mean at the end of the day the media are trying to sell newspapers or win viewers for television programmes or whatever and we're going to do things that we think are new and interesting as a result of that. We're not in the business of sort of public communication of science. There's a big difference between journalism reporting and public information as it were. [Science Editor, UK-Quality Newspaper]

This chapter discussed the role of news media in nanotechnology-related communication. Based on the reviewed studies, one can say that nanotechnology is presented rather in a positive than negative light in newspapers. In the early years of reporting on the topic, a scientific frame was in a dominating position, but towards the middle of the first decade of the 21st century, the viewpoints and contexts in reporting have become more variable. Especially in the United States, newspapers have emphasized the benefits of nanotechnology and presented it in the context of business activities. In the European publicity (studies only from UK and the Netherlands), nanotechnology has been presented in a wider societal context and there has been a stronger opposing voice for the overly optimistic views on the benefits of nanotechnology.

Newspapers are one channel to bring emerging technologies, such as nanotechnology, to the public awareness. However, this needs to happen according to the journalistic conditions. For example, the British science journalists whose opinions were reviewed in the previous section opposed interpretations about their role as some kind of mediators or explainers of the scientific results to the general public. Instead, they saw their role strongly to be in defending and advancing democracy. Therefore also, their interest to nanotechnology originates from journalistic basis, which means that nanotechnology as an issue is not a reason to write about, but a journalistically interesting event is needed to publish anything on the topic.

4. Public opinion on nanotechnology

How have researchers approached the question about public opinion on nanotechnology? Based on the brief survey that was done for this review, one can recognize at least the following approaches or questions that have interested researchers. The first one is a descriptive approach that is interested in the public perceptions in general and the state of public knowledge about nanotechnology (e.g. Bainbridge 2002; Cobb & Macoubrie 2004; Priest 2006). Also, correlation between the level of knowledge about the issue and attitudes is an interesting question for this approach. Usually, a positive correlation between these two is assumed. Some researches question such connection between knowledge and attitudes (e.g. Kahan et al. 2007). They have a hypothesis that emotions have a significant role in the formation of attitudes, and this principle applies also to the attitudes towards emerging technologies, such as nanotechnology. Therefore, a question about values and emotions and their relation to nanotechnology attitudes becomes a central one for research. These two approaches are mainly based on quantitative research methodologies. Additionally, there are some examples of qualitative studies (The Royal Society… 2004; Cook & Fairweather 2005) which are aimed to identify public concerns and attitudes on nanotechnology. In the following, findings of studies applying these approaches are presented.

Most of the research articles that were found and reviewed for this report were written in the U.S. The earliest one was from the year 2002 (Bainbridge 2002), so one can say that the question about the public opinion on nanotechnology has been on the research agenda from the beginning of this millennium. A general finding of the studies is that people (or Americans) know little about nanotechnology. Based on one study (Cobb & Macoubrie 2004), more than 80 % of survey respondents indicated that they had heard “little or nothing” about nanotechnology and when their knowledge was tested, only 3.1 % of the respondents could answer correctly to three “true or false” questions about nanotechnology,

34.4 % had two correct answers, 33.1 % one and 29.5 % did not have a single correct answer. However, even if the knowledge of nanotechnology is poor, people tend to have relatively positive attitudes towards it. Bainbridge (2002) found out that 57.5 % of the respondents agreed with a positive statement on nanotechnology, and only 9 % with a negative one. In a comparative study on attitudes of the U.S. citizens and Canadian respondents (Priest 2006) it was found out that 46 % of respondents in the U.S. and 39 % in Canada thought that nanotechnology "will improve our quality of life in the next twenty years", 13 % in each country thought it will "have no effect", and only 6 % in the U.S. and 5 % in Canada thought that it will "make things worse". Fully 35 % of those in the U.S. and 43 % of Canadians did not know or declined to answer, which probably indicates also a poor knowledge level of the issue.

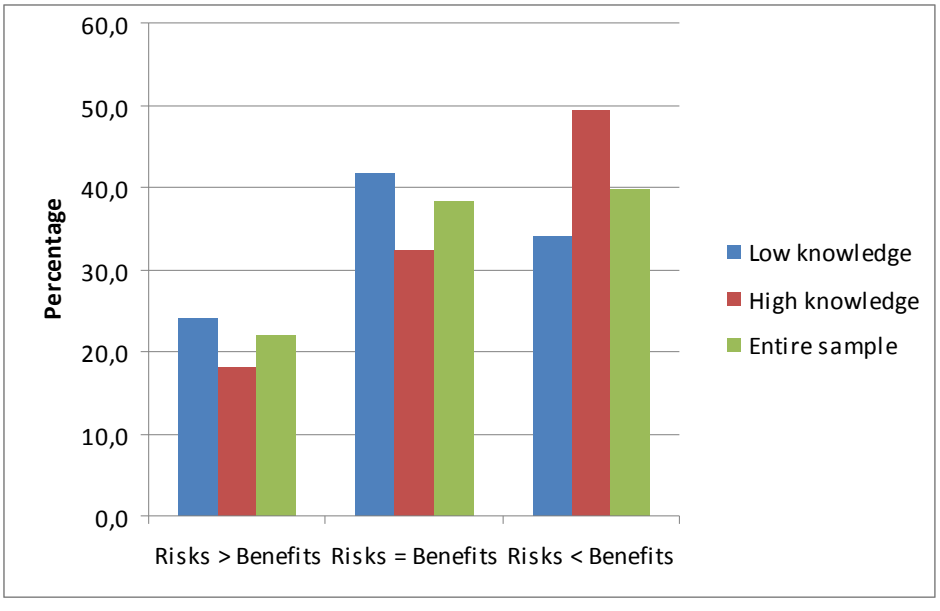

Figure 7. Perceptions of risks and benefits of nanotechnology, by respondent's knowledge. (Data from Cobb & Macoubrie 2004; data collected in the U.S., size of the sample N = 1536.)

Figures 7–9 show the results of a study (Cobb & Macoubrie 2004), in which the connection between the level of knowledge and perceptions of nanotechnology was studied. As can be seen in figure 7, greater knowledge was associated with more positive perceptions of risks and benefits. Of those who had higher knowl-

edge of nanotechnology – meaning that they could answer two or three "true or false" questions about nanotechnology correctly – almost 50 % perceived the risks of nanotechnology smaller than benefits. The differences between the groups with different nanotechnology perceptions are even greater, if the division is done by respondent's perception of science in general. If the respondent thought that "science creates problems", he/she had also more negative perception of nanotechnology risks in relation to benefits (see Figure 8). Only one percent of those who had negative perception of science thought that nanotechnology benefits will outweigh risks. On the contrary, almost 60 % of those who had positive perception of science believed also that nanotechnology benefits are greater than risks. Cobb & Macoubrie (2004) studied also feelings about nanotechnology. The respondents were asked to evaluate how hopeful, angry or worried they are about nanotechnology. Result of the analysis was that knowledge does not affect feeling angry or worried about nanotechnology, but it strongly shapes feeling hopeful: less knowledge about nanotechnology is associated with less hopefulness (see Figure 9).

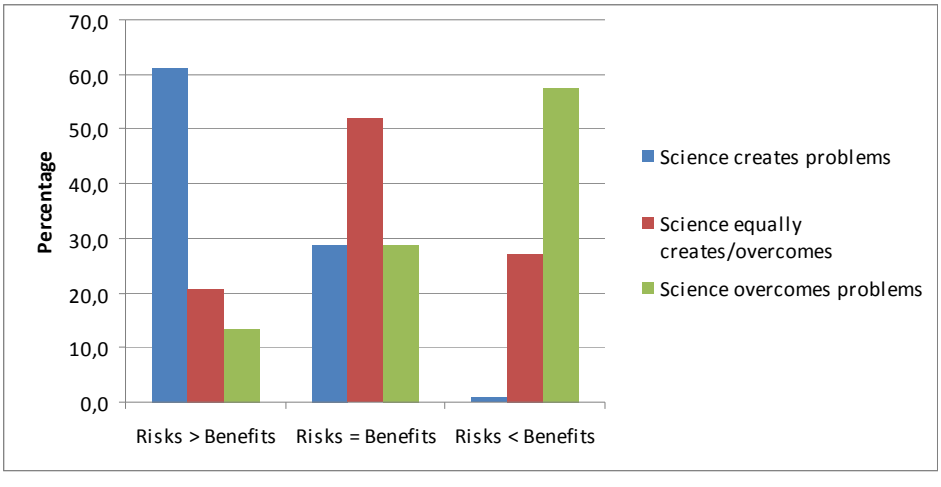

Figure 8. Perceptions of risks and benefits of nanotechnology, by respondent's views of science. (Data from Cobb & Macoubrie 2004; N = 1536.)

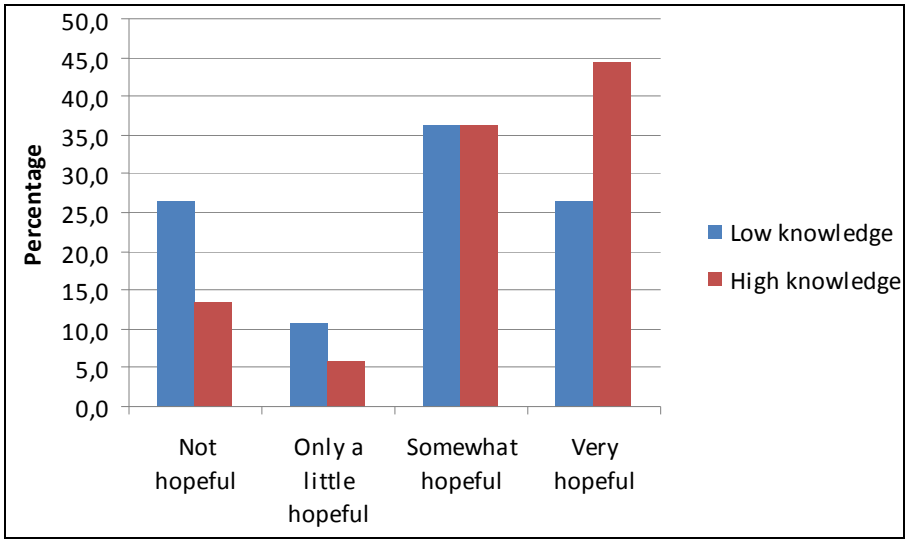

Figure 9. Connection between the feeling of hopefulness about nanotechnology and the level of knowledge. (Data from Cobb & Macoubrie 2004; N = 1536.)

The low level of knowledge creates challenges for communication. Castellini et al. (2007) studied the public baseline knowledge of nanotechnology to identify an appropriate starting point for communication of scientific results. In the study, (American) respondents were asked to report the smallest thing that they could think of and to rank microscopic and small visible objects in order of size. It was found out that the biggest share of respondents (almost 60 %) who answered that atom is the smallest thing that they could think of, corresponded to the age at which students first learn about atoms at school. After this age, the share of respondents who reported an atom as the smallest thing that they could recall dropped, and was on the lowest level among those who had the longest education behind (approximately 30 % of college educated respondents). Only 7 % of respondents correctly ranked all the microscopic items (cell, bacterium, atom and water molecule) in order of size, and 45 % was able to correctly rank the visible objects (housefly, dust, eyelash and grain of salt). According to the writers (Castellini et al. 2007), these results indicate that general public's factual knowledge of atoms and the nanometer size scale does not translate to conceptual understanding of nanotechnology. Therefore, researcher should pay special attention to communication of research results in the field. The writers list the following guidelines for communication.

- The presenter must provide a clear definition of nanotechnology in order to establish a common ground on which the conversation can be built. The definition should also involve the term nanometer, which is poorly understood because it is so much smaller than what can be seen by the eye. Also, the basic concepts about atoms and size scale should be re-taught before jumping into the details of research, because it is not evident that public knows them.
- The presenter should favor visual elements in the presentation. For example a pictorial review of the metric system can be effective showing powers of 10 working from macro range down to the nano.
- Interaction is important, because it is a way to determine the audience's level of understanding. It has been shown that audiences are more receptive and retain more knowledge when they are actively engaged with the presenter as opposed to passively listening.
- When finally poised to begin discussing the specific nanoscale science and engineering topic at hand, researchers must be very selective in what key concepts they try to convey; too many new concepts can leave the audience overwhelmed and confused. The number of key concepts should be limited to two or three and they should be repeated several times and explained in several different ways to ensure that they are understood and remembered. Analogies to everyday life can be effective for achieving better understanding, as well as demonstrations and animations.

The above approach of descriptive research can be criticized about its inability to explain the direction of cause and effect; does knowledge increase positive attitudes towards nanotechnology, or is positive attitude towards the topic a reason to learn more about it. Some researchers argue that emotions are more important influencers in the formation of nanotechnology perceptions than knowledge. For example Lee et al. (2005) found out in their study that knowledge about nanotechnology did not increase general support for nanotechnology if respondents had strong negative emotion toward nanotechnology. However, the effect of knowledge about nanotechnology on the general support of nanotechnology was significant in a group with low level of negative emotion. A similar connection between knowledge and emotion was found out in relation to risk-benefit perceptions. Knowledge about nanotechnology had a significantly stronger effect on risk-versus-benefit perceptions if the individuals also had low levels of negative emotion toward nanotechnology.

Also, Kahan et al. (2007) found out that emotional reaction to nanotechnology explained better nanotechnology risk perceptions than knowledge. For example, anxiety about environmental risks, such as climate change or nuclear power, was in connection to more negative reaction against nanotechnology. Respondents' values had also an effect on the attitudes. Respondents with individualistic values had more positive attitude towards nanotechnology. Individualistic values are connected to relative preference of a person for a society in which individuals secure the conditions for their own flourishing without collective interference. An opposite view to this one is communitarianism in which the collective is charged with securing its members' basic needs and individual interests are subordinated to collective ones. Another dimension of worldviews used in the study was hierarchy-egalitarianism. Hierarchic worldview refers to the relative preference of persons for a society in which resources, opportunities, privileges and duties are distributed along fixed and differentiated lines (of gender, race, religion, and class, for example). Egalitarians, on the other hand, prefer society in which such divisions do not exist. Another aim of the study was to examine how information about nanotechnology affected the views about it. A subsample of respondents received information about nanotechnology before their views were elicited. The information consisted of balanced description of potential benefits and risks of nanotechnology. The result of the analysis was that exposure to the information produced no overall shift in risk/benefit perceptions. However, there was a significant difference among subgroups of respondents. The factor that affected the most the shift in risk/benefit perceptions was values. Individualists and hierarchs believed more in the benefits of nanotechnology when they got additional information, while egalitarians and communitarians were more negative after receiving more information (see Figure 10).

The conclusion of the researches was that people read and interpret information so that it confirms their initial values and worldview. This means that people adopt an initial stance toward the topic, and it takes an even more partisan shape as they conform information to their cultural and political values. A consequence of this finding is that it is not possible to shape people's perceptions only by offering more information about nanotechnology. Therefore, it is highly important to concentrate on the framing of information to find ways to communicate nanotechnology related issues so that people with different values and worldviews can receive the same factual content.

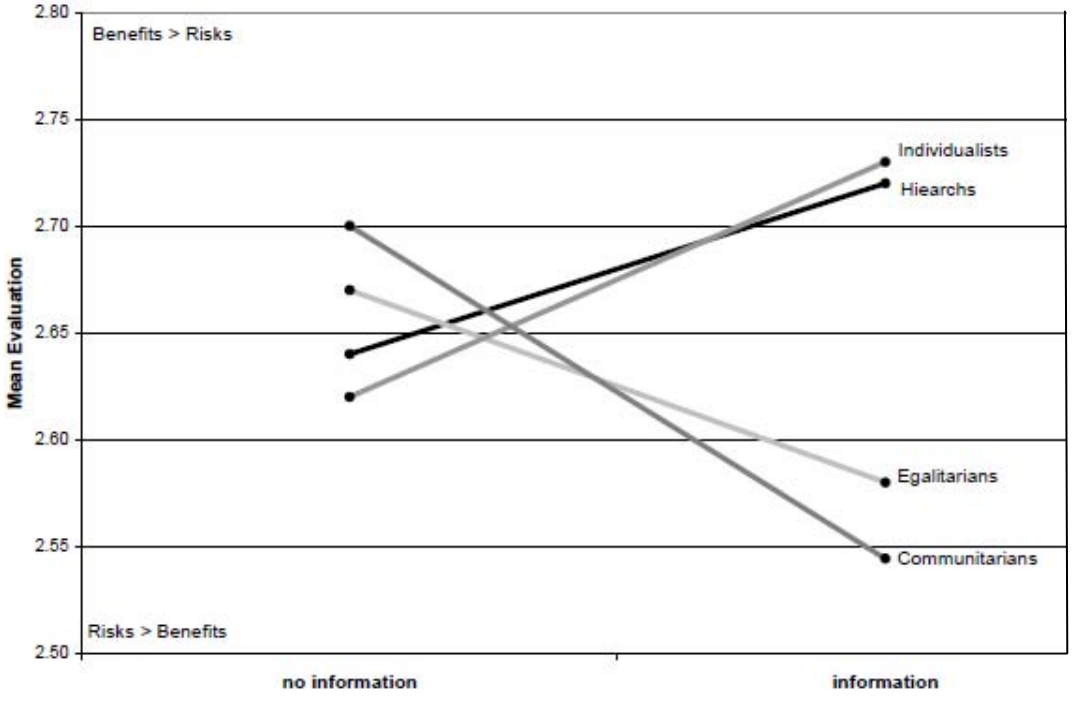

Figure 10. Information made egalitarians and communitarians to believe more on the risks and individualists and hierarchs to believe on benefits of nanotechnology (Figure from Kahan et al. 2007).

An example of a qualitative research approach to the question about public opinion on nanotechnology is a focus group study carried out in Great Britain (The Royal Society… 2004). One aim of the study was to examine public views on nanotechnology's likely environmental, health and safety, social and ethical implications. The participants were asked first their reactions to nanotechnology based only on the basic concept of nanotechnology. After that they were given further information about possible applications of nanotechnology and their reactions were asked again. Participants found it difficult to react to the basic concept of nanotechnology without concrete examples of the ways in which it could be used. After receiving information on the possible applications they considered the implications nanotechnology might have on several different areas, which are summarized in the following.

- Ethical implications: "Playing God" was a phrase that was used in a negative sense, and one which participants spontaneously reached for disparage certain technological developments. However, they were not able to explain

the use of this phrase very specifically, but it contains a feeling of something being fundamentally "not right". This phrase was brought up also in the discussion about ethical implications of nanotechnology. This was related to the characteristic of nanotechnology to involve manipulating matter at the molecular level to form entirely new materials. Parallel with GM was also raised a number of times during the discussion. It was felt, as GM is different from the normal process of cross-fertilization of corps, similarly changing materials at the molecular level was different from any process of manufacturing new materials by more "natural" means.

- Financial implications: The amount of money that should be invested in the development of nanotechnology was felt to be large for the country to invest. Some participants also expressed concern that the level of investment required was so high that only Government and corporations would be able to allocate funds and these would make such a large investment only if they could be sure of a return. It was felt that this return might not be one which was necessarily beneficial to society.
- Social and political implications: Social issues that were considered in the discussions covered employment, social control, developing nations and increased hold of corporations over society. Especially, participants who were skilled and semiskilled manual workers were concerned about the impact of nanotechnology on traditional industries and possible losses of jobs in them. Social control refers to concerns about potential violations of privacy due to surveillance equipment that are invisible to the naked eye. Participants were also worried about the potential to have 'chips' implanted in the arm, for example to monitor health, and the possibility that people could be implanted with such a chip without their knowing. Some participants were concerned that the gap between industrialized world and developing nations might widen because the latter ones could not afford to take part in the development of nanotechnology. The power of corporations was felt to increase as they would only make the financial commitment needed to develop nanotechnology in the hope of some return, and this could involve exploitation of consumers in both the industrialized and developing world, for example, by the creation of patents, thus artificially inflating prices. This could mean that consumers might not benefit from some of the potential impacts of nanotechnology, such as decreases consumption of raw materials and energy driving down prices.

- Environmental implications: Possible ways in which it was thought nanotechnology might affect the environment included the potential issues around disposability of material created thorough nanotechnology.
- Health and safety implications: Medical applications were generally agreed to be potentially the most important uses of nanotechnology. However, it was stressed that information gained through improved diagnostics, for example, should remain private, and not be shared with organizations such as insurance companies or employers. Concern about potential long-term and side-effects of nanotechnology, such as allergies, were also brought up in the discussion. These concerns rose because participants were aware that there are already products containing nanoparticles for sale.

The findings above indicate that lay people are able to consider complicated technological and scientific developments from very wide perspectives, if they are provided with proper possibilities for that. In the previous study (The Royal Society… 2004), there were nanotechnology scientists participating in the process as experts to deliver a basic explanation of the concept of nanotechnology and tell about the uses of it. The experts answered also the questions that participants had during the workshops. The lack of knowledge is a challenge for research on public opinion on nanotechnology. As the studies reviewed above showed, general knowledge of nanotechnology is very low – or it was at least in the beginning of the decade when most of the studies were made. Some of the studies showed also that feelings and values are in an important role in the formation of nanotechnology perceptions. Therefore, it seems that education or information is not an effective strategy to influence attitudes towards nanotechnology. On the contrary, information may just confirm the initial attitudes, as people tend to interpret information based on their former experiences and knowledge. This is why a more dialogical approach may be more effective if one intends to communicate certain message about nanotechnology to the public. First, one should know the concerns and risk/benefit perceptions that lay people have. A qualitative approach is a good alternative to examine these, because it allows the participants to formulate their views from their own perspectives, unlike quantitative survey. Another central question is message framing. The communicated messages should be framed so that people with different values and worldviews could extract the same factual content. The effect of framing is, however, a difficult question and would probably require more research.

5. NGO perspectives on nanotechnology

This chapter provides an overview of how non-governmental organisations (NGOs) perceive nanotechnology. For this purpose, we have reviewed a number brochures, commentaries, reports and internet sites of NGOs such as Friends of the Earth, Greenpeace, Which? and ETC-Group. Complementary data was provided by a research report (Türk et al. 2006) on the ethical, legal and social benefits and risks on nanotechnology applications in the view of civil society and researchers. The data (see appendix 1) was analysed from the point of view of concerns and benefits perceived, perspective of assessment, and action priorities.

All NGOs mainly focused on the *risks and concerns* of nanotechnology and assessed them from the point of view of citizens, consumers, and workers. In their reports, the expected benefits were typically more briefly touched, sometimes even downplayed and labelled as nano-hype. Part of the data dealt with nanotechnology in general and another part with specific applications e.g. sunscreens, cosmetics, food & food packaging, medical diagnostics, agriculture, or energy conversion and production.

The presumptions on the dynamic power nanotechnology varied among different NGOs. In the one extreme, the changes accompanying nanotechnology were considered as “the highest, widest technology wave ever encountered” (ETC Group 2005) while in the other extreme they we considered “likely to be gradual as, on the whole, the displacement of an old technology by a new one tends to be both slow and incomplete” (Arnall, 2003, 41). Respectively, some NGOs expected nanotechnology to create turbulence and have breathtaking societal implications while others were more cautious in their assumptions of its implications.

5.1 Major concerns and expected benefits

In the following, we will firstly capture the key nanotechnology concerns reported by the NGOs and secondly describe the potential benefits that were referred to in their reports. Their major concerns can be divided to those that related to safety and health and those that related to socio-political issues.

5.1.1 Environmental safety and human health concerns

The potential impact of nanostructured particles and devices on the environment was considered the most high profile of contemporary concerns. The current safety and testing standards (chemical, biological and toxicological) were not considered to be sufficient to predict the behaviour of nanomaterials or to adequately manage the risks that large-scale introduction of nanobiotechnical organisms introduces. Mainly two kinds of threats were taken up from this perspective.

First of all, quantum dots, nanoparticles, and other throwaway nanodevices were feared to constitute new classes of non-biodegradable pollutants. There was a fear that nanomaterials provide an avenue for rapid and long-range transport of waste in underground water and that they will cause harm to soil and air.

Self-replication was presented as the best-known long-term danger of nanotechnology. There was a worry that self-replicating nanorobots capable of functioning autonomously in the natural environment are able to quickly convert natural environment into replicas of themselves on a global basis. Although this prophesy of ‘grey goo’ was mentioned, however, it was not typically considered very real.

The concern for human health implications was widely shared. These concerns were mostly short-term but also long-term. There were multiple ways that damage to human health was feared to take place. Firstly, nanomaterials binding to certain common but harmful substances in the environment, such as pesticides or PCBs, has lead to worry of such materials infiltrating humans. A frequently mentioned concern was nanoparticles causing lung disease and cancers that may, however, take decades to develop. Secondly, nanoparticles were perceived to have the ability to penetrate to living cells and accumulate to animal organs. Thirdly, it was pointed out that nanoparticles may have the ability to slip past the human immune system unnoticed.

One prominent concern related to the structural similarities between nanotubes and asbestos fibres raising a worry that nanotechnology could become the 'new asbestos'. The reports pointed out that health risks could be different throughout a product's life cycle – from worker safety to the end consumer and then waste disposal. The NGOs worried about the lack of understanding of the life cycle impact of nanotechnologies.

5.1.2 Socio-political issues

The crucial socio-political concerns expressed by the NGOs can be summed up by dividing them into issues of medical ethics and the possible 'nanodivide'.

Widely shared ethical concerns were related to enhancement medicine, using NBIC[1] technology. The possibilities of this emerging field to improve on existing capabilities or to add new capabilities have lead to worry of genetic discrimination. There is also on a longer time-scale fear that it might lead to de-selection of characteristics that would be judged socially unwanted or forcing enhancements upon people.

Another ethical concern related to impinging civil liberties and medical privacy e.g. through development of sensing devices or other surveillance applications. The reports referred to presently available gene-chip technology that can provide an almost instant readout of an individual's genetic predispositions, and nanofluidics that can provide rapid analyses of biological samples such as blood. The threat was that employers and insurers may be interested to get hold of this kind of information.

In the longer run, there was a concern that the enhancement medicine could lead to a perception of basic medical treatment without obtaining performance productivity outcome as futile care and enhancement with a positive performance productivity outcome as the only acceptable treatment. It has been suggested that preference for enhancement over curative medicine is a real possibility and that it could lead to exacerbation of existing inequities and creation of new ones.

Partially related but a wider discussion relates to the so-called nanodivide. Many nations are already witnessing an IT-divide that correlates with inequality

[1] Acronym standing for Nanotechnology, Biotechnology, Information technology and Cognitive science.

in the distribution of wealth. Among NGOs there was a widely shared worry that this gap will be exacerbated by any impending nanotechnologial revolution, forming a so-called nanodivide. Many NGOs feared striking differences.

Nanotechnologies were expected to further concentrate economic power in the hands of multinational corporations and to lead to restructuring of industries. Nanotechnology was claimed to be the first 'platform' (or enabling) technology that is almost wholly owned by private interests. This is because many of the key ideas and the fundamental processes of nanotechnology have already been patented. This was claimed to amount to "a wholesale privatisation of a technological tsunami" that will change many areas of life. Patent holder will control who gets access to the technology and at what price. (Arnall, 2003, 38). The worry is captured well in the next citation:

> The fact that nanotechnologies, nanomaterials and nano-products are likely to be patented and controlled primarily by large corporations – and given that nanotechnology is likely to facilitate the concentration of corporate control both within and across industrial sectors – also reinforces the likelihood that the nano-economy will be biased towards large-scale, globally oriented, and corporately-controlled forms of production. It is these corporations that will determine what products are developed and commercialised, driven of course by commercial interests and the profit-motive rather that green principles per se. (Scrinis 2006.)

The risks related to military applications of nanotechnology were taken up by some NGOs. The changes to military activities were considered to be of pervasive nature (nanotechnology providing stronger and lighter armour and reduce maintenance costs). The worries linked to nanotechnology in military use were wide ranging. They related to its potential to threaten existing weapons treaties, ability to make chemical and biological weapons easier and "safer" to use, or possibly enabling new nuclear weapons to be developed.

5.1.3 Expected benefits

The potential benefits most often mentioned related to improving efficiency in the production and use of energy and health benefits.

Nanotechnology was expected to enable more efficient use of resources and energy across all industrial and economic sectors due to the capabilities of new nanomaterials and production techniques. The reports referred to prospects of nanomaterials that are stronger, lighter, more durable and reliable that the conventional material they replace. Nanotechnologies' potential to contribute to cleaner environment was also pointed out. This referred e.g. to improved water

and air filtering technology for cleaner drinking water and for reducing air pollution emissions, to biosensors for the detection of pollutants and pathogens, and to environmental remediation applications such as products for cleaning up contaminated water and soil.

Health related applications were often mentioned among the main expected benefits or nanotechnology in the NGOs reports. Nanotechnology applications were expected to enhance human health through earlier disease detection and better targeted application of treatment. Nanomedicine was expected to greatly improve existing drug delivery, increasing drug solubility, increasing drug potency, allowing controlled release over longer time periods, and enabling molecules to be targeted to individual organs for drug delivery or imaging purposes.

5.2 Action priorities

In terms of action priorities, the NGOs tended to take a precautionary and publicly transparent approach to nanotechnologies. They were pushing for application of precautionary principle to products where there are potential risks but where it is not currently possible to assess their safety. This would include prohibiting marketing of untested uses of nanomaterials and requiring manufacturers and distributors to bear the burden of proof. Underlying worries related mainly to the health and safety of the public and workers as well as environmental safety. The NGOs demanded assessment of life cycle effects prior commercialization.

A widely shared idea was that the public has the right to be informed in order to make educated choices. This related to demand for labelling of consumer products containing nanomaterial ingredients. A related claim concerned installing protective measures to workplaces and setting safety testing data available to public scrutiny.

The right of the public to participate in the deliberative and decision-making processes was strongly addressed by all NGOs. This demand was based on nanotechnologies' potential to transform the global social, economic and political landscape. The NGOs stressed that this participation must also be meaningful so that it informs policy development and decision making. Full public participation referred to democratic involvement in multiple processes by which nanotechnologies are developed and used and to ensuring that public concerns and values guide nanotechnology oversight. Additionally, as nanotechnology will go through different stages societal debate will need to be an ongoing proc-

ess rather than a single outcome. Many NGOs and the citizens stressed that not only technical and toxicological aspects were relevant, but that also social, ethical and equity aspects need to be assessed. They called all stakeholders to prevent nanodivide: governments to tackle the issues internationally and business to realise opportunities of selling to the bottom of pyramid market and developing applications to meet societal needs. (Türk et al. 2006, 67.)

The current legislation was generally claimed to provide inadequate possibility to assess and control nanomaterials. This is why all the NGOs considered nano-specific regulations necessary. However, among the interviewed researchers and citizens in the Nanologue study (Türk et al. 2006, 61) there was little agreement as to whether new regulation was needed. Interviewees were cautious to call for new regulation per se. Instead, they preferred assessing specific regulatory needs case by case or sector by sector.

Gaining public acceptance was seen as a pressing challenge. There were several references to the GMO (genetically modified organism) debate and the question was raised what can be learned from it about the potential public acceptance (or rejection) of nanotechnologies. The NGOs suggested that it is time to create dialogue and consensus to prevent the kind of confrontations occurring that plagues the development of biotechnology.

The demands for action were focused to various stakeholders. Manufacturer liability was demanded. NGOs stressed that all actors dealing with nano-product production and distribution must be held accountable. In the Nanologue study, the citizens pointed out that the present lacking guidance on liability may form a barrier to market for new nanotechnical applications (Türk et al. 2006). Generally, business was expected to act more transparently, provide information and take charge of labelling products with nanomaterials. Governments were expected to take a central role as supporter and governance of basic research. There was a demand for focusing funding more comprehensively on pressing human problems such as medical diagnostics and treatment as well as sustainable energy production. Institutional responsibility was expected also from research institutions (e.g. Parr 2005). They were expected to rethink of what is being researched and to what ends, and show real engagement with public concerns.

All in all, the overview of NGO perceptions highlights two aspects. Firstly, the NGOs pointed out the importance of *public transparency* in nanotechnology research and development, and *open dialogue.* These demands are among the major lessons of GMO depate. It seems that although too much information can lead to confusion there may be a greater danger that a lack of transparency will

result in a backlash from the public. According to NGO perception, the process of development and use of nanotechnology must be as open and transparent as possible.

Secondly, the NGOs called for *societal relevance* of nanotechnology research and development. This implies that nanotechnology development should be closer linked to sustainable development. In fact, from communication aspect, it has been suggested that nanotechnology 'vision' should be refocused not around risks but around a vision of sustainable development (Türk et al., 2006, 73). This vision would give the technology a context in which to communicate the benefits and demonstrate the economic, social and environmental potential. Contextualisation in terms of a need for certain (societally relevant) application may help communication, as well.

Public acceptance is a pressing challenge in nanotechnology research and development. The Nanologue project phrases the link between nanotechnology's contribution to sustainable development and its public acceptance as follows:

> If stakeholders are united over an objective to ensure that the development of the technology follows as sustainable a path as possible and it is clearly and consistently couched in terms of societal benefit, the acceptance will be much greater amongst public. (Türk et al., 2006, 74.)

6. Conclusions

The objective of this review was to gain understanding of consumers' and NGOs' attitudes to nanotechnology, and to formulate guidelines for consumer communication about nanotechnology related issues based on the literature. Communication in this context can be understood as one-way information to the public or as two-way dialogue with representatives of the public. The choice between these two is related to the understanding that we have on the public and its role in decision-making. If we understand public as citizens, we think that it has political power and rights to participate in decision-making. This understanding calls for participative processes to engage the members of general public in decision-making. On the other hand, if we consider public as consumers, it is enough to provide them information on products and give the public an opportunity to make informed decisions about consumption choices on the market. A disadvantage of the latter approach is that consumers can express their opinion only after products have already been placed to market. If the consumers decide not to buy the product, all the development investments have been lost. Therefore, it may be in the producers' interest to collect information about consumers' wishes and needs already in the beginning of the production development process.

The studies reviewed revealed that general knowledge of nanotechnology among lay people is very low. This creates challenges for communication. Therefore, it is important to remember a few guidelines when any presentations of nanotechnology are given to the general public. First, the presenter must provide a clear definition of nanotechnology in order to establish a common ground on which the conversation can be built. Second, the number of key concepts should be limited to two or three because too many new concepts can leave the audience overwhelmed and confused. It is also important to make clear distinction between facts and fiction in communication. Analogies to everyday life can be effective for achieving better understanding, as well as demonstrations and

animations. Interaction is also important, because it is a way to determine the audience's level of understanding. Audiences are also more receptive and retain more knowledge when they are actively engaged with the presenter as opposed to passively listening.

Making information available is important. However, information may not be enough to affect the general opinion because feelings and values have been shown to be important factors in the formation of nanotechnology perceptions and attitudes. If the recipient has negative feelings about nanotechnology, additional information may even strengthen these attitudes. This is why a dialogical approach may be more effective if one intends to communicate certain message about nanotechnology to the public. First, one should know the concerns and risk/benefit perceptions that lay people have. A qualitative approach is a good alternative to examine these, because it allows the participants to formulate their views from their own perspectives, unlike quantitative survey. Another central question is message framing. The communicated messages should be framed so that people with different values and worldviews could extract the same factual content. The effect of framing is, however, a difficult question and would probably require more research.

The concept of framing appeared also in the context of news framing. This refers to the context in which an issue is presented in newspapers. News frames help to identify what is essential in the flow of information, why an issue matters. Studies on the framing of nanotechnology in newspapers showed that a scientific frame was the most common in the late 1990s. Later this frame lost its prevailing position and more varied frames, such as societal implications of nanotechnology become more popular. As an example of this, the Nanologue project (Türk et al. 2006) recommended framing or focusing the nanotechnology dialogue to a vision of sustainable development. This change towards societal implications has brought also varying views of nanotechnology in the media publicity, even if the tone of reporting has been generally positive so far.

Based on the reviewed literature, it is possible to formulate the following guidelines for researchers or other people who need to deal with media in the context of nanotechnology related issues:

- Remember that the rules of journalism are different from the rules of scientific research. Even the most novel advancements of research do not interest the press if the fascination value of results or significance in the real life is not evident. Also, the detailed technical terminology

and scientific accuracy need to give place to the bigger picture. However, it is important to emphasize to journalists that findings in one study or characteristics of one nanomaterial are not possible to generalized to other materials. Because the communication needs a context it is recommended to focus on specific application instead of nanotechnology in general.

- Think about framing. What is the greater context that your results are connected to? Is there in the current discussion some theme or issue that could be clarified by your results. Why your results could interest the general public? Be careful, however, to come up with too dramatic associations which may turn against your cause. For example, too dramatic risks that could be solved by nanotechnology may shift to be the risks of nanotechnology in the minds of readers or viewers.
- You can always ask the possibility to review your statements before publication (at least if you are dealing with Finnish journalists), but respect the journalist's ultimate authority on their own text.

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Appendix A: Data for analysing NGO perceptions

NGO	Data	Description
Friends of the Earth	"Size Does Matter. Nanotechnology: Small Science – Big Questions!" Chain Reaction. The National Magazine of Friends of the Earth Australia. 2006	Friends of the Earth is an international environmental network and campaigning organisation. It is dedicated to preserving the health and diversity of the planet for future generations. Friends of the Earth Australia: Theme number of Chain Reaction magazine on nanotechnology. Materials in http://nano.foe.org.au/
	Nano & Biocidal silver, June 2009	Report, 44 pages
	Out of the laboratory and on to our plates. Nanotechnology in Food & Agriculture, March 2008	Report, 63 pages
	Nanotechnology & Sunscreens a consumer guide for avoiding nano-sunscreens, August 2007	Report,13 pages
	Nanomaterials, sunscreens and cosmetics: Small ingredients big risks, May 2006	Report, 29 pages
Greenpeace	Future Technologies, Today's Choices: Nanotechnology, Artificial Intelligence and Robotics. A technical, political and institutional map of emerging technologies. A report for the Greenpeace Environmental Trust by Alexander Huw Arnall, Imperial College London; University of London. 2003. Foreword by Dr. Douglas Parr, Greenpeace Chief Scientist, making Greenpeace stand on those technologies.	Greenpeace is a global campaigning organization. It acts to change attitudes and behavior, to protect and conserve the environment and to promote peace. http://www.greenpeace.org/international/ A background report dealing with nanotechnology, artificial intelligence and robotics commissioned by Greenpeace. 62 pages of which 40 pages on nanotechnology.
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ETC group	A tiny primer on nano-scale technologies and "the little bang theory". 2005: http://www.etcgroup.org/upload/publication/55/01/tinyprimer_english.pdf	24 pages ETC Group is an international civil society organization dedicated to the conservation and sustainable advancement of cultural and ecological diversity and human rights. Nanotechnology is one issue on ETC Group's agenda: http://www.etcgroup.org/en/
Other material	"Principles for the Oversight of Nanotechnologies and Nanomaterials", 2007.	8 pages A common declaration of multiple NGOs
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Nanotechnology perceptions

Literature review on media coverage, public opinion and NGO perspectives

Abstract

Nanotechnology development is in its early phase and there is a growing debate on its potential benefits and risks. This report reviews literature on public opinion and NGO perspectives concerning nanotechnology. It starts with a discussion on the position of public in the context of nanotechnology development. Different constructions of public (citizens, consumers, human beings, populations, patients) contain different understandings of the possibilities for action, responsibilities and needs for information.

The report discusses the role of news media in nanotechnology communication. One central issue is message framing which refers to the context in which an issue is presented. Framing of nanotechnology in newspapers has changed in time. In the late 1990s scientific framing was common but currently more varied frames are used, e.g. societal implications of nanotechnology.

The report reveals that general knowledge of nanotechnology among lay people is currently very low. However, various studies suggest that lay people are able to consider complicated technological and scientific developments from wide perspectives, if they are provided with proper possibilities for that.

The analysis indicated that NGOs view nanotechnology not only from the perspective of health and safety, but also from the perspective of its societal implications. The NGOs point out the importance of public transparency and societal relevance of nanotechnology research and development.

The lack of knowledge of nanotechnology among lay people creates challenges for communication. Making information available is important. However, various studies have indicated that feelings and values have an important role to play in the formation of nanotechnology perceptions. This is why an interactive and dialogical approach may be more effective than one-way information in communicating a message about nanotechnology to the public.

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