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

Risk Perception of Nanotechnology – Analysis of Media Coverage

Project implementation:
Frank Marcinkowski, Matthias Kohring, Anne Friedemann, André Donk (University of Münster)

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Risk Perception of Nanotechnology –
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Preface

Since 2000 research initiatives on nanotechnology have intensified and discussions of potential risks have also been taken up by growing circles of the public at large. The European Commission, for instance, published its communication paper “Towards a European strategy for nanotechnology” in May 2004 which also addresses research on health and environmental risks. In October 2006 the “Nano Dialogue” was launched by the Federal Ministry of the Environment, Nature Conservation and Reactor Safety in which stakeholders from politics, trade and industry, science, public institutions and associations discuss the opportunities and risks of nanomaterials. It was also during this period that the “Magic Nano” case occurred. It involved acute intoxication cases at the end of March 2006 triggered by the use of a surface sealing spray which had the word “nano” in its name but did not actually contain any nanoparticles.

In the field of consumer protection the debate about the potential risks of nanotechnology is shaped to a major degree by the offerings and activities of the Federal Institute for Risk Assessment (BfR). For instance, our Institute conducted an expert Delphi survey, staged a consumer conference in 2006 and carried out a representative population survey on nanotechnology in 2007. In 2008 BfR undertook a content analysis of Internet fora. Furthermore, several expert hearings, expert meetings and in November of this year a BfR Consumer Protection Forum were held on the subject of nanotechnology.

One of BfR's tasks is to examine questions of risk perception. This is particularly important in the case of new technologies like nanotechnology which could be associated with previously unknown risks. The perception of risks is influenced not only by concrete exposure to and the hazards associated with substances and products but also depends on psychological, social and cultural factors. At the interface between consumers and “decision makers” the media contribute to the public perception of a topic and also to the decision-making process.

Against this backdrop the goal of the project “Risk perception of nanotechnology – Analysis of media coverage” was to examine whether nanotechnology in media coverage is tackled more from the angle of risks or benefits and how the topic is played down, expanded on and blown up in media coverage. The results of this study will be used to tailor BfR's risk communication activities in the field of nanotechnology to its target groups with a view to further improving consumer health protection.

Professor Dr. Dr. Andreas Hensel
President of the Federal Institute for Risk Assessment

Abstract

This content analysis examines German media coverage of nanotechnology between January 2000 and December 2007 in a total of 1,696 articles published in the national quality newspapers *Financial Times Deutschland, Frankfurter Allgemeine Zeitung, Frankfurter Rundschau, Süddeutsche Zeitung*, *taz, Die Welt*, the news magazines *Focus* and *Der Spiegel*, and the weekly newspaper *Die Zeit*. The results show that on average 212 articles were published every year. After the peak of 248 articles in 2004, there was a decline in coverage to 170 articles in 2007. The main topics covered are “fundamental research” and the “application information and communication technologies”. The central actors are “persons/institutions in the field of science” and “economic actors”. Overall, the media coverage of nanotechnology very much focussed on the potential benefits of the technology. Risks are only discussed to a minor degree. In a framing analysis five issue-specific frames were identified: “Research and Development”, “Progress in information and communication technologies”, “Economic use”, “Medical benefit” and the “Risk-opportunity debate”.

1 Question and goals of the study

The research project “Risk perception of nanotechnology - Analysis of media coverage” was carried out by the Institute for Communication Science at the Westphalian Wilhelms University Münster on behalf of the Federal Institute for Risk Assessment (BfR). Professor Dr. Matthias Kohring and Professor Dr. Frank Marcinkowski were in charge of the project and it was carried out by the research assistants Anne Friedemann M.A. und André Donk M.A.

The remit and the related research goals of the study are presented in the first part of this final report. The research questions, their theoretical basis and methodological implementation are briefly described. Furthermore, the current state of research is discussed.

1.1 The question

Nanotechnology is seen as one of the most important future technologies. Science, trade and industry and political circles all believe it offers major innovation potential (BMBF 2007). Although there are now numerous products in whose fabrication nanomaterials or nanotechnological methods are used and research in the nanorange is seen as an academic growth area, it is still an emerging technology. This also applies to public perception. Nanotechnology, its material foundations and its products do not lend themselves to direct sensory perception and are, therefore, very much open to associations and surrogate perceptions. As knowledge about nanotechnology is steadily growing in the population but can still be described as relatively limited, social debate about this technology offers an opportunity - more than in the case of the debates about modern biotechnology or nuclear technology - to examine the influence of media-driven public communication on the perception and assessment of new technologies. The project “Risk perception of nanotechnology” seeks to identify the width of social perspectives of the topic, to record their plurality and to classify them.

Media-driven public communication has the potential to exert a major influence on the social perception and assessment of topics and objects. The central research question is therefore: How is nanotechnology presented in the news media? This prompted the following questions:

- On what scale and by means of which positioning (section) is there media coverage of nanotechnology? In the course of time have there been changes in the scale of reporting and how can they be explained?
- How do the media cover nanotechnology? Which topics and interpretation frames are found in media coverage? Is there a risk-opportunity debate?
- On what scale are our political, social, economic and scientific actors and groups of actors present in media coverage? How do these actors position themselves vis a vis nanotechnology?
- What arguments are used for and against nanotechnology? Which actors or groups of actors use these arguments?
- How is nanotechnology connotated in coverage? Which actors or groups of actors use which semantic strategy in order to trigger specific perceptions?

These questions were examined using systematic, standardised content analysis of the leading German daily newspapers, weekly newspapers and news magazines. The survey was conducted between 2000 and 2007.

1.2 Basic theoretical and empirical concepts

In accordance with the preferred approach used here which stresses the constructive performance of the public media sphere, the question must be asked how the basically open topic of nanotechnology is played down, expanded on or blown up in media coverage. This method is very similar to the agenda-setting approach where media impact is seen as the influence of media discussions on the perceived relevance of public topics by the population at large. In this context the weighting of a topic in media coverage influences the importance which readers, listeners or spectators attribute to that topic. Based on broad research literature the media do influence the topics the recipients place on their agenda (Rössler 1997). Agenda-setting research focuses on the methodological comparison of media agenda and topic weighting amongst the public at large. This project is, however, designed as a content analysis study and is, therefore, limited to recording the “independent” process variables. It cannot prove the effect itself but it can illustrate the discussion processes in the mass media and point out the potential impact of their coverage.

The orientational function of journalistic news media goes beyond mere discussion. It also encompasses complex perspectives of society which are presented to the recipients as frames or an orientation framework. The above-chance linking of specific attributes to topics is an interpretation pattern which is called a media frame by communication science. Frames of this kind define action situations or action areas. They present possible ensuing actions to the recipients and rule out others. This is where media coverage has the potential to exert a considerable influence.

A fundamental distinction can be made between the frames of communicators (e.g. associations, ministries, organisations), journalists and recipients and the actual media frames. Framing by communicators or social actors (strategic framing) has been examined above all in conjunction with social movements where the main attribute is influencing public opinion formation (Benford/Snow 2000; Gamson 1992; Gerhards/Rucht 1992). The term journalistic framing assumes that, besides the general news values, the journalists' frames also shape the selection and presentation of public topics (Scheufele 2003). Fewer empirical studies on recipient framing have been carried out (Gamson/Modigliani 1989; Iyengar 1991; Neumann/Just/Crigler 1992). In this case it is assumed that the recipients already have individual information processing frames and that they do not simply take on board media-driven frames in conjunction with the media impact. Finally, a distinction is made between media and text frames (Harden 2002; Kohring/Matthes 2002; Semetko/Valkenburg 2000; Simon/Xenos 2000). Media frames cannot be placed on a par with journalistic frames. This is because, besides the journalistic framing, the journalist selection criteria and presentation forms influence the final text, too.

In research on media framing, which is the central reference point for the project presented here, a distinction can be made between various concepts of framing and the related different operationalisations and empirical access points. In principle we can list a) issue-specific framing, b) generic framing and c) equivalence framing as different, albeit combinable concepts.

In the case of *issue-specific framing* research is interested in describing specific frames in terms of content for each topic (biotechnology, unemployment, abortion). In this way framing, for instance, of a topic in various national cultures can be compared (e.g. biotechnology, cf. Kohring/Matthes, 2002). In order to increase the methodological quality of empirical framing studies, a component model has been suggested which designs frames as above-chance patterns of individual components which occur in several texts like problem definition, impartial assessment, causal attribution of responsibility and proposed solutions, and endeavours to implement them empirically (Kohring/Matthes 2002; Matthes/Kohring 2004; Dahinden 2006).

Studies on *generic media framing* adopt a slightly different approach. They see media frames as formal-stylistic reporting patterns which are used independently of the respective topic in order to give the media text a specific "face" which can be recognised by the recipient. Some of the frames identified are very similar to known news values whereas others (for instance moral framing) are separate components in the above-mentioned component model. In the overview of several individual studies, some frames are apparent that can claim a certain degree of "universality" as independently of one another, they can be identified again and again in a large number of studies on various media topics. They include *conflict framing* (each problem always has two antagonistic sides), *episodic framing* (abstract and general problems are depicted using individual cases), *strategic framing* (hidden motives are always suspected behind public actions and articulated interests), *loss and gain framing* (in each affair there are winners and losers) amongst others (Iyengar 1991, Capella/Yesmieson 1997, Semetko/Valkenburg 2000, De Vreese/Peter/Semetko 2001).

The concept of *equivalence framing* takes up early experimental studies by von Tversky und Kahneman (1981) which have also been understood as challenging basal assumptions of the rational choice theory. Without explicitly using the framing concept, their works show that different language formulations of logically identical situations are capable of triggering systematically and above-chance different behaviour in test persons. In the field of media research these works are seen as a reference to the importance of metaphors, stigma-related words and emotive words. Lawrence (2006) and Entman (2006) provide more recent evidence of this type of framing research. They point out random differences in the use of the words "torture" and "abuse" in American media coverage of incidents in the Abu Grahib prison.

If this framing approach is used for nanotechnology, too, it is likely that the news media will supply very different situation definitions and orientation frameworks. Traditional risk communication about large-scale technologies has often failed because it did not take this multi-perspectivity seriously and consequently pursued unsuitable communication strategies. Already for these strategic reasons efforts should be made to give a more complex description of the social debate about a new technology. The framing approach is used for this very purpose in this study.

1.3 Science journalism and science coverage

The understanding of science journalism on which this study is based is outlined below. In this context science journalism is defined as media coverage that discusses the relationship between science, technology and medicine in society. The reason for media coverage may lie in the science itself (e.g. a new research finding); it may equally lie in the social environment of science (e.g. a research policy decision). Science journalism, therefore, deals with all actual and possible interactions between society and science (including the closely related modern technologies and modern medicine). Science journalism is, therefore, coverage *from* science – classic examples of this are reports about new inventions or the findings of new studies. Science journalism is also coverage *about* science – for instance the importance of science for economic prosperity or the moral debate about whether science should do everything that it is capable of doing or about the research policy discussions surrounding university funding etc.

An understanding of this kind goes beyond the traditional ideas of science coverage as a "transmission belt" of science for the public at large. This has to do with the general understanding of journalism presented here which is basically designed as an independent observer (Marcinkowski 1993). Only when media reports are undertaken by independent observers of social developments can they serve as orientation in a complex society that has become confusing for the individual actor. This social function of orientation regarding social

interdependencies (Kohring 2005) means that journalists must always first ask what consequences certain scientific events have for their social environment. Hence, journalists pick out scientific events based on important they are for their readers, listeners and spectators. The decisive factors for the choice of scientific events as topics for coverage are, therefore, the relevance criteria of the social environment of science. Science is only interesting for a very small, highly educated public *as* science. The public at large is not interested in the process of knowledge generation itself – as a rule the direct effects of science on society or on parts of society are what people want to read about in the media.

Science coverage of nanotechnology, too, is therefore by no means confined to the special, rather rarely published science sections. The greater the social relevance of a research area, the more frequently it is covered outside the actual science section. It is this coverage in particular that can provide the greatest insight into the social assessment and acceptance of nanotechnology.

1.4 Current state of research: Nanotechnology, media and framing

Social scientific studies on nanotechnology mainly focus on the public perception and acceptance of nanotechnology as an emerging technology (Bainbridge 2002; Macoubrie 2006; Waldron/Spencer/Batt 2006). For instance in their study Pense and Cutcliffe (2007) look at how social groups like, for instance churches, trade unions and environmental associations affected by a nanotechnological innovation, communicate on anticipated problems and the solutions to them. In this context the authors draw on three examples of development and analyse their presentation and discussion in publications of these social actors. Rogers-Hayden and Pidgeon (2007) discuss a report of the Royal Academy on the future prospects of nanotechnology in 24 expert interviews with stakeholders, too. These experts agree with the main conclusion in the report that nanotechnology and its science(s) are indeed on the up and up.

Furthermore, a few studies look at the visualisability and visualisations of a phenomenon like nanotechnology that does not lend itself to direct human perception. Lösch (2006) examined visualisations of nanotechnology in daily newspapers and science magazines and establishes that these images act as a communication link between science and its public. He identifies three visualisation phases (cf. ibid: 233): In the pioneer phase (end of the 1990s up to mid 2000) the dominant visualisations are of future nanorobots, in the problematic phase, (mid 2000 up to the end of 2001) of “market-damaging” nanorobots and in the fictionalisation phase (from 2002) of metaphoric depictions of nanorobots. Thurs (2007) also reported that visualisations from the field of science fiction aree what attracted the attention of journalists.

In recent years the subject nanotechnology has been widely examined in communication science. The 2/2005 issue of the journal *Science Communication* looks at nanotechnology and the public at large (cf. Lewenstein 2005). Lee, Scheufele and Lewenstein (2005) present a study which examines the attitudes of the public at large to an unknown technology like nanotechnology. Using a representative telephone survey in the USA the authors show that the use above all of science-oriented media has a positive impact on support for nanotechnology and that people with a “negative feeling” about nanotechnology tend to see the risks rather than the opportunities of this emerging technology. Schummer (2005) analyses whether and, if so, how the non-scientific public at large obtains information about nanotechnology and notes that the “normal” reader tends towards visionary literature which focuses on potential future developments. A comparison of survey data from the USA and Europe reveals (Gaskell *et al*. 2005) that 50% of US citizens are of the opinion that nanotechnology will improve their lives whereas most Europeans (53)% are not convinced of this.

News coverage is indeed seen as a relevant influencing factor (cf. Scheufele/Lewenstein 2005 with explicit reference to the framing concept). However, no systematic empirical studies of media coverage have been conducted in German-speaking countries. If statements are made about media coverage then they are either hypothetical or are founded on cursory considerations and are not systematic (Siegrist 2006). One example is a study by Kulinowski (2004). Based on a non-systematic evaluation of media coverage and specialist literature the author concludes that the public debate about nanotechnology is shifting from “enthusiastic” to “critical”.

The perception of nanotechnology in the news media was examined by the Swiss foundation Risiko-Dialog although this study was not very differentiated or systematic from a theoretical or methodological angle. During the study period 2001-2005 a random sample of articles from German quality newspapers underwent content analysis (cf. Grobe/Eberhard/Hutterli 2005). A few studies are available for the US-American and British markets which have examined coverage of nanotechnology (Anderson *et al*. 2005; Friedman/Egolf 2005; Laing 2006; Gorss/Lewenstein 2005; Stephens 2005) or the influence of media knowledge on attitudes towards nanotechnology (Lee/Scheufele 2006). Table one gives an overview of the studies which have a direct link to this research project.

Table 1: Overview of studies of media coverage of nanotechnology

Authors	Cornell University Gorss/Lewenstein	University of South Carolina, Stephens	Foundation Risiko-Dialog, Grobe/Eberhard/ Hutterli	Cormex Research, Laing	Anderson/Allan/ Petersen/Wilkinson	Friedman/Egolg
Year	2005	2005	2005	2006	2005	2005
Analytical period	01/1986–06/2004	1988–15/2007	01/2001–04/2005	01/2004–12/2004	04/2003–06/2004	01/2000–12/2004
Publications examined	New York Times, Washington Post, Wall Street Journal, Associated Press	Important US American and non-US American daily newspapers	47 German-language publications (for instance FAZ, NZZ, Die Zeit, FTD)	15 Canadian and 12 US American newspapers	10 British daily newspapers/8 weekly newspapers (for instance The Times, The Guardien, The Observer)	Daily newspapers from the USA and UK (for instance *New York Times, Washington Post, Guardian, Financial Times*)
Type of recording	Partial recording (no details of random sample collection)	Partial survey, random sample from 1330 articles	Partial survey (non-systematic random sample, no details)	Partial recording from 942 articles (search word nano; inclusion criterion: more than one statement)	Full survey	Full survey of all articles on health and environmental risks (key word: risk)
Number of articles	620	350	449	381 (40 %)	344	121 (71 U.S./50 U.K.)
Main results	• Rapid increase in number of articles between 1986-2004 • More coverage of opportunities throughout the entire study period (>65%) • Focus on progress and economic advantages • Topic focus: applications in the medical and environmental areas	• Main topics: scientific discoveries or projects (27%) as well as ethical, legal and social implications of nanotechnology (ELSIs) (17%) • Positioning: 36% in business/finance • 45% of the articles on ELSIs are neutral, 30% opportunity-oriented • Ratio: opportunities to risk focus in articles 3:1	• Mainly positive coverage • Opportunity focus in 70% of the articles • Positively rated topics: applications in the field of medicine and information and communication technologies • Risks are only discussed superficially	• Scarcely any coverage • Number of articles per month and newspaper: USA 13.3; C 15.5 • Interest in nanotechnology does not increase over time • Risks/benefits: no risks are mentioned in 66.9% (C) and 75% (USA) of the articles; by contrast no opportunities are mentioned in only 9.4% (C) and 31.2% (USA) • Frames: 3 major frames are identified (no explanations of method): profiling new technology; societal risk/benefit discussion; business/market news	• Concentration on a few “elite” daily newspapers • 3 dominant frames: (a) science fiction and popular culture, (b) scientific discovery or project, (c) business story • 38% of articles are opportunity-oriented • 11% risk-oriented • Main actors: scientists (39%)	• Approximately 48% /44% of the articles have negative headline • Articles mostly balanced • No detailed discussion of health risks in 47% /38% of the cases • 60% of articles no detailed discussion of environmental risks • Mention of social risks (35% /48%) as side-effects • Regulation does not play any role in <40% of the articles

1.5 Operationalisation of the main study categories

Data are collected on two levels. (1) The collection unit on the first level is the full newspaper article. This level records not only the most important identification characteristics but also presentational and content characteristics like, for instance, constellation of spokespersons, main topic and its framing. (2) Further characteristics are recorded on the level of the individual spokesperson's comments. A spokesperson's comment is counted when a clearly identifiable individual or collective actor is quoted with a comment which refers to the topic under debate. Comments of this kind may either come from the journalistic author of the contribution or actors outside the media (Gerhards/Neidthardt/Rucht 1998; Wessler 1999; Marcinkowski 2005). The use of this fundamental distinction means it is possible to separate the "voices of the media" (Eilders/Neidhardt/Pfetsch 2004) from the voices of actors presented in the media in the evaluation. Comments by third parties are either presented in the media coverage as a verbatim quote or indirect speech. This level mainly records who says something, which aspects of the topic are touched on, which positions are conveyed and which arguments are used, the form of communication and the target groups etc. All coverage characteristics, which are recorded on the level of the spokespersons' comments may be aggregated through corresponding data transformation on the contribution level. This means that all analyses can also be included on the highest level (cf. for a procedure of this kind Gerhards/Lindgens 1995: 16 ff).

The agenda-setting approach highlights the importance of topics which are interpreted here as sub-topics of nanotechnology. Hence topics are identified using a comprehensive list of topics which include as upper categories the areas "fundamental research", "health care", "textile industry" or "chemical industry". These generic topics are then broken down into corresponding aspects which means that each topic could be adequately recorded. In this way it is possible firstly to show whether nanotechnology is a quantitatively weighted topic in media coverage. Secondly, it can also be shown which related sub-topics are present on what scale in the media coverage.

From the perspective of issue-specific framing it is about formulating indicators for the four components of a frame (cf. Matthes/Kohring 2004). The mention of the main topic and the damage-benefit assessment of this topic are used *to define the problem*. The indicator for the *causal interpretation* is the mention of the actor responsible for the previously listed benefit or damage. The *moral assessment* is undertaken via direct assessments of the main topic; it can also be expressed in positive or negative acceptance statements. Calls to implement or renounce nanotechnology developments or applications are indicator for a *recommended action*. Besides the identification of frames, an additional language analysis was undertaken for instance of metaphors and key words in order to gain insight into the differing language shaping of these content perspectives of nanotechnology.

Up to now Semetko und Valkenburg (2000) have developed the most advanced method for recording non-topic-specific or generic frames. In a study on Dutch media coverage of the EU Summit in Amsterdam in 1997, the authors formulated a total of 20 content analysis variables by means of which five generic frames were to be identified. The formulation of the items was based on a meta-analysis of the available framing literature. The corresponding set of variables was also designed as a questionnaire in which the coders had to answer each of the questions about the text with "yes" or "no". All dichotomous variables were then entered in a cluster analysis, a statistical method that compiles if possible similar elements in if possible different groups in order to clarify which of the individual items occur together in an above-chance manner. These clusters were then identified as generic frames. In this way the authors succeeded in operationalising typical journalistic frames (conflict, strategy, win/loss etc.) on the basis of a limited number (normally 3) of indicators. The corresponding items have since been used repeatedly in research. They constitute a kind of standard tool for recording the above-listed constructs.

2 Research design and methodological implementation

The first step involved outlining the central research questions, the theoretical foundations and the operationalisation steps derived from them. The second part presents the construct of the recording tool. It begins with a description of the content analysis method. This is followed by explanations about the steps involved in this research project for drawing up the codebook over the selection of the texts down to coding.

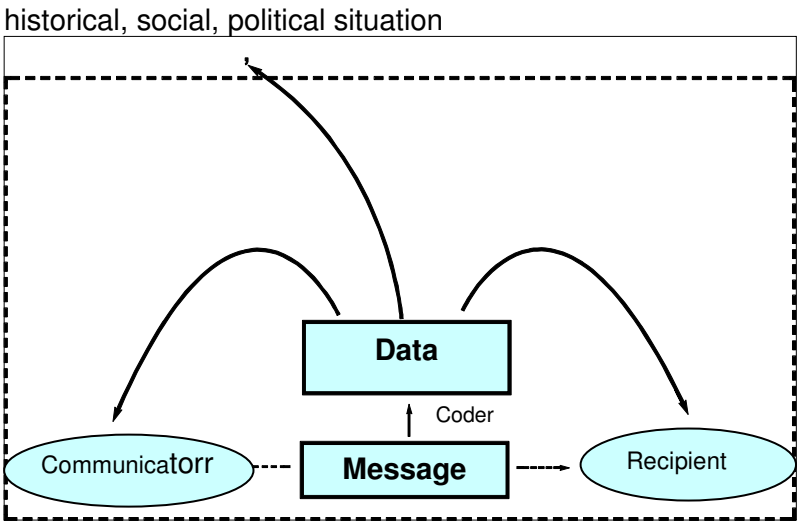
2.1 Content analysis

As already mentioned in the first chapter, media coverage of nanotechnology is examined using systematic, standardised content analysis in the areas of discussion processes and framing. Content analysis - a method of the empirical social sciences - describes the generic term of various scientific methods of text analysis. Texts in the wide sense of the term are the subject matter of content analyses. Besides newspaper or magazine articles, interviews and images are also deemed to be texts (verbal and visual texts). As a rule, content analyses are undertaken on three different levels: on the syntax level the occurrence of letters, words, expressions etc. is examined; on the semantic level the focus is on the relationship between symbols and their importance; on the pragmatic level the use and function of specific signs are analysed. “Content analysis examines the systematic recording and evaluation of text, images and films [...] However, the term “content analysis” falls short on one point: content analysis need not necessarily be restricted to the “contents” of texts or other material [...]. It is far more the case that attention focuses on formal aspects of texts, films or images like for instance stylistic characteristics, sentence length, frequent use of verbs etc.” (Diekmann 2001: 481).

In the modern media society everyone is surrounded daily by the most diverse media texts. However, in daily life people tend to react to these texts in a rather unsystematic and intuitive manner. When one for example flicks through the arts section of a newspaper for “interesting” reviews, one has a least a very concrete idea of what one finds interesting but in most cases one would have difficulty explaining this idea to a third party. The same applies to the widespread presumption that the *taz* newspaper is more to the left, the *FAZ* rather on the conservative side of the political spectrum. An assumption of this kind is very plausible. However, in order to turn an intuitive, daily consideration of media contents into a systematic, intersubjectively transparent content analysis, the criteria used for the respective consideration must be outlined and documented. This brings us closer to what is called in science content analysis, i.e. the guided systematic observation of texts (cf. Klammer 2005: 249 ff). One strength of this method is that it is comparatively easy to use. Printed texts can be examined largely independently of time and space. Even today the German media coverage of World War I can be examined as long as the newspapers have been archived and are accessible. You don't have to go out and do field work for this or set up a laboratory. Entire periods can be examined whereas many other methods only permit statements about a specific period. In principle, the results of content analysis can be reproduced whenever required.

“Communication does not take place in a vacuum but in a specific social environment, i.e. in a social situation” (Atteslander 2008: 202). This means that each content, each communication is subject to a large number of conditions when it is created or processed which can then be identified in an analysis. Based on the media content these conclusions (inferences) permit (to a certain degree) statements about aspects of social reality.

Fig. 1: Inference about content analysis (Rössler 2005: 29)



The most important contexts for inferences are 1) the communicator, 2) the recipient, 3) the historic, political or social situation. The questions that can be asked for instance about the texts as the basis of content analysis in this context are 1) Who says something and to what end? 2) For whom is the statement intended? 3) What standards are the basis for communication? To sum it up empirical content analysis is, therefore, "a research technique by means of which conclusions can be drawn about every type of signifier by means of systematic and objective identification of its elements which should also apply beyond the individual analysed document" (Kromrey 2006: 319).

2.2 Analytical tool

An inductive and deductive procedure was adopted when drawing up the analytical tool. The inductive procedure includes the review and evaluation of a random sample of material and expert meetings. On the basis of this preliminary work content analysis "categories" (observation criteria) were established, in this case for language analysis, the probable "actors" and the expected arguments in the "risk-opportunity debate". Demands, instructions and topics could also be identified in this way and corresponding categories formed. By way of preparation for the analysis, discussions were also held with the experts Professor Dr. Stefan Linz from the Institute for Theoretical Physics of Münster University and Professor Dr. Harald Fuchs from the Münsteraner Centre for Nanotechnology (CeNTech). Professor Linz, who is a member of both the DFG special initiative and the DFG research group 845 "Self-assembling nanostructures through low energy ionic beam erosion", provided information in a meeting on 5 July 2007 about common definitions, work areas and applications of nanotechnology from the angle of physics. Following this first conversation a working definition for nanotechnology was established for this project:

> Nano (Ancient Greek for dwarf): in the scientific context nano is a measurement unit which corresponds to one billionth part (10^{-9} = 0.000000001). Nanotechnology operates in a range of one billionth of a metre (10^{-9} metre). This describes the range in which more and more quantum physics effects are playing an important role. Nanotechnology describes and offers procedures/processes which open the door to manipulation of these tiny components of nature. Hence nanotechnology cannot be reduced to an area or market – it is interdisciplinary. Almost all natural science faculties and research institutions and a large number of economic sectors can use nanotechnology.

Furthermore, based on preliminary work, lists were drawn up about probable frequently occurring researchers, research groups and research areas or nanotechnology applications. The focus of the meeting on 15 July 2007 with Professor Dr. Fuchs was on the opportunities and risks of nanotechnology as well as demarcating this area from biotechnology. CeNTech, of which Professor Fuchs is the scientific director, is a member amongst other things of the EU project “Nano2Life”. The results of these expert conversations played an important role in drawing up the analytical tool.

The procedure for constructing the tool was deductive to the extent that current studies on media coverage of nanotechnology were systematically evaluated. In particular the work of the foundation Risiko-Dialog, which posted its codebook on the Internet, was used to this end.

The measurement tool (codebook) produced specifically for this project encompasses several related sets of variable which are explained in more detail below.

- A. Formal characteristics: This set encompasses the variables V1 - V14_2 which serve as identifiers, for instance date, medium, journalistic form.
- Word field analysis: variables V15_1 - V15_3 look at the link between the article and nanotechnology or the context in which nanotechnology is mentioned. Furthermore, new words are recorded in a string variable. The word field analysis is only conducted under specific, above-mentioned conditions.)[1]
- B. Recipient view: variables V16 - V19 constitute a content unit which asks about the subjective impression after reading. Variables on comprehension are one focus.
- C. Image analysis: if visual material is used in the article, then the variables V20- V22 are recorded.
- D. Topic structure: in this set which encompasses variables V23 - V27, statements on the localisation, concern and on the subject of the main and sub-topics of the articles are recorded. Comprehensive topic lists are available for the classification of the topic in the annex to the codebook.
- E. Actor level: variables V28 - V33 encompass for instance type, prominence and general statements on nanotechnology by an actor; extensive lists are also available for the classification of actors. Up to 3 different actors may be recorded per article.
- F. Opportunities/benefits and risk dimension: this set encompasses variables V34 - V49. Details are recorded here about opportunities and risks and the expectation of occurrence by actors, named responsible persons and any instructions.
- G. Generic framing: variables V50 - V65 record article characteristics like negativity, personalisation or conflict.
- H. Language level: variables V69 - V74 variables grouped in this set examine the metaphors used, the frequency of negative or positive adjectives in conjunction with nanotechnology etc.

A first pretest of the analytical tool was conducted on 10 August. The tool was then refined and tested during a coder trainer session on 23 August (this is examined in more depth in Chapter 2.5).

[1] The set of variables for field analysis was only used to code the articles which were outside the inclusion criterion (cf. Fig 2).

2.3 Selection and procurement of the texts

The print media included in the analysis were selected by the customer. They are the national daily newspapers *Financial Times Deutschland*, *Frankfurter Allgemeine Zeitung*, *Frankfurter Rundschau*, *Süddeutsche Zeitung*, *taz*, *Die Welt*, the news magazine *Focus* and *Der Der Spiegel* and the weekly newspaper *Die Zeit*.

The selected print media are all quality or opinion-leading media. The *Süddeutsche Zeitung* (circulation in the first quarter of 2008: approximately 465,000) is characterised as a liberal newspaper with broad national news and media sections. The *Frankfurter Allgemeine Zeitung* (circulation in the first quarter 2008: approximately 389,000) is considered to be a liberal-conservative newspaper whose strength lies in its large worldwide network of correspondents – the independence of agencies in the business section was praised on several occasions. The right wing-conservative newspaper *Die Welt* of the Springer group achieved circulation in the first quarter of 2008 of 227,000. The *Frankfurter Rundschau* (circulation in the first quarter of 2008: approximately 163,000) is deemed to be a left-wing/liberal daily newspaper. The *taz* is the smallest (circulation in the first quarter 2008: approximately 57,000) of the national quality newspapers and is seen as a left-wing/alternative publication. The most recent newcomer (21 February 2000) in the field of national daily newspapers is the *Financial Times Deutschland*. Aside from the *Handelsblatt* it is the only national daily newspaper which is primarily intended for business. In the first quarter of the 2008 it had a circulation of around 106,000. The daily newspaper *Die Zeit* (circulation in the first quarter of 2008: approximately 496,000) is one of the opinion leaders in Germany because of its high journalistic standards. It is considered to be liberal. The news magazine *Der Spiegel* (circulation in the first quarter of 2008: approximately 1.06 million) and *Focus* (circulation in the first quarter of 2008: approximately 718,000) are opposites: the main attribute of *Der Spiegel* is its investigative research whereas *Focus* links political or scientific topics to a greater degree with service functions and entertainment (cf. Meyn 2004: 94 ff).

This study is designed as a full survey of the years 2000 up to 2007. Hence it encompasses all articles on the topic of nanotechnology during that period. The following procedure was adopted to identify the population. First, all corresponding articles were sourced via the database portal *Genios GBI* (www.gbi.de). *Genios GBI* is a search engine which carries out a full text search in the online archives of daily newspapers, magazines and journals etc. for specific search words in defined periods. Hence a search was carried out for the above selection of print media using the search term "nano*"[2] during the period from 1 January 2000 up to 31 December 2007[3].

[2] "Nano*": The asterisk* after the word nano expresses the fact that nano and all conceivable words and combinations with the prefix "nano" were sourced in an open manner.

[3] As a standard procedure these results were verified once again to the extent that corresponding search tools were available. For instance some newspapers have their own search function in their online archives which normally confirmed the Genios search. Any deviations are noted further below for each print medium. In the case of deviations, the articles which were identified in addition to the Genios search were recorded.

Table 2: Compilation of the texts according to Genios GBI

Source	Number of articles in the study period
FAZ	1748
FR	989
FTD	708
SZ	853
TAZ	377
Welt	1144
Zeit	298
Focus	155
Spiegel	178
Total	6450

For material procurement and archiving two students were hired from June 2007 to January 2008. They drew up hit lists using the above-mentioned procedures, checked then for accuracy and completeness and then procured the corresponding materials. Missing articles were entered in a separate list and recorded later. There were several options for procuring material. Some articles were available as original issues or were stored on microfiches/microfilms in the press archives of Münster University and were copied there or printed out. Other articles were procured from the online archives to which there was access via a network of the library at Münster University or for which a short-term subscription had to be taken out. A third path was the procurement of annual CD-ROMs. In the case of the electronic variants, the majority of the articles were available as faxes and could, therefore, be printed out. Some of the articles hadn't been archived as originals via any of the above-mentioned paths which meant that pure text files from the GBI database were used. For the individual media publications sourcing and archiving were done as follows:

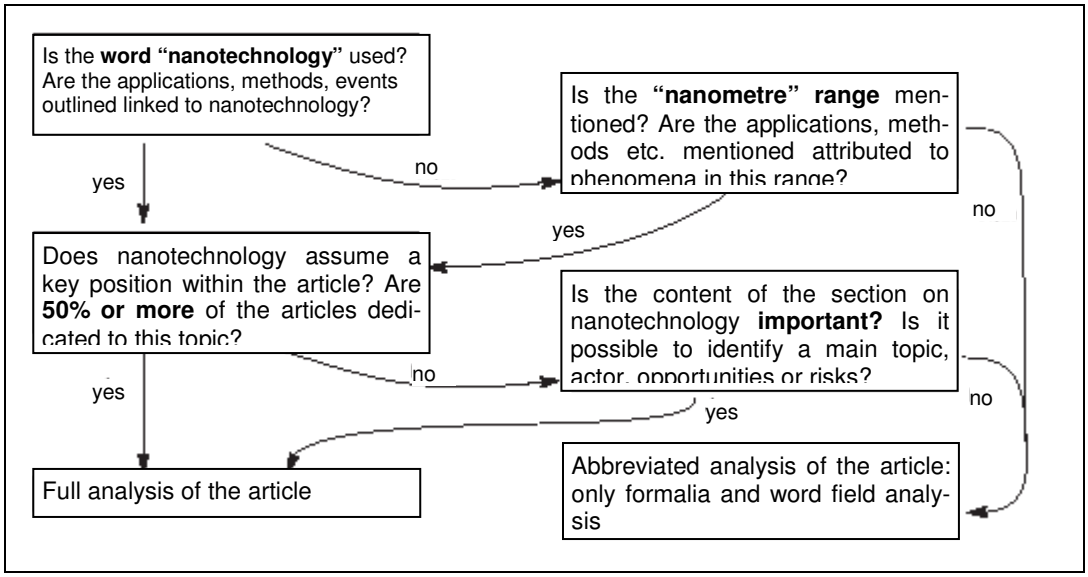
- FAZ: The articles to be recorded were accessible online as pdf files. The search was carried out on http://business-archiv.faz.net/intranet/biblio/FAZ. Based on the hit list all identified articles were stored and printed out. For the year 2000 the articles were only available in HTML format, from 2001 onwards as full newspaper pages. No articles were recorded which are described as FAZ.NET, dossiers or Sunday newspapers or are clearly recognisable as a local section.
- FTD: The articles to be recorded were accessible online as PDF files: www.ftd.de/recherche/archiv.html. The articles were available as full newspaper pages. No articles were excluded from recording. As the Genios search identified a larger number of articles than were found in the online archive, theses additional articles were recorded in print form after conclusion of the online search in the press archives of Münster University.
- Focus: The articles to be recorded were available in print format. The hit list was drawn up via Genios GBI. By way of deviation from the standard settings, the search mask “Focus Money” was excluded as a search criterion. The articles were then recorded in the newspaper and press archive of ULB Münster.
- FR: The articles to be recorded were available as microfiches. A hit list was drawn up via Genios GBI for the corresponding period. During recording it emerged that some articles could not be found. After consulting the *Frankfurter Rundschau*, the reason for this is that many of the local sections and regional issues were not available in the national issue but were still identified by Genios as hits as well. Hence Sport Rhein-Main, Kultur Rhein-Main, Wirtschaftsspiegel Frankfurt, Frankfurt, Rhine/Main and Hesse, city districts of Frankfurt and four local sections (Hochtaunus, Wetterau, Main-Taunus, Kreis Offenbach) were excluded from the section search and deleted from the overall hit list. In addition all articles entitled “culture leisure service” were excluded from the hit list because they are clearly part of the local issues.

- Spiegel: The articles to be recorded were available online as PDF files. Spiegel articles were sourced online via the archive search (http://service.spiegel.de/digas/archiv). In this case, “search in” was selected as the search option “in full article”. All other sources (e.g. SpiegelOnline, KulturSpiegel) were excluded aside from *Der Spiegel*. Based on the hit list for a specific period the articles were purchased, stored in full and then printed out.
- SZ: The articles to be recorded were available on microfilms. The hit list was drawn up via Genios GBI. The articles were sourced in the press archives of Münster University on microfilms. In order to ensure rapid sourcing of the articles, the articles were assigned to a specific section from the hit list for the section search on Genios. If articles could not be assigned to any section, a search was conducted in the entire newspaper for the article. This process was repeated several times over if the article was not found the first time round. No articles were excluded from the search. A comparison of the Genios hit list with the SZ-DVD search (up to 2005) showed that some articles could be found in addition via the DVD search. These additional articles were then sourced in the newspaper and press archives of ULB Münster on microfilms or in print format.
- TAZ: The articles to be recorded (http://www.taz.de/digitaz/archiv/suche.demo,1) were available online or on CD-ROM. Based on the specific hit lists all articles were recorded and no articles were excluded. Articles, which could be assigned to local sections, were excluded during the control of the years. The articles were available in text format.
- Welt: The articles to be recorded were available from 1 January 2000 up to 8 January 2001. From 8 January 2001 onwards they were available online as PDF files. A hit list was drawn up for both periods via Genios GBI.
- Zeit: The desired articles were available for the period 1 January 2000 up to 31 December 2006 in electronic format on annual CD Roms as text files. The corresponding articles were sourced for the full year 2007 on Genios GBI and copied in the newspaper and press archives of Münster University.

2.4 Analytical units and inclusion criterion

The individual article was selected as the analytical unit. Within the article nanotechnology must play a central role (half of volume). One exception to this 50% criterion is when the article contains a section of major importance on nanotechnology, i.e. a main topic, an actor or opportunities and risks can be determined at least for a concrete part of the article. The mere mention of nanotechnology – for instance in stock exchange reports or reports by universities – does not meet this requirement. Contributions of this kind, which do not permit the content coding of central topic characteristics were merely identified in this analysis and entered in the word field analysis in order to at least record the connotation of the use of the partial word “nano”. Another part of the population was included in analytical body via the identification of the partial word although the term “nanotechnology” was not itself used in it. In these cases a contribution could be identified as coverage of nanotechnology when it described events, new methods or novel applications in conjunction with the size range nanometre. One necessary precondition for this is that the size range in which nanostructures are observed is explicitly mentioned. The following figure seeks to illustrate the complex inclusion criterion:

Fig. 2: Selection procedure to identify the analytical path



2.5 Conduct of the content analysis

In the following chapter the individual steps for carrying out the content analysis are described in detail. If individual elements of this process have already been presented in earlier chapters, they are briefly repeated here and references made to the corresponding section in the final report. The content analysis is oriented towards five prototype phases proposed by Werner Früh (2007): 1) Planning phase, 2) Development phase, 3) Test phase, 4) Application phase (coding) and 5) Evaluation phase.

To start with two frequently used technical terms from methodology of content analysis are explained to improve understanding of the text: coder and codebook. As number codes are attributed in content analysis methods to the relevant characteristics of a text, in order to be able to evaluate this statistically at a later date, this process is called "coding". A coder is, therefore, a processor who identifies manifest characteristics of a text and translates them into number codes. The codebook is a set catalogue of questions and, to a certain extent, work instructions for the coder. It ensures that a uniform procedure is adopted by all coders and that measurements can be replicated.

2.5.1 Planning phase

The planning phase covers the definition of the epistemological interest, the selection of study material and the drawing up of a schedule. The goal of the study is to answer the central research question "How and on what scale is nanotechnology covered in the German quality press? (see Chapter 1.1). The definition of the sample is per force linked to this epistemological interest. The schedule was defined as the years from 2000 up to 2007 and the print media to be examined are the above-mentioned national quality newspapers and news magazines (see Chapter 2.3). The articles which belong to the population were identified using the search mask *Genios GBI* and then recorded. The project had a term of 13 months for which the following schedule was laid down:

Table 3: Schedule and work plan

Months	2007							2008					
	6	7	8	9	10	11	12	1	2	3	4	5	6
Selection/procurement of texts	■	■	■										
Development of category system and codebook	■	■	■										
Pretest			■										
Data recording				■	■	■	■	■	■				
Data analysis							■		■	■	■		
Writing of final report											■	■	■

The schedule and work plan were largely complied with only the material procurement took far more time than had been initially allocated.

2.5.2 Development phase

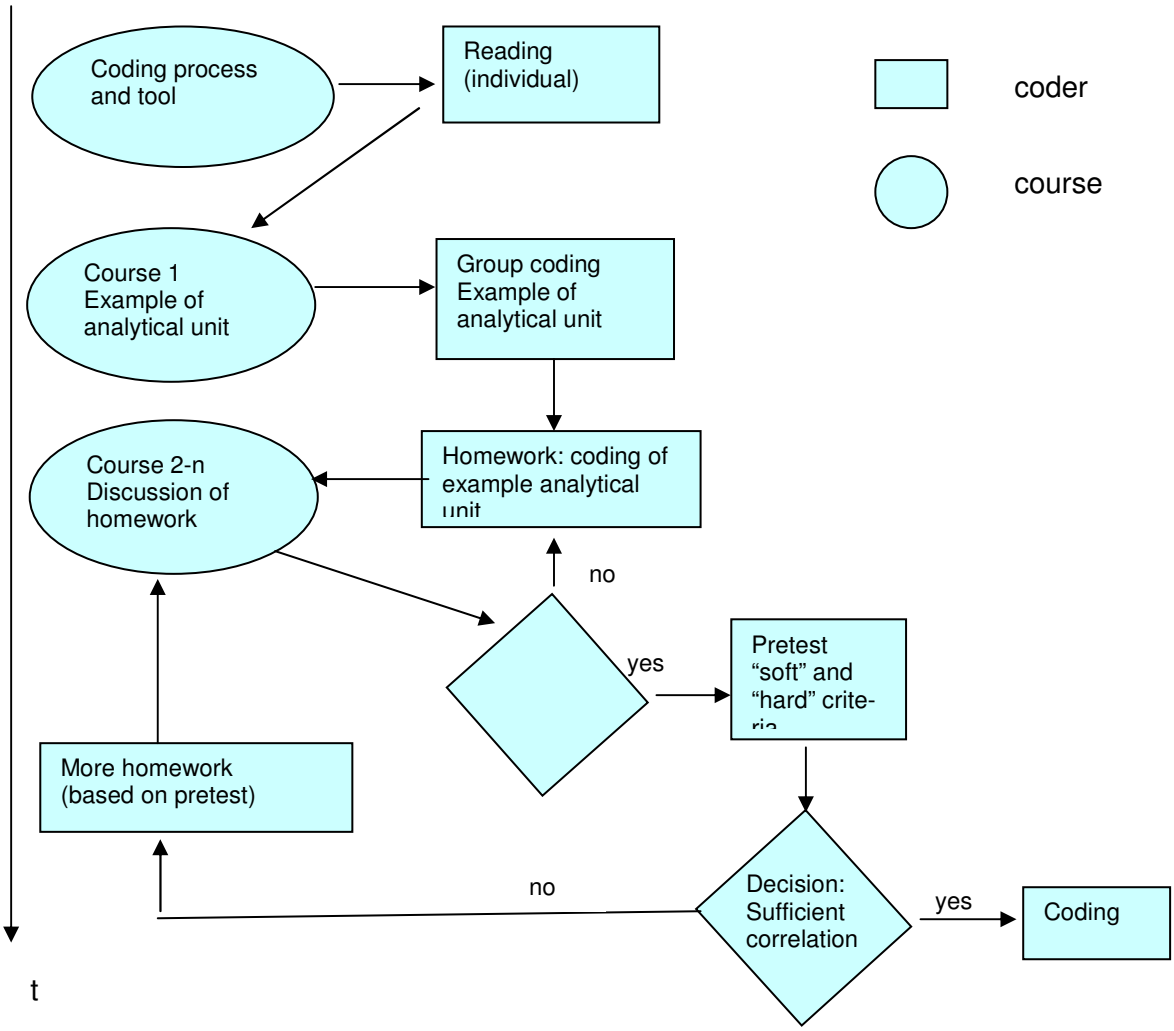
Based on the research questions and the theoretical foundations – the discussion function of media coverage and the presence of certain frames in media texts – a codebook (see Chapter 2.2) was prepared for the systematic and transparent recording of the relevant contents of newspaper texts. Two expert interviews and the review of a partial random sample of the texts were taken over into the development of the codebook as inductive components. The codebook consists of 74 variables which assign a number code to the individual text characteristics like for instance the actors, topics or risk assessments. The individual variables and their examples are defined in the codebook. The issuing of a number code is explained which means that each coder is capable of undertaking a clear attribution when it is correctly applied. The numerical codes permit a summary and comparative statistical evaluation of the text characteristics at a later stage.

2.5.3 Test phase

The test phase encompasses the work steps sample coding, coder training and the reliability test. Initial test codings were undertaken during the drawing up of the codebook by the project leaders, project staff and a small group of students using a random sample of the material. These test codings were then compared, discussed extensively and the tool was then refined. Prior to commencement of data recording an extensive training course was staged at the beginning of September 2007 (for programme see Fig 3). Firstly, the coders were familiarised with the analytical tool, i.e. with each individual variable in the codebook to enable them to use the codes in a uniform manner and if possible to reach the same coding results when coding the same analytical material (article). Secondly, efforts were made to ensure basic uniform understanding of the analytical object “nanotechnology” as this was essential for the reliable identification of articles on nanotechnology in which the term itself was not used. After the training session each coder was asked to test code 25 articles within the framework of a pretest[4]. At a second coder training session results were extensively discussed and any unclear elements identified. Based on the results of the first pretest the analytical tool was refined and, with the help of further sample codings, tested for practicability, clearness of the categories and logic. Once the results of this second test run were deemed to be satisfactory, the data recording phase was launched at the beginning of October 2007 and was completed by the end of February 2008.

[4] A pretest is a sample recording in the run-up to the actual field phase which is used to test and refine the recording tool.

Fig. 3*:* Structure of coder training (Rössler 2005: 170)



The content analysis method seeks to achieve the highest possible degree of intersubjectivity and comparability. A reliability test can determine the extent to which this is achieved, i.e. the extent to which all coders assign the same codes to the test text characteristics in the vast majority of cases. "The reliability of a measurement instrument is the benchmark for the reproducibility of measurements" (Diekmann 2001: 217). Not just every current coder was to assign the same codings with the help of the codebook but also future coders should reach the same results when the same material was analysed afresh.

To test intercoder reliability, i.e. the correlation of all coders in the coding (analysis) of the same material (article), 55 newspaper articles were randomly selected which were evenly distributed between all 9 publications examined. For each of the pairs consisting of four coders, the coefficients Holstis R and Scotts Pi were calculated, as proposed for the determination of reliability for more than two coders, and the average was then determined for all coders (cf. Kolb 2004; Rössler 2005: 185 ff). This led to a reliability for all variables of the codebook of R = .87 and Pi = .79.[5] Given the number of coders this result is very acceptable. Furthermore, it can be assumed that the "true" correlation of codings is higher as the evaluation of data did not cover all categories of a variable; several categories were compiled into meaningful abstract upper categories (cf. Matthes/Kohring 2004).

[5] The reliability values of the V15_1 - V74 variables were calculated on the basis of 47 articles for which all four coders chose the same analytical path. The calculation was done with PRAM (Program for Reliability Assessment with Multiple Coders).

Table 4: Intercoder reliability of selected variables

	Set of variables	Scale level	Holsti´s R	Sotts Pi
V3_1 – V6, V11, V12	Formal details	nominal	.95	.91
V10_new	Scale	ordinal	.89	.83
V_analysis	Analytical path	dichotomous	.92	.84
V24_topic	Main topic	nominal	.87	.81
V28_I_new – V28_III_new[a]	Main actor	nominal	.76	.63
V33_I – V33_III[a]	Assessment of nanotechnology	ordinal	.79	.66
V34_I – V34_III[a]	Mention of benefit	nominal	.82	.72
V37_I – V37_III[a]	Actor responsible for benefit	nominal	.87	.80
V39_I – V39_III[a]	Mention of risk	nominal	.90	.83
V42_I – V42_III[a]	Actor responsible for risk	nominal	.95	.91
V44_I – V44_III[a]	Demand	nominal	.97	.95
V48_I – V48_III[a]	Forecast	nominal	.90	.83
V50 – V67[b]	Generic Framing	dichotomous	.94	.90

[a]: Mean value for all 3 mentions in the analysis
[b]: Mean value for the 17 variables which were used to record generic framing

2.5.4 Application phase

Great care was taken to ensure that there was a non-chronological, mixed distribution of analytical units to all coders to ensure that they were able to process articles from all years and publications. In this way systematic differences arising from the selection of articles (e.g. series and coder effects) could be avoided and undesirable “learning effects” (Wirth 2001) could largely be neutralised. Thanks to these precautions learning effects of this kind – which are to be expected in conjunction with nanotechnology which is still a comparatively “new” topic for the average reader – did not impact on a specific time period.

For the coding of the individual article all coders were instructed to proceed in three stages (see Code book, p.6, annex C): first of all the article was to be read in full in order to determine whether the inclusion criterion “nanotechnology as the main topic” was met and which analytical path (word field analysis vs. full analysis) was to be selected for the article concerned. In a second reading the content coding should begin. In this context it may have been necessary for the article or parts of the article to be reread for the purposes of coding individual variables. In the case of uncertainty or complex texts a third reading was recommended. Coding itself was done via an input mask developed for this survey directly into the data base. The input mask guided the coder through the individual steps in the codebook and contained a register card for each of these sections in which the values for the corresponding variables were entered. The data set per article could only be closed and saved when all fields had been completed. Furthermore, the input mask was programmed to only allow the codes defined for each variable – hence misentries could largely be avoided.

In order to be able to react to problems during the recording phase two and to be able to fully document decisions, a joint work file was set up on the online work platform BSCW to which all project staff had access.

2.5.5 Evaluation phase

The statistical analysis of the content analysis data is oriented primarily towards the main questions (see Chapter 1.1) of the Federal Institute for Risk Assessment (BfR). In a first step it is time based in order to examine temporal developments and shifts. To this end the data are compacted into larger natural periods (quarters, years). In the case of a process of this kind it should be borne in mind that the mere selection of time periods can have a major impact on the evaluation result and its graphic depiction. In more recent research on reporting courses, efforts have, therefore, been made to avoid arbitrary periodisation steps (for instance annual limits) and to develop theoretically based phase breakdowns which avoid this problem (cf. on this subject in particular Kolb 2005). In the case of this analysis of reporting on nanotechnology, a breakdown based on fixed reporting phases - as undertaken for instance by Kolk (2005) and Burkhardt (2006) using the example of coverage of environmental damage from street traffic and leaded petrol, and media scandals - was not found to be very helpful largely for two reasons:

(1) Firstly, the analytical object “nanotechnology” is not strictly speaking a clearly demarcated topic but far more an object for which many individual topics can be identified, for instance: fundamental research in the field of nanotechnology, nanotechnology in the application medicine and health or nanobiotechnology. In this context the topic based on Eichhorn (1996) is understood as a hierarchically structured knowledge concept which applies a label to a group of events, actions and interpretations (cf. Matthes 2007: 144).

(2) Secondly, the communication object “nanotechnology” and individual topics from that field during the period under review (01/2000–12/2007) were not particularly problematic or conflict-ridden. Hence no peak phases could be observed which, besides the ideal courses of public conflicts or problem-solving processes, could contribute to a phase determination.

For these reasons and to ensure transparency and understanding of the analysis, the evaluation work in this report is mainly done on the annual level. The course-related answering of the research questions (see Chapter 1.1) is supplemented by detailed considerations on the level of the nine publications examined.

The goal of a further analytical step in this work is to identify issue-specific frames in the media coverage of nanotechnology. As described in Chapter 1.2, a frame can be understood as a coherent horizon of understanding – as a consistent attitude towards a topic. The component model proposed by Kohring and Matthes (2002; cf. Matthes/Kohring 2004; 2008; Mat thes 2007 and Dahinden 2006) constitutes the foundation of empirical recording. Media frames are designed as above-chance patterns of individual components that occur in several texts like problem definition, impartial assessment, causal attribution of responsibility and solutions and are then empirically analysed. This is based on the assumption that the previously theoretically defined frame elements recorded in the individual variables (cf. Engleman 1993) are grouped characteristically and can be identified with the help of the statistical cluster analysis method.

Cluster analysis is one of the multivariate methods of explorative data analysis. The goal is to identify “hidden” groups of cases (articles) in the data whereby the cases within the group should, if possible, be similar or homogeneous and the individual groups should, if at all possible, differ or be heterogeneous (cf. Janssen/Laatz 2007: 487 ff).The two-step cluster analysis method was used to identify the frames in the coverage of nanotechnology which can be seen as a combination of the methods of hierarchical cluster analysis and cluster centre analysis (K-means).[6] It offers several advantages which advocate its use (cf. ibid.: 491):

[6] Hierarchical cluster analysis, which uses the Elbow criterion to determine the number of clusters, was not used in this analysis because the data set with 1696 cases exceeded by far the number of processable cases. For the use of cluster centre analysis, which is only suitable for metric variables, the scale of the majority of variables is too low.

- Category and metric variables can be used at the same time.
- The procedure is capable of determining the optimum number of clusters.
- Large data files can be processed.
- Outlier cases can be separated.

The clusters are determined in a two-step cluster analysis: in the pre-cluster phase the cases are processed sequentially and sub-clusters are formed with similar cases. Only in the ensuing cluster level are the sub-clusters merged into the actual end clusters using agglomerative hierarchical cluster analysis. For a detailed description of the statistical method, reference is made at this point to Backhaus *et al*. (2006: 490–555) and Janssen and Laatz (2007: 487–512). One of the strengths of two-step cluster analysis is that a cluster number is either stipulated or the automatic determining of the optimum cluster number can be selected. In the evaluation undertaken here, automatic determination of the cluster number was selected as a specific number did not emerge from the expected frames of nanotechnology either from the descriptive basic evaluation or from the theoretical analyses. The quality of cluster application was tested using discriminance analysis in addition to the small t-test (test of the mean difference between two groups for significance). The goal of discriminance analysis is to determine or forecast the group affiliation of elements (articles in the case of this analysis) from the values of one or more independent (explanatory) variables. It can, therefore, be described as a confirmatory method. As discriminance analysis - like all multivariate methods is a complicated mathematical procedure - no details explanations are given and reference is made instead to Janssen and Laatz (2007: 513–530).

Finally, attention should be drawn to the fact that the majority of multivariate analytical methods (discriminance analysis, too) are dependent on a metric scale of the variables to be examined which is only reached in this study by some of the variables. In particular for the key variables for the analysis of issue-specific framing – e.g. “main actor”, “main topic”, “mention of opportunity”, “mention of risk” or “ responsible actor” - - are nominally scaled. Dummy variables were formed to enable them nevertheless to be included in the above-mentioned methods, i.e. binary variables which only assume the values 0 and 1 and can thus be used like interval-scaled variables (cf. Raithel 2006: 159).For the preparation of cluster analysis and the following methods those variable expressions of the individual frame elements, which show a frequency of more than 5%, were transformed into binary coded dummy variables with the expressions 0 “x does not occur” and 1 “x does occur” (cf. on this procedure Backhaus *et a*l. as well 2006: 265–272).[7]

[7] Comparisons with this method for the preparation of the empirical determination of media frames with the help of cluster analysis, also Matthes 2007: then Fröhlich/Scherer/Scheufele 2007 and Kohring/Matthes 2002.

3 Word field analysis – "nano" in the media

3.1 Analytical path

The subject manner of this analysis is nationwide coverage of nanotechnology during the period from the beginning of 2000 to the end of 2007. To establish the population the first step involved sourcing all articles (= analytical unit) in the *Frankfurter Allgemeine Zeitung*, the *Suddeutsche Zeitung*, *tageszeitung*[8], the *Frankfurter Rundschau, Die Welt,* the *Financial Times Deutschland, Die Zeit, Der Spiegel* and *Focus* in which the search term "nano" occurred using the media database Genios. The search identified a total of 6450 articles for the above period which were obtained using the procedure outlined in the Chapter 2.3.

The non-relevant articles were then removed from the body of texts in order to guarantee that only nationwide coverage was analysed. The following were excluded from the analysis:

a) Publishing house and special supplements as they were mostly non-editorial articles which are not distributed in a uniform manner on the nationwide level;

b) Event tips;

c) Articles in the local section of various publications which were not distributed nationwide.

The adjusted body of texts finally encompassed 5125 articles. They are distributed to the following publications as indicated below:

Table 5: Distribution of the selected articles on nanotechnology to the publications

	Frequency	Percent
Frankfurter Allgemeine Zeitung	1628	31.8
Süddeutsche Zeitung	705	13.8
Tageszeitung	208	4.1
Frankfurter Rundschau	425	8.3
Die Welt	987	19.3
Financial Times Deutschland	615	12.0
Die Zeit	267	5.2
Der Spiegel	150	2.9
Focus	140	2.7
Total	5125	100.0

As, however, the declared goal of this study is to make statements on articles whose *main topic* is nanotechnology in general or a specific application, only those articles which dedicate at least 50% of their content to the topic and/or make important statements on this topic were analysed. Strictly speaking, they make up population (as this is a full survey) for analysis. The identification of the analytical units was done using the decision tree described in Chapter 2.4.

The first criterion was the scale of the relevant statements. The inclusion criterion for full analysis – 50% of the article must be dedicated to the topic nanotechnology – was met by 1110 articles (21.7%) (Table 6).

[8] Hereinafter referred to as *taz*.

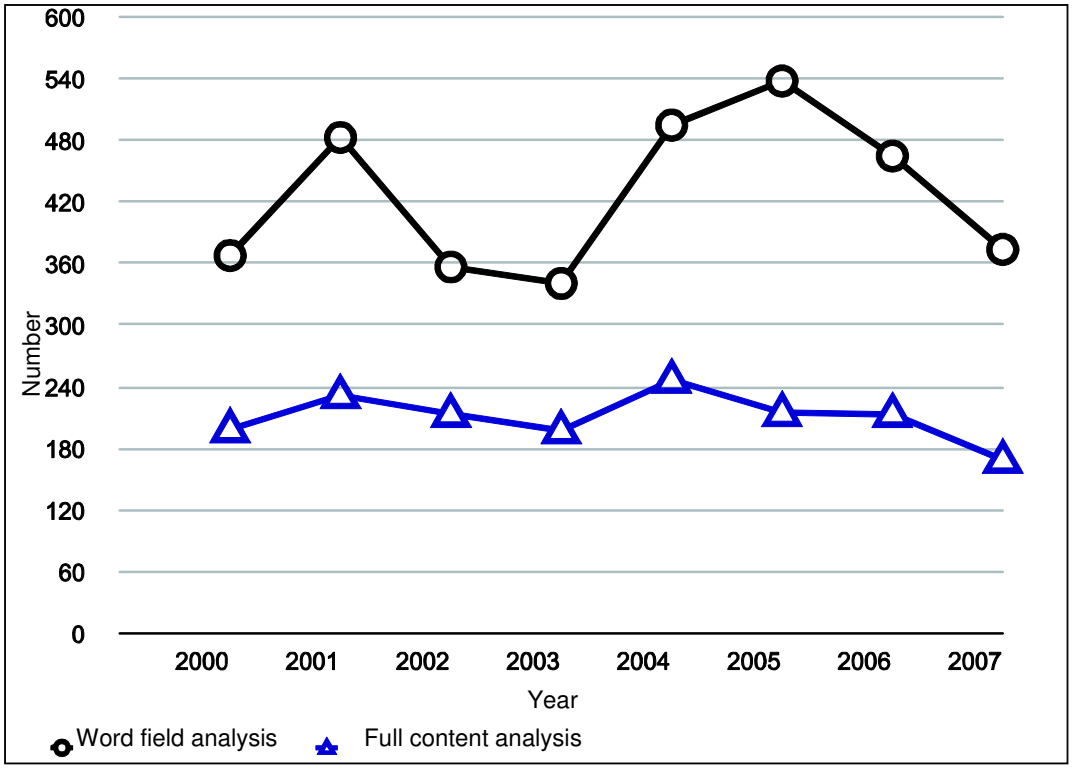
Table 6: Proportion of article dedicated to the topic nanotechnology

	Frequency	Percent
No link to nanotechnology[a]	1627	31.7
up to 25 % of the articles	1996	38.9
up to 50 % of the articles	392	7.6
up to 75 % of the articles	348	6.8
up to 100 % of the articles	762	14.9
Total	5125	100.0

[a] In articles for which "no link to nanotechnology" was coded, the term "nano*" is used independently of nanotechnology, e.g. in the metaphorical sense for unimaginably small objects or incredible speeds, pure weight details (in the field of sport doping) or product designations which cannot be attributed to nanotechnology (e.g. iPod nano).

For all articles with a link to the topic nanotechnology (n = 2388), but which devote less than half of their volume to this subject, the contents were examined for relevance[9]. A further 586 articles could be classified as relevant for the full analysis. Overall, 1696 articles were identified for full analysis which focused on nanotechnology.

Fig. 4: Analytical path of the articles by year



[9] The relevance for this topic is determined via recordability of the main actors, opportunities and/or risks. As soon as statements are made in an article about the opportunities or risks of nanotechnology which can be attributed to a spokesperson, it is deemed to be relevant per definition irrespective of the pure text volume which deals with the topic examined here.

All other 3429 articles in which "nano*" was clearly used as a partial word or this topic was not particularly important, were not fully excluded from analysis but examined in a word field analysis for their importance and how the term was used[10]. Table 7 shows the distribution of the selected analytical path for all 9 publications examined.

Table 7: Distribution of the analytical pathway for all 9 publications (as %)

Analytical path	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
Word field analysis	66.0	76.2	83.2	72.9	61.6	52.4	76.8	68.7	68.6	66.9
Full examination	34.0	23.8	16.8	27.1	38.4	47.6	23.2	31.3	31.4	33.1
Total	100 n=1628	100 n=705	100 n=208	100 n=425	100 n=987	100 n=615	100 n=267	100 n=150	100 n=140	100 N=5125

3.2 Word field analysis: "Nano" - a fashionable word at the beginning of the 21st century

Via this analytical path 3429 out of the 5125 nationwide articles were examined in which the partial word "nano*" is used but in which the topic nanotechnology does not assume a central role. Over the entire study period this applies to approximately two-thirds (66.9%) of all articles on average per newspaper/magazine. The exceptions here are the *tageszeitung* (taz) with a total of 83.2% (n = 208) and the *Financial Times Deutschland*, which have the most balanced coverage on average across all years with 52.4% word field analysis compared to 47.6% full analysis (n = 615) distributed over both analytical paths.

The core of the word field analysis is examination of the context of use of the partial word "nano*": 47.4% of the articles use the partial word with no direct or identifiable link to nanotechnology. 51.4%, by contrast, have a direct link. These numbers prompted the question about what "nano*" refers to in individual cases.

Table 8: Context of use of "nano*" (n= 3429; as %)[11]

Context: in what context is the partial word "nano*" used?	No link to nanotechnology	Direct link to nanotechnology	Not clearly identifiable	∑
Speed (real)	5.7	0.2	2.6	2.8
(Unimaginable) speed	3.8	0.3	-	2.0
Weight (real)	19.1	0.1	-	9.1
(Unimaginable) lightness	0.6	-	-	0.3
Size/length (real)	24.6	7.9	33.3	16.1
(Unimaginable) size	7.1	6.0	-	6.4
Power (real)	0.1	-	-	-
(Unimaginably low) power	-	0.2	-	0.1
Nanotechnology as a course of study/field of research	0.6	46.8	5.1	24.4
"The nanotechnology"	1.4	24.9	7.7	13.5
Company name	4.4	3.6	12.8	4.1
Product names	11.5	0.3	2.6	5.6
Nanotechnology products	0.5	7.3	17.9	4.2
Mention of individuals	12.6	1.7	-	6.9
Other	8.1	0.8	17.9	4.5
Total	100.0 n=1627	100.0 n=1763	100.0 n=39	100.0 N=3429

[10] Annex B.1 contains a small selection of articles which merely underwent word field analysis.
[11] The context of use by year is not presented here as no significant differences were identified.

Articles with no link to nanotechnology are mainly to be found in the sports (14.4%) and political sections (politics/domestic + politics/foreign: 12%) in addition to the knowledge/science section (25.7%, n=1627). In these articles "nano*" is primarily used as a real indication of length (24.6%) ("this cylindrical construct which is only a few nanometres thick is the antenna"; *Frankfurter Allgemeine Zeitung*, 14.11.2007) and a weight unit (19,1%) ("with 1,320 nanogram per millilitre urine the value was far higher than the limit value"; *Frankfurter Allgemeine Zeitung*, 03.08.2007) or as part of a product name (11,5%) ("iPod nano: Snow White lies in a plastic coffin"; *Focus*, 24.09.2007). References to individuals (12.6%) – the most prominent example here is Fatos Nano, Albanian Prime Minister ("Prime Minister Meta resigns because of dispute about nano"; *Frankfurter Rundschau*, 30.01.2002; "Nano strengthened through elections"; *Frankfurter Allgemeine Zeitung*, 17.10.2003) – led to increased identification of articles with no association with nanotechnology.

What is also noticeable is that the partial word "nano*" is used not only in conjunction with real phenomena but also in a metaphorical sense, for instance as an actual speed or unimaginable speed, real size or unimaginable size along the lines of tiny (Fig. 5). As shown by the proportion of metaphorical use (11.5%) of "nano", this partial word is increasingly being used in media jargon as a popular form for trivialisation or putting in perspective or as a modern sounding synonym for "tiny".

Fig. 5: Examples for the use of the partial word "nano*" in the real and figurative sense

Speed (real): "Travel time (…) is reduced to an incredible 16 nanoseconds" (taz, 25.07.06, p. 20)

Unimaginable speed/exaggeration: "You're sitting in the cinema. All of a sudden it appears out of the dark at the ba*ck and* within a few *nanoseconds* grows into an eerie roar." (taz, 31.01.2006, p. 20)

Size/length (real): "The shortest waves used today are just under 200 nanometres long." (Die Zeit, 16/05)

(Unimaginably small) size/exaggeration: "If 54,000 new full time jobs are recorded compared with the same month last year, then that is a nano-sized miracle." (Spiegel, 32/2006, p. 23)

Articles that have a direct link to nanotechnology but do not focus on this mainly refer to nanotechnology as a course of study or field of research (46.8%, n=1763) (what is popular is the triad bio, nano, info) when listing important technologies of the 21st century ("nano, bio, info: these are, in short, the disciplines in which we are investing."; *Frankfurter Rundschau*, 21.11.06) as well as making quite general references to "the nanotechnology". Consideration of the context of use provided further insight into use of this term[12]. In line with the reference to study courses and nanotechnology as a field of research, the scientific perspective is dominant (41.6%, n=1763), followed by the economic perspective. Another important context for coverage is the political one (research policy) with 15.1 %.

As the partial word "nano*" is used in many different contexts in German nationwide coverage and leads to the coinage of new terms, these were frequently recorded in an open manner. Figure 6 gives selected results of the word field analysis:

[12] The corresponding question in the codebook was: "In what context is nanotechnology mentioned?" (V15_2b)

Fig. 6: Examples of new words in the material analysed

Nanoage	Zeit, 1.1.2006
Nanogate	FTD, 6.2.2007
nanosquare	Welt, 6.6.2006
Nanograins	FAZ, 20.2.2006
Nanomatic	FAZ, 10.7.2006
nanometre-fine	Spiegel, 17.2.2007
Nanopigments	FTD, 7.2.2007
Nanopolis	FAZ, 30.3.2007
nanoporous	FTD, 24.7.2006
Nanosolar	FTD, 19.2.2007
Nanotechnology logis-tics Internet boom	FAZ, 11.7.2006

Nanocity	Welt, 8.9.2006
Nanodiet	Welt, 1.4.2006
Nanoaquarium	FAZ, 13.3.2007
Nanohype	Spiegel, 17.7.2006
Nanosculptures	FR, 14.10.2006
Nanonemesis	taz, 21.5.2001
Nanobots	Spiegel, 1.1.2001
nanoscale	FTD, 11.11.2005
Nanotie	FTD, 11.11.2005
Nanopolis	FAZ, 30.3.2007
Nanosecond culture	SZ, 29.6.2000
Nanowire	Welt, 22.6.2007
Nanovan	FAZ, 24.01.2006

4 Analysis of nationwide coverage of nanotechnology

The results of the study are presented below in line with the research questions and the logics of the content analysis presented in Chapter 1.1. Besides a general description of the database (4.1), the results are presented on the topic structure and discussion processes (4.2) and on the analysis on the spokesperson level (4.3). In Chapters 4.4 and 4.5 the opportunity-risk debate and argumentation structures are presented as demands and instructions. In a detailed consideration of the processing of the nanotechnology content (4.6), an overview is given on the conveying of information on nanotechnology (4.6.1). Furthermore, results of the language analysis (4.6.2) and image analysis (4.6.3) are presented. The frames and issue-specific media frames (4.7) identified for coverage of nanotechnology are then presented for the overall analysis.

4.1 Description of the database

All the articles, in which the main theme is nanotechnology or a specific application of nanotechnology, were included in the full analysis. This led to an analytical body of 1696 articles (cf. Chapter 3.1 on selection).

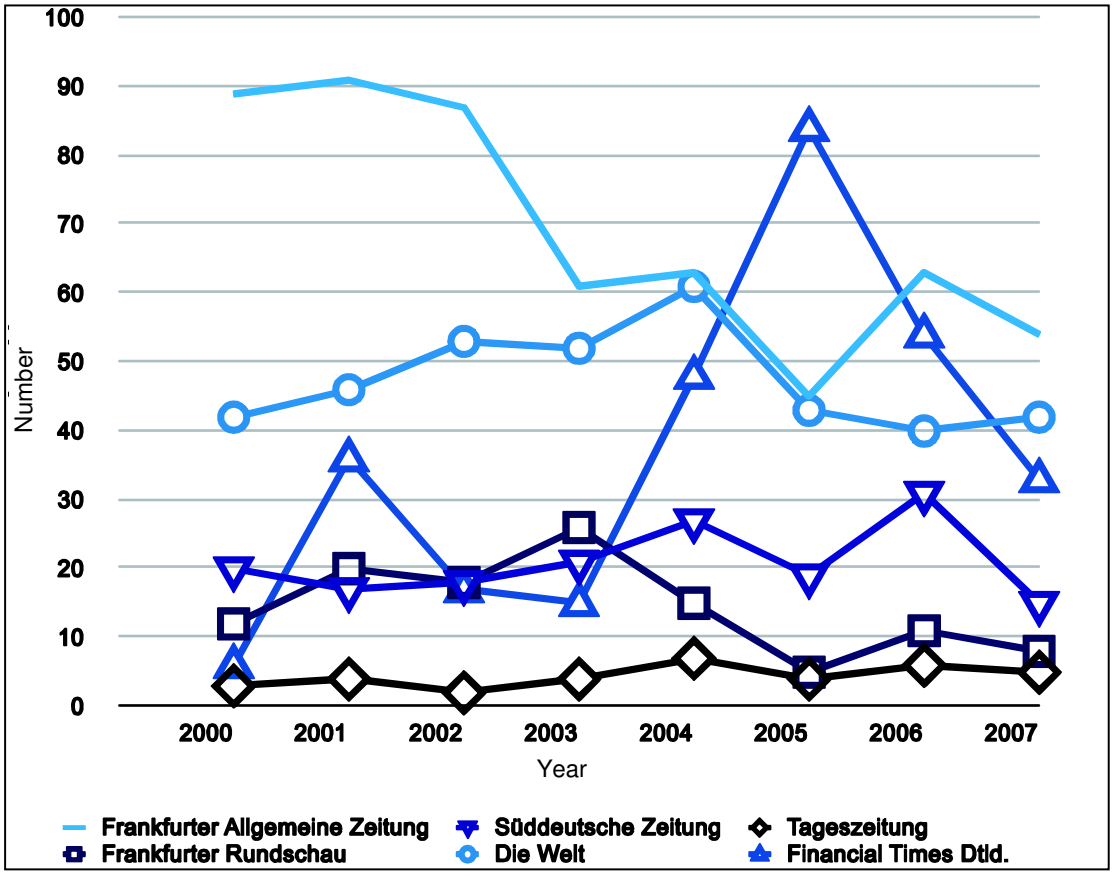
4.1.1 Scale of coverage

The scale or intensity of coverage was measured in this study using the number of published articles and the scale of the individual articles. The *Frankfurter Allgemeine Zeitung* was found to have highest number of articles (m=69, SD= 17.5[13]) overall (n=553) and across all years in the study period. Particularly in 2000 (89 articles), 2001 (91 articles) and 2002 (87 articles) it differs considerably from the other daily newspapers and published almost twice as many articles as the publication in second place, *Die Welt* (2000: n=42; 2001: n=46; 2002: n=53). Only in 2005 was the *Frankfurter Allgemeine Zeitung* (n=45) overtaken by the *Financial Times Deutschland* (n=84) which achieved its coverage peak that year. In terms of coverage frequency over the entire study period, the next in line was *FAZ* followed by *Die Welt* with 379 articles (m=47.7; SD= 7.2) the *Financial Times Deutschland* with 293 articles (m=36.6; SD= 25.2), the *Süddeutsche Zeitung* with 168 articles (m=21; SD= 5.3) and the *Frankfurter Rundschau* with 115 articles (m=14.3; SD= 6.8) in eight years. The *taz* differs considerably from the other nationwide newspapers analysed with only 35 published articles (m=4.37; SD= 1.5), which were very evenly distributed over the years 2005-2007. Figure 7 shows the course of coverage intensity during the study period.

This means that the German daily press can be roughly broken down into two groups based on the scale of coverage of the topic: two newspapers (*FAZ* and *Die Welt*) dominate public communication on this topic; three others (*FR, SZ, taz*) report rarely up to moderately frequently but regularly on nanotechnology. Up to 2003 the *Financial Times Deutschland* belonged to this last group and since then to the trio of newspapers that devotes the most attention to this topic.

[13] M = Mean; SD = Standard deviation

Fig. 7: Coverage intensity in the news media 2000–2007



Of the weekly publications *Die Zeit* has the highest coverage intensity (n=62; m=7.75; SD= 3.2). Only 47 (m=5.8; SD= 3.1) and 44 (m=5.5; SD= 1.8) articles were published in the *Der Der Spiegel* and *Focus*, respectively over the eight years. However, if one links the number of articles to publication frequency (6 issues per week for daily newspapers compared to one issue per week for magazines and weekly magazines), then *Die Zeit* (n=62) comes just behind the *Frankfurter Allgemeine Zeitung* (n=92) and *Die Welt* (n=63). On this basis *Der Spiegel* and *Focus* are comparable with the *Financial Times.*

If one looks at the course of coverage of nanotechnology overall, then two relative peaks can be identified in 2001 (n=233) and 2004 (n=248). After 2004, however, coverage frequency steadily declined to 170 articles in 2007.

When it comes to the scale of coverage of nanotechnology measured in newspaper pages, the *Frankfurter Allgemeine Zeitung* with a total of 86.25 newspaper pages (2001-2007) and 141 A4 pages (in 2000) again differs markedly from the other publications (Table 9 gives a comparison).[14]

[14] The scale of the articles was measured on the basis of the available analytical material in this study. Whereas in the case of the Frankfurter Allgemeine Zeitung from 2001 to 2007, the Süddeutsche Zeitung, the Frankfurter Rundschau, Die Welt and the Financial Times copies of the full, original newspaper pages were available, which could be compared with one another, recourse had to be made for the Frankfurter Allgemeine Zeitung from 2000, for the tageszeitung and for Die Zeit to A4 print-outs of the articles available on DVD and in the online archives. Measurement of the scale of coverage in the A4-format news magazines Der Spiegel and Focus, was done on the basis of copies of the original format. For this reason three different ways of measuring scale were needed (for the exact methodology see V10_1, V10_2 and V10_3 in the codebook, Annex C) which could only then be compared in a second step.

Fig. 8: Coverage intensity in the weekly publications 2000–2007

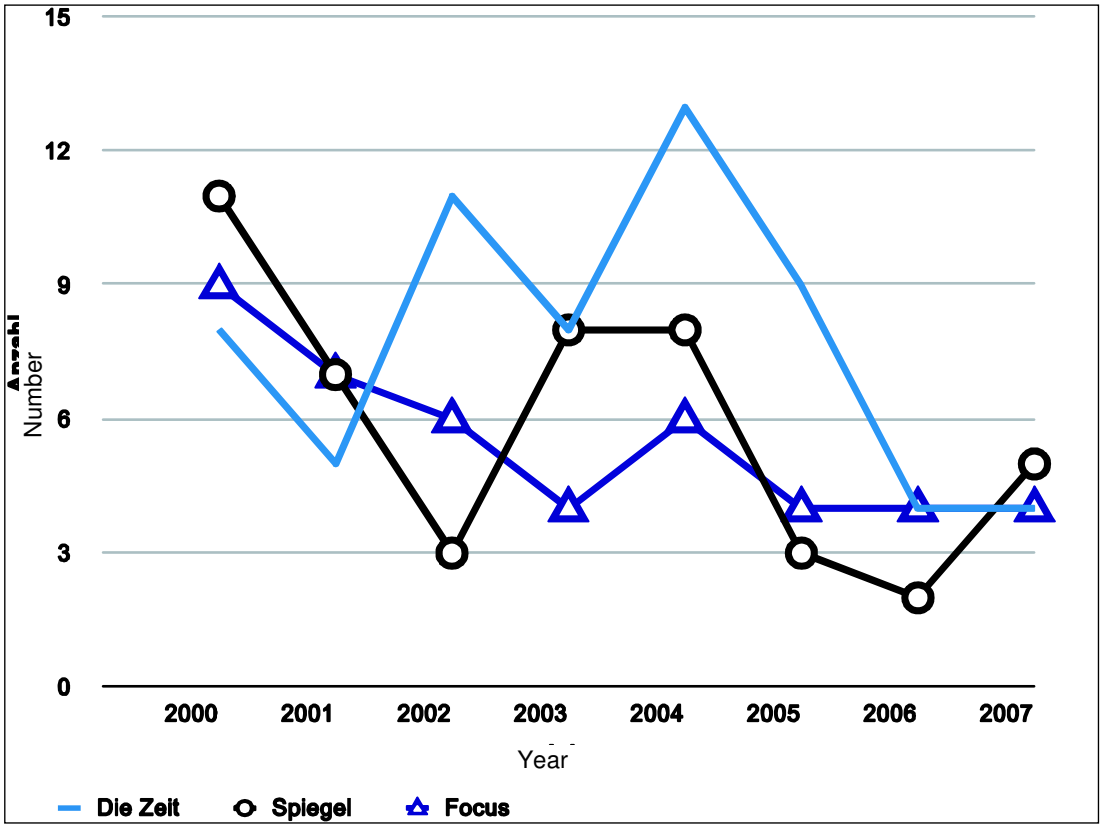


Table 9: Size of the articles as published pages (2000–2007)

Unit used to measure size	Publication	Scale in pages
Copies of newspaper pages	Frankfurter Allgemeine Zeitung (2001–2007)	86.25
	Süddeutsche Zeitung	33.38
	Frankfurter Rundschau	26.31
	Die Welt	70.87
	Financial Times Deutschland	74.58
A4 printouts	Frankfurter Allgemeine Zeitung (2000)	141
	Tageszeitung	26
	Die Zeit	57.75
Copies of magazine pages	Der Spiegel	68.5
	Focus	63.5

In approximately 75% of all cases the articles on nanotechnology range in size from small to very small (m=1.99; SD=0.91)[15], i.e. only in the rarest of cases do they exceed 12% and 6% of a newspaper page in daily newspapers; even in the case of *Focus* and *Der Spiegel* they are rarely larger than half a magazine page and are relatively small down to very small (Tables 10 and 11 give an overview of the distribution of article size by year and publication). A comparison of mean values shows that the most extensive articles were published in 2000 (m=238; SD=1.1).

[15] The relative size of the articles was recorded using a 5-level scale (1 = very small up to 5 = very big)

4.1.2 Form of coverage

Across all publications and the entire study period, the various topic areas of nanotechnology are mainly presented in the journalistic form of news (31.9%) and reports (60.8%). In 2006 42.3% of the articles are even presented in the comparatively most dense and shortest form of coverage – news. Opinion-oriented forms like commentaries, columns, main articles or interviews are rarely used (6.9%). Only in 2000 the year in which the debate was launched on the social implications of nanotechnology by Bill Joy's essay "Why the future doesn't need us" in the *FAZ* of 6 June 2000[16] did this increase to a substantial 16.5% (= 33 articles) – and in the *Frankfurter Allgemeine Zeitung* in the same year to 14.6% of all articles (n=89).

4.1.3 Positioning

Across all the years articles on nanotechnology – a comparatively young technology – are mainly placed in the knowledge-science section (58.5%, n=1696). Other important sections are business/finance (14.2%, n=1696) and the feature/arts section (11.6%, n=1696). The fact that the press still finds it comparatively difficult to position topics to do with nanotechnology is illustrated by the unusually high proportion (11.9%, n=1696) of "other" sections (cf. Table 12). These are pages which deal with related topics under collective headings like for instance "information technology", "consumer electronics" (*Financial Times Deutschland*) or "media" (*Süddeutsche Zeitung*).

Consideration of the various individual publications shows that both *Süddeutsche Zeitung*, *Die Welt* and also *Die Zeit* and *Der Spiegel* mainly anchor their coverage of nanotechnology in the knowledge/science section. The *Financial Times Deutschland* – a newspaper with a clear economic focus – largely adopts this classification as well. *FAZ* occupies a special position when it came to the positioning of this topic. Over the entire study period 29.3% of all articles (n=553) are positioned in its *Feuilleton* (feature/arts section). In 2002 the proportion of articles in the Feuilleton was 40.2% (n=87), and in 2003 the Feuilleton was even home to the largest proportion of overall *FAZ* coverage (49.2%, n=61).[17]

[16] For more details on this subject please go to Chapter 4.2.2.

[17] In the FAZ Feuilleton natural science topics are the subject of essays, commentaries, reports several times a week, and this includes nanotechnology. Since 2000 Frank Schirrmacher, co-publisher of FAZ has removed scientific topics from the pure science pages and placed them in the Feuilleton in order to cover the philosophical and cultural aspects of modern research, too. Hence articles are written not only by philosophers and ethicists but also by science fiction authors and natural scientists. The essay by the US computer scientist, Bill Joy "Why the future doesn't need us" of 6 June 2000 led to a whole series of follow-up articles. In his essay, Joy develops an apocalyptic scenario in which self-replicating nanorobots destroy the entire biosphere. In an interview with Thomas Gauly, Frank Schirrmacher explains the shift in the FAZ Feuilleton from a section for reviews to a section for debate as follows: "This has to do with the fact that biology and everything associated with it is penetrating and redefining culture. That is a topic for the Feuilleton, for the business section and of course for the political section. However the topic fundamental research is presented in the Feuilleton because it has a social dimension. Aside from that, it is certainly not wrong to subscribe at least to a minimum degree to Goethe's educational ideal of universal knowledge" (Gauly 2001).

Table 10: Size of article by news medium (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
Very small	23	31.5	28.6	35.7	35.4	38.6	16.1	46.8	54.5	31.5
Small	57.7	48.2	60	40.9	45.9	29.7	62.9	12.8	13.6	46
Average	13.4	18.5	11.4	11.3	14.5	20.5	19.4	29.8	18.2	16
Big	3.4	1.2	-	8.7	4	9.2	1.6	6.4	4.5	4.7
Very big	2.5	0.6	-	3.5	0.3	2	-	4.3	9.1	1.9
Total	100 n=553	100 n=168	100 n=35	100 n=115	100 n=379	100 n=293	100 n=62	100 n=47	100 n=44	100 N=1696

Table 11: Article size by year of publication (as %)

Article size	2000	2001	2002	2003	2004	2005	2006	2007	∑
Very small	21.5	27.9	34.9	29.6	35.1	29.2	40.9	31.8	31.5
Small	42	50.2	47.4	51.3	44	44.9	42.3	45.9	46
Average	21.5	12.9	14.4	14.6	18.1	19.9	11.6	14.7	16
Big	7	6	1.4	4	2.4	5.1	5.1	7.1	4.7
Very big	8	3	1.9	0.5	0.4	0.9	-	0,6	1.9
Total	100 n=200	100 n=233	100 n=215	100 n=199	100 n=248	100 n=216	100 n=215	1.0 n=170	100 N=1696

Table 12a: Positioning by news medium (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
Not identifiable	0.7	-	11.4	0.9	0.5	1	-	-	2.3	0.9
Title page	0.5	0.6	2.9	0.9	2.4	0.3	-	-	-	0.9
Politics/domestic	1.8	0.6	2.9	-	0.8	1	1.6	-	-	1.1
Politics/foreign	0.4	-	-	1.7	0.5	0.3	4.8	2.1	2.3	0.7
Economics/finances	15	14.3	17.1	20.9	14.8	10.6	14.5	6.4	11.4	14.2
Feature/arts section	29.3	4.8	11.4	4.3	2.4	1.4	3.2	-	4.5	11.6
Knowledge/science	46.5	65.5	34.3	45.2	69.4	70	67.7	70.2	40.9	58.5
Sport	-	0.6	-	-	0.5	-	-	-	-	0.2
Other/other section	5.8	13.7	20	26.1	8.7	15.4	8.1	21.3	38.6	11.9
Total	100 n=553	100 n=168	100 n=35	100 n=115	100 n=379	100 n=293	100 n=62	100 n=47	100 n=44	100 N=1696

Table 12b: Positioning over time (as %)

	2000	2001	2002	2003	2004	2005	2006	2007	∑
Not identifiable	0.5	0.4	-	-	0.4	0.9	2.3	2.9	0.9
Title page	2.5	1.7	0.9	1	0.4	0.5	0.5	-	0.9
Politics/domestic	1	2.1	-	0.5	3.6	0.9	-	-	1.1
Politics/foreign	1	0.4	0.5	-	0.4	0.9	1.4	1.2	0.7
Economics/finance	10.5	12	12.1	10.6	17.3	12	22.8	15.9	14.2
Feature/arts section	15.5	9.4	18.1	16.1	9.3	7.9	8.8	7.6	11.6
Knowledge/science	57.5	61.4	58.1	62.3	55.6	69.9	47.4	55.3	58.5
Sport	-	-	-	0.5	0.4	-	-	0.6	0.2
Other/other section	11.5	12.4	10.2	9	12.5	6.9	16.7	16.5	11.9
Total	100 n=200	100 n=233	100 n=215	100 n=199	100 n=248	100 n=216	100 n=215	100 n=170	100 N=1696

Between 2000 and 2007 nanotechnology only managed to reach the front page 16 times. Table 13 gives an overview of the headlines

Table 13: Nanotechnology on the front page

Date	Publication	Headline
06.06.2000	FAZ	Why the future doesn't need us
05.07.2000	Welt	Bill Joy: New technologies jeopardise mankind
11.08.2000	Welt	New invention could revolutionise chip electronics
24.08.2000	FAZ	Brain researcher Singer against artificial intelligence
24.11.2000	Welt	Mini-U-boat is to explore the human body
25.11.2000	taz	Together we can reach the 50,000
02.05.2001	Welt	Breakthrough for computer chips
09.05.2001	Welt	New margarine said to reduce cholesterol
08.08.2001	FAZ	The code in the coating
09.04.2002	Welt	Beat thirst by sweating
19.09.2003	Welt	Peres: Nanotechnology means prosperity and a future
09.12.2003	FR	Playing with atoms
18.06.2004	FTD	Gearing up for leisure and fun
30.07.2004	FAZ	Stricter legislation demanded for nanoparticles
27.04.2005	FTD	Infineon’s loss shocks brokers
05.07.2006	SZ	The Sidelight

In line with the sections the other articles are placed inside. Statements on individual numbers of pages – and by extension statements on the prominence of the articles – are not very informative as the individual publications differ in terms of page size and sequence of internal sections. Furthermore, some of them separate page numbers for each section.

In addition to the size of the articles and their positioning, visualisation can be used as an indicator of the importance attributed to nanotechnology in the coverage. In around 28.4% of the articles illustrations are used to visualise the topic. Chapter 4.6.3 contains an overview of the results of the image analysis.

4.1.4 Outcome composition

Judging by the external form, nanotechnology coverage, which can be described in the wider sense as science coverage, is mainly the work of the journalists themselves. Across all publications and the entire analytical period, 83.4% of all articles could be identified by name or by editorial board. Only 8.7% are clearly wire news. Only the *taz* (20%, n=35), the *Frankfurter Rundschau* (15.7%, n=115) and *Die Welt* (19.3%, n=379) make more frequent use of wire news. By contrast, the *Frankfurter Allgemeine Zeitung* has the highest proportion of its own articles (93.1%, n=553).

4.2 Topic structure and discussion processes

4.2.1 Focus of coverage

As already mentioned in Chapter 2.5.5, nanotechnology cannot be viewed in the strictest sense as a topic but merely as a subject of coverage for which various topic areas and topics can be identified. Besides "fundamental research" (34.1%, N= 1696), the most important topics over the entire study period are the application "information and communication technologies" (14.2%), "not consumer-related applications" (11.0%)[18], general "overviews"[19] of nanotechnology (8.2%) and the application "health care" (7.4%). Table 14 gives an overview of the overall distribution of coverage to the main topic complexes. These complexes were established by compiling a large number of individual topics which are the basis for the content analysis.

Table 14: Overview of the main topics covered

	Frequency	Percent
Fundamental research	579	34.1
Application: health care	126	7.4
Consumer-related applications[20]	69	4.1
Application: information and communication technologies	241	14.2
Not consumer-related applications	186	11
Debates about nanotechnology in general and ethical aspects	62	3.7
Nanobiotechnology	75	4.4
Politics	69	4.1
Economy	122	7.2
Overview of nanotechnology	139	8.2
Other	28	1.7
Total	1696	100

If one looks at the content of the topics covered most, then in the field of "fundamental research" most of the articles are on structure formation and nanostructures (85.8%, n=579). For the application "information and communication technologies", miniaturisation (32.8%, n=241), electronic components (29%) and data carriers with nanostructures (24.1%) are the main topics whereas surface coating and finishing (12.4%, n=186), the production of solar cells/photovoltaic cells (9.1%), catalysis/catalysers (8.1%) and energy stores (7.5%) are the dominant themes in coverage of not consumer-related applications of nanotechnology. For the application health care, the sub-topics tumour/cancer treatment (23%, n=126), treatment (15.9%) and diagnosis/early detection of other diseases (20.6%) and drug delivery developments (7.9%) are particularly important.

What is noticeable is that in around 60% of all articles only one topic/application of nanotechnology is discussed. Topics from the applications healthcare and information and communication technologies are only supplemented in 15% and 14.5% of the cases (n=241) with comments on fundamental research. The presentation of the main topic consumer-related applications is combined in 11.6% of the cases (n=69%) with the sub-topic not consumer-related applications which seems to indicate a general focus on applications in these articles.

[18] The not consumer-related areas include the applications "surface coating" (2.7 %, n=1696), "armaments, aerospace" (2.1 %), "energy management" (2.8 %), "construction" (0.6%), and "chemical industry" (2.8 %)

[19] They include all articles aiming to give an overview of the broad spectrum of nanotechnology – definition of terms, applications, possible opportunities and/or risks

[20] The consumer-related applications include the following applications: automotive industry (1.5 %), textile industry (1.6 %), cosmetics industry (0.4 %) and food industry and agriculture (0.5 %).

In line with the positioning of the majority of the articles in the knowledge/science and business/finance sections, the dominant perspectives covered are scientific (65.5 %, n=1696) and economic (21.6 %). Whereas articles on fundamental research and on the application healthcare are almost all written (94.5 %, n=579 and 95.2 %, n=126) from the scientific perspective, the economic perspective plays an important role in articles on the application information and communication technologies (39 %, n=251), not consumer-related (22 %, n=186) and consumer-related applications (60.9 %, n=69). Social (25.8%), cultural (24.2 %) and ethical-moral perspectives (21 %) were only identified in the topic complex - debates about nanotechnology in general and ethical-moral aspects (n=62) (cf. Table 15).

Table 15: Coverage perspective of the topics (as %)

	Fundamental research	Application: Healthcare	Consumer-related applications	Application: Information and communication technologies	Not consumer-related applications	Debates about nanotechnology in general and ethical aspects
Not decidable	0.5	0.8	-	-	-	-
Political perspective	0.2	0.8	-	0.8	0.5	3.2
Social perspective	0.7	1.6	11.6	2.1	5.4	25.8
Cultural perspective	0.7	-	2.9	0.4	1.1	24.2
Legal perspective	0.3	-	1.4	0.4	-	-
Economic perspective	2.2	1.6	60.9	39	22	-
Ethical-moral perspective	0.7	-	-	0.4	0.5	21
Scientific perspective	94.5	95.2	20.3	56.8	61.8	25.8
Military perspective	0.2	-	2.9	-	8.6	-
Other	-	-	-	-	-	-
Total	100 n=579	100 n=126	100 n=69	100 n=241	100 n=186	100 n=62

In most cases coverage focuses on current events (91.7 %) mainly in Germany (34.6% of cases). Furthermore, the USA is another geographical focus of reported events (26.5%) (cf. Table 16).

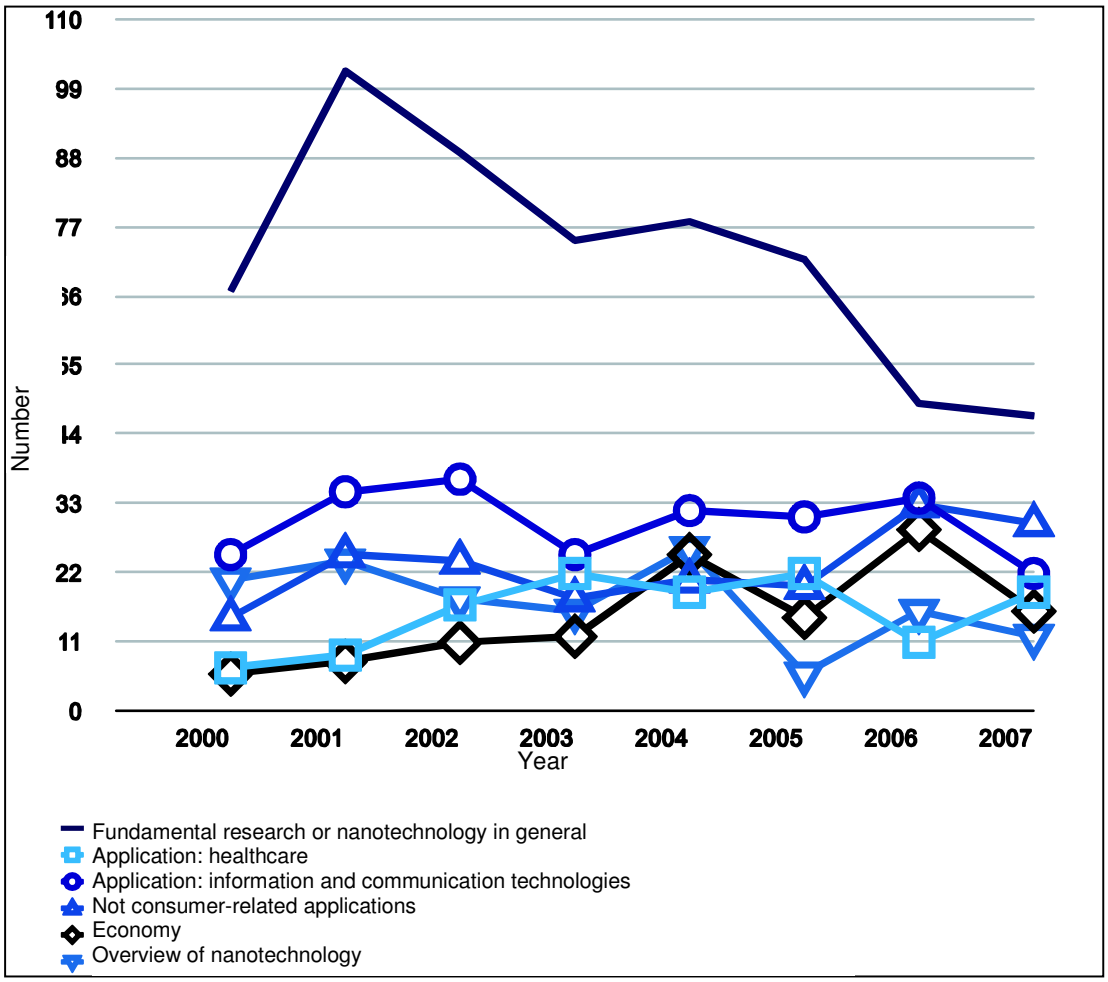
Table 16: Main topic and coverage region (as %)

	Fundamental research	Application: Healthcare	Consumer-related applications	Application: Information and communication technologies	Not consumer-related applications	Debates about nanotechnology in general (...)	Nanobiotechnology	Politics	Economy	Overall distribution
Not identifiable	3.8	6.3	11.6	18.7	5.4	38.7	8	4.3	13.1	10.1
Australia	0.2	1.6	-	-	1.1	-	-	-	-	0.4
China	0.9	-	-	-	0.5	-	-	-	-	0.4
Germany	27.6	34.9	58	22.4	36	16.1	18.7	63.8	58.2	34.6
France	0.9	-	-	0.4	0.5	1.6	-	-	-	0.5
Israel	0.5	1.6	-	-	0.5	-	2.7	-	1.6	0.6
Japan	5	0.8	-	2.5	2.7	-	1.3	-	2.5	2.7
Netherlands	0.7	-	1.4	0.8	1.6	-	6.7	-	-	0.9
Switzerland	1	1.6	1.4	1.2	-	-	1.3	-	-	0.8
South Korea	0.2	-	-	0.4	-	-	-	-	-	0.1
UK/England	2.2	-	1.4	2.1	3.2	4.8	4		0.8	1.9
USA	35.8	37.3	14.5	32	26.3	21	29.3	2.9	9.8	26.5
EU/EC	-	-	-	-	0.5	-	-	-	0.8	0.2
Several countries (including Germany)	11.2	11.1	7.2	12	14.5	16.1	20	14.5	9.8	13.3
Several countries (excluding Germany)	6.7	3.2	1.4	4.6	2.7	-	8	-	1.6	4.1
Europe	-	-	-	-	0.5	1.6	-	10.1	1.6	0.7
North America	0.3	-	-	-	1.1	-	-	-	-	0.2
Asia	0.7	-	-	0.8	-	-	-	-	-	0.4
Other	2.2	1.6	2.9	2.1	2.7	-	-	4.3	-	1.8
Total	100 n=579	100 n=126	100 n=69	100 n=241	100 n=186	100 n=62	100 n=75	100 n=69	100 n=122	100 N=1696

4.2.2 Time-based analysis

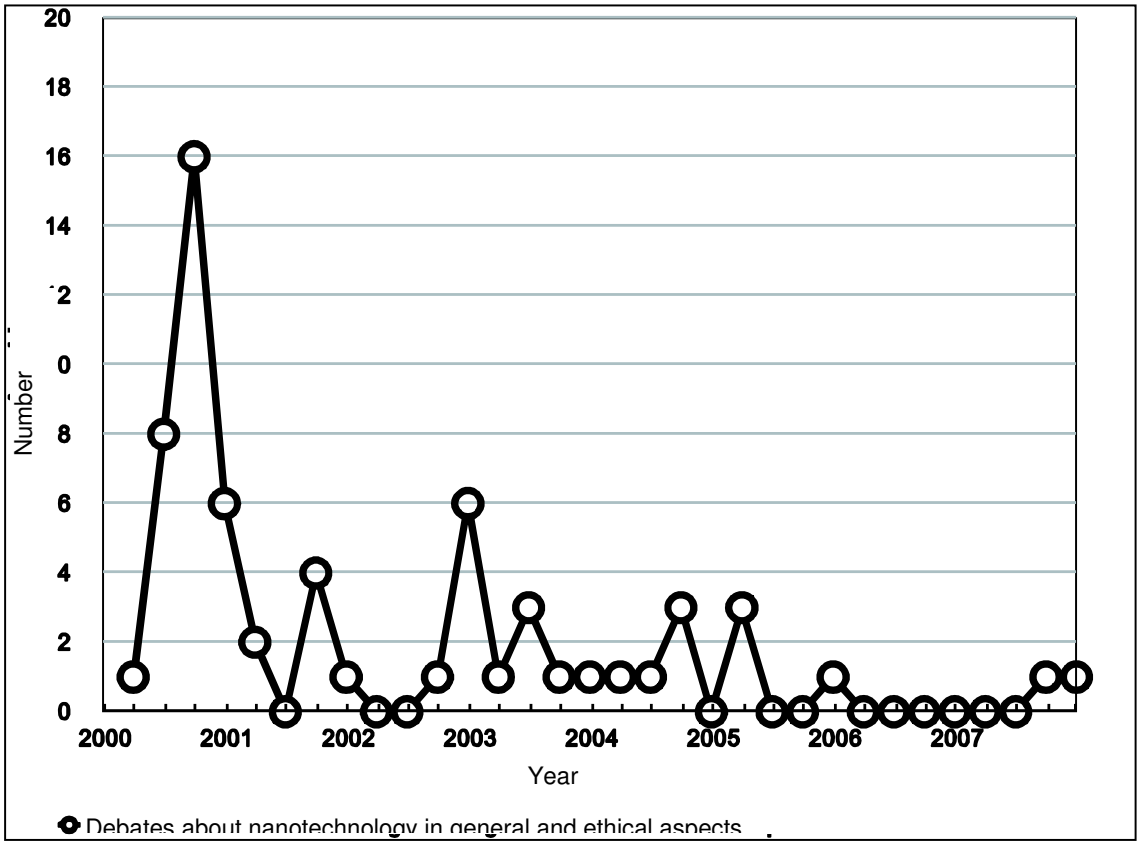
The annual comparison revealed minor differences in the content variance of the topics. The topic fundamental research was predominant in coverage over the entire study period. However, in 2006 (22.8 %) and 2007 (27.6 %) this topic clearly lost its dominant position. Parallel to this the applications healthcare (2005: 10.2 %; 2007: 11.2 %), information and communication technologies (2005: 14.4 %; 2006: 15.8 %), economy (2004: 10.1 %; 2006: 13.5 %) and more particularly not consumer-related applications (2006: 15.3 %; 2007: 17.6 %) took on importance as topics covered. Figure 9 shows the coverage course for the main topics.

Fig. 9: Main topics of coverage of nanotechnology



2000 is an exception: with 15.5 % the topic debates about nanotechnology in general and ethical aspects is in second place behind fundamental research (33.5 %) in the ranking of the topics covered most. In the following years this topic area almost disappeared completely from the media agenda. Hence it seems appropriate to undertake a detailed examination of the discussion process in the course of which coverage is briefly outlined (cf. Fig. 10).

Fig. 10: Time course of the topic "Debates about nanotechnology"



The "Bill Joy debate"

The high level of coverage summed up under debates about nanotechnology in general and ethical aspects was triggered in 2000 by the publication of an essay by the US computer scientist Bill Joy - "Why the future doesn't need us" in the Feuilleton of the *Frankfurter Allgemeine Zeitung* dated 6 June (No. 130, p. 49). This is an abbreviated version of the article "Why the future doesn't need us" already published in March in the high tech journal "Wired". In it, Joy points out the serious consequences of important key technologies of the 21st century – genetic engineering, nanotechnology, robotics. In particular he focuses on the risks. In this context he makes comparisons with 20th century weapons of mass destruction in order to highlight the threat to mankind. What Joy finds particularly worrying in this context is the risk of misuse of technologies by terrorists. Furthermore, the author sees a threat if the artefacts created by man were to develop a will of their own. Key terms and images in his argumentation – particularly with reference to nanotechnology – involve a comparison with DDT-resistant malaria mosquitoes, Goethe's sorcerer's apprentice, Pandora's box, nanorobots and so-called assemblers. Given the uncertainty and limited knowledge about ongoing technical developments and their far-reaching potential, Joy calls for a research moratorium i.e. renunciation of the development and use of these techniques.

Whereas an interview with Bill Joy about the risks of nanotechnology, which had already appeared on 23 March in *Die Zeit* (No. 13) entitled "democratisation of evil" did not prompt any major media reaction, the printing of the article in the *FAZ* unleashed a major debate which has since been called the Bill Joy debate. In this debate the *Frankfurter Allgemeine Zeitung* - with16 of the 31 articles published on this subject in 2000 (equivalent to 51.6%) - is the opinion leader. Furthermore, albeit on a far lesser scale, *Die Welt* (16.1%) and the *Frankfurter Rundschau* (9.7%) contributed to the debate. The fact that the social or cultural dimensions are accentuated in the debate about the benefits and above all risks of nanotechnology is confirmed by its positioning in the Feuilleton (64.5% of 31 articles).

In July and September 2000 the focus in the *Frankfurter Allgemeine Zeitung* was on discussion articles and responses to Bill Joy's theories amongst others by Ray Kurzweil (17.6., 05.07., 04.12.2000), a leading intellectual force in the field of artificial intelligence, the physicist and computer scientist Ralph C.. Merkle “Swords into nanoarms” (11.09.2000), Nathan Myhrvold “A weapon doesn't turn us into killer”,(12.09.2000) and Wolfgang Heckl “The benefits of the tiniest particles for our life” (01.11.2000). They put things in perspective and stresses the opportunities offered by this technology – sometimes as utopian expectations of healing. In addition, there are also articles which recommend a critical stance on new research developments in the field of nanotechnology, for instance John Rennie “Intelligence, Beast” (19.09.2000). *Die Welt* also took up the Bill Joy debate – albeit on a lower scale – with discussion contributions from various angles. They began with a guest article by Michael Mersch (08.06.2000) entitled “Help, the robots are coming!” in which he polemically refuted Bill Joy's theories as “unimaginative science fiction clichés” and “conventional moral platitudes”. This was followed on 05.07.2000 by the article “Bill Joy: New technologies threaten mankind” in which Joy's theories are set out and an article by Amory Lovins (08.07.2000), “The four risks to mankind”) which supports them. Jürgen Schremp's article “Bill Joy is an apocalyptist, I by contrast am a realist” (17.07.2000) adopts a more realistic attitude towards nanotechnology which is comprehensively presented in a positive manner in another article (11.09.2000).

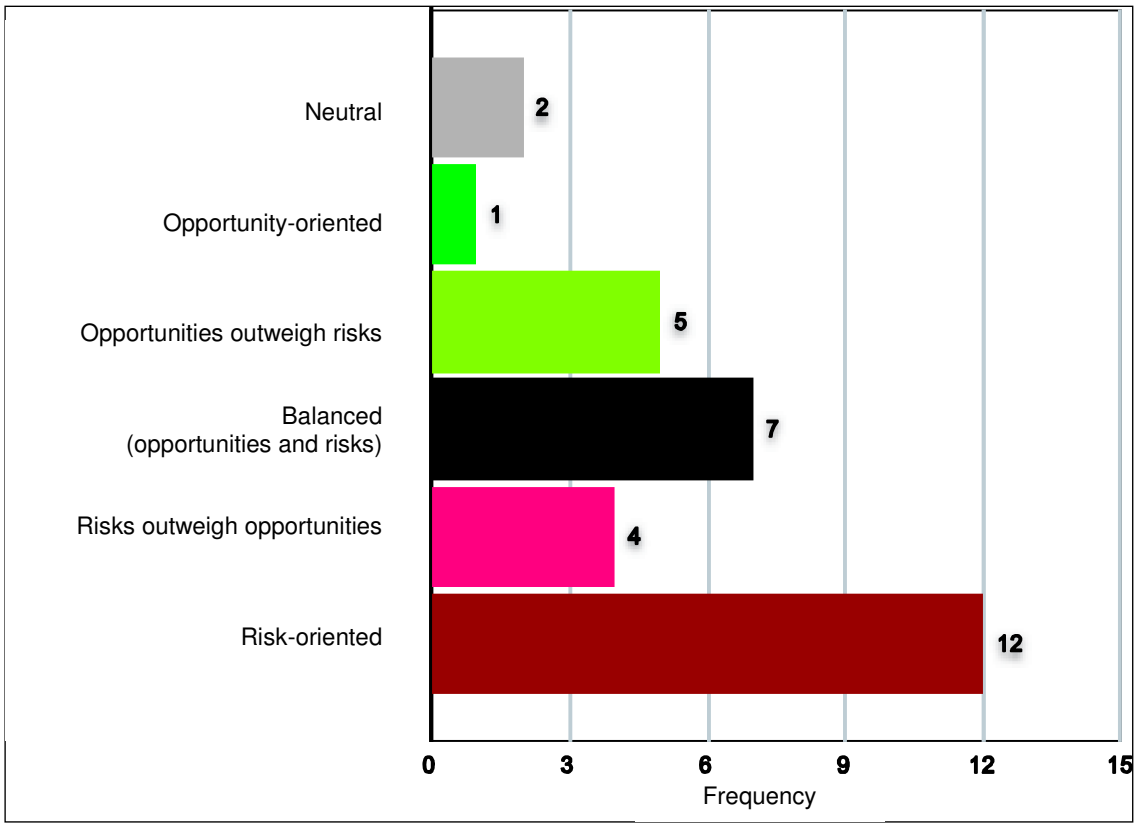
Although it is not until Chapter 4.4 that a risk–benefit assessment of nanotechnology in general and visual applications in particular is given, detailed consideration of the first phase of the Bill Joy debate, which can restricted in terms of time to between June 2000 and December 2000, should conclude here with a presentation of the risk-opportunity assessment within the social debate (see Fig. 11). Overall, it can described as risk-oriented. Twelve of the 31 articles, which were attributed to the debate, only mention the risks of nanotechnology. They are specified first and foremost as ethical-moral (15 mentions), military (13 mentions) and public/social risks (8 mentions). In addition general/non-further specified scientific and individual risks are discussed.

Coverage by the two publications (*FAZ, Die Welt*) with the highest media participation in the debate can be described as more or less balanced (cf. Table 17).

Table 17: Risk-opportunity focus in the Bill Joy debate (2000)

	Frankfurter Allgemeine Zeitung	Frankfurter Rundschau	Die Welt	Overall coverage
Neutral	-	-	20	6.5
Opportunity-oriented	-	-	20	3.2
Opportunities outweigh risks	23.5	-	20	16.1
Balanced (opportunities and risks)	29.4	66.7	-	22.6
Risks outweigh opportunities	11.8	-	-	12.9
Risk-oriented	35.3	33.3	40	38.7
Total	100 n=17	100 n=3	100 n=5	100 N=31

Fig. 11: Opportunity and risk orientation in the Bill Joy debate



Social debates and critical examinations of the ethical-moral aspects of nanotechnology could only be found in an isolated manner – on a scale of between 3 % (2001/2003) and 1.2 % (2007)[21] – in coverage of nanotechnology in the following years. Only in the months November and December of 2002 (23.11.2002–24.12.2002) is there another, albeit moderate, increase in coverage of this topic. This mainly involves the book "The Prey" by Michael Crichton, a horror scenario of tiny man-eating cells and self-assembling nanorobots (*Süddeutsche Zeitung*, 27.11.2002; *Frankfurter Allgemeine Zeitung* 29.11.2002; *Focus*, 02.12.2002; *Financial Times Deutschland* 13.12.2002). Another topic is the risk of transhumanism in the "Triumph of a naturalistic philosophy?" (*Frankfurter Rundschau*, 24.12.2002). Overall these contributions are rather risk-oriented.

Politics

Another topic which can be attributed special social relevance is politics (4.1 %, n1696). Whereas legal and business politicies (5.8% respectively (n=69) play a relatively minor role, the focus is on educational policy and research support (together 79.7 %). The relative maximum value of coverage observed in 2004 – particularly in the first half of the year (9.7 %, n=248) can be explained by research support initiatives like for instance the new "German Future Offensive Nanotechnology".

Fundamental research

As the topic fundamental research is of immense importance for coverage of nanotechnology, it is also examined below from the angle of the specific course of discussion. Overall the *Frankfurter Allgemeine Zeitung* (46.5%, n=553) closely followed by the *Süddeutsche Zeitung* (40.5%, n=168) place the greatest emphasis on this topic in their coverage. Although the

[21] This finding is also confirmed by Göpfert (2001: 76) for the scientific coverage by selected German daily newspapers: "Independently of the timing of examination, ethics in science and technology development, scientific research, public understanding of science technologies and other topics of reflection on the sciences are only present on the fringes on a scale of approximately 2%".

course of discussion is, as a whole, far more intense than for the other topics, 2001 can be described as a busy phase. In the months March (11 articles), June (18), September (14) and November (13), there were more than ten articles on research in the nanofield. In particular the *Frankfurter Allgemeine Zeitung* (61.5 %, n=91), the *Süddeutsche Zeitung* (70.6 %, n=17) and the *Frankfurter Rundschau* (50%, n=20) manifest an elevated level of media activity. The main focus is on research on nanowires and nanotubes that can be used in nanotransistors and logic gates (roughly 45 of the 102 articles). Overall, the coverage can be described as "development and progress". Typical formulations used are, for instance, scientists have developed a method which (…) or scientists have made major progress (…). Correspondingly, the coverage of fundamental research in the field of nanotechnology is again consistently opportunity-oriented in 78.4 % (n=102) or neutral in 17.6 % of the cases in 2004.

Table 18: Risk-opportunity orientation of coverage of fundamental research (2004)

	Frankfurter Allgemeine Zeitung	Süd-deutsche Zeitung	Frankfurter Rundschau	Financial Times Dtld.	Overall coverage
Neutral	16.1	33.3	20	7.1	17.6
Opportunity-oriented	82.1	66.7	70	85.7	78.4
Opportunities outweigh risks	-	-	10	7.1	2.9
Balanced (opportunities and risks)	1.8	-	-	-	1
Total	100 n=56	100 n=12	100 n=10	100 n=14	100 N=1696

The *Magic Nano case*

Coverage of the intoxication cases linked to two bathroom sprays of the company Kleinmann GmbH – "Magic Nano bathroom and WC surface sealing agent" and "Magic Nano glass and ceramic surface sealing agent", which was important for the Federal Institute for Risk Assessment, only attracted very little attention in the print media examined (11 articles) (cf. Table 19).

Table 19: Coverage of the Magic Nano case (March-June 2006)

Date	Publication	Headline
30.03.2006	Frankfurter Rundschau	"Magic-Nano" bathroom product triggers intoxications
30.03.2006	tageszeitung	Bathroom cleaning agents recalled
01.04.2006	Süddeutsche Zeitung	Dangerous bathroom cleaning
01.04.2006	tageszeitungen	Bathroom sprays: 44 intoxication cases
06.04.2006	Frankfurter Rundschau	Number of intoxication cases caused by bathroom spray increases
13.04.2006	Süddeutsche Zeitung	Fine dust in blood
15.04.2006	Frankfurter Rundschau	Coming soon
24.05.2006	Frankfurter Allgemeine Ztg.	Toxic dwarves
01.06.2006	Frankfurter Allgemeine Ztg.	No nano in this spray
02.06.2006	Süddeutsche Zeitung	Normal cleaning agent
02.06.2006	tageszeitung	Consumers misled

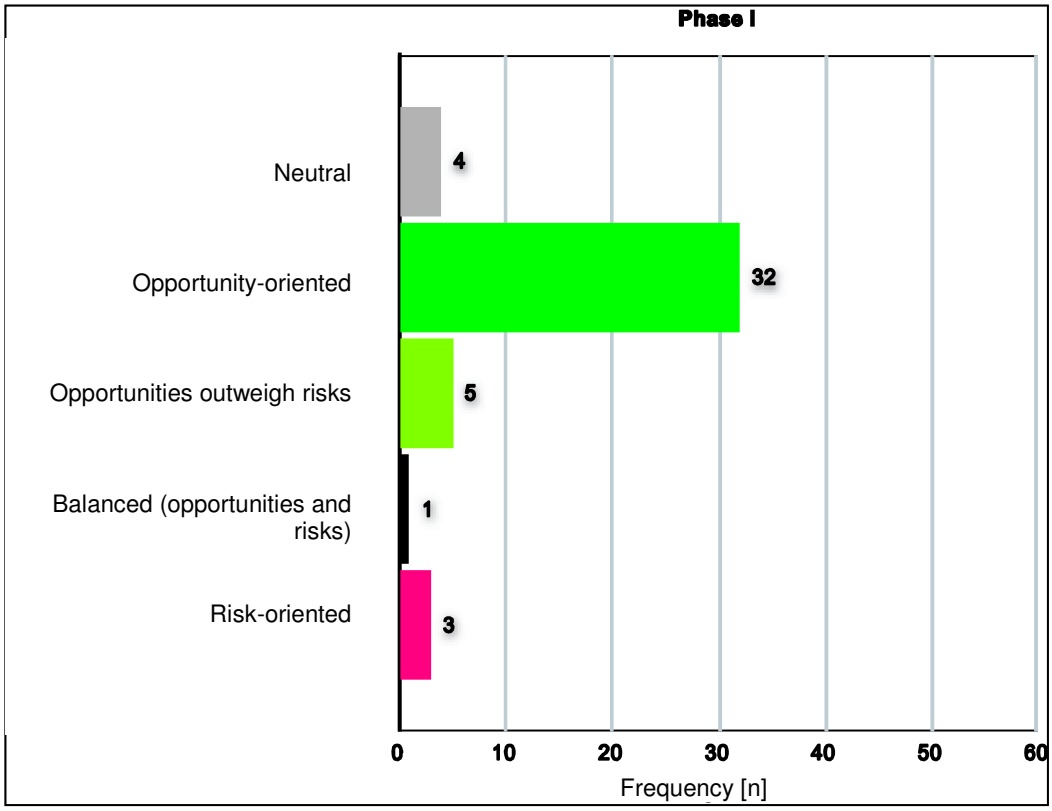
In order to assess whether the Magic Nano case had an impact on coverage of nanotechnology, the scale of coverage was considered first. An increase in coverage intensity (frequency) was indeed observed but given the topics and the description of article contents, this could not be attributed to the Magic Nano case. In a second step the content of coverage on the basis of the topics discussed and a general assessment of the subject nanotechnology were examined. To this end, three comparable time phases were defined: 1) 3 months (01.01.2006–29.03.2006) prior to the first media reports of intoxication cases caused by Magic Nano on 30.06.2006, 2) the phase of coverage of the Magic Nano case (30.03.2006–30.6.2006) and finally 3) the phase after the Magic Nano case (01.07.2006 – 30.10.2006). No major shifts in the topics was observed during the coverage phases. Table 19 shows the

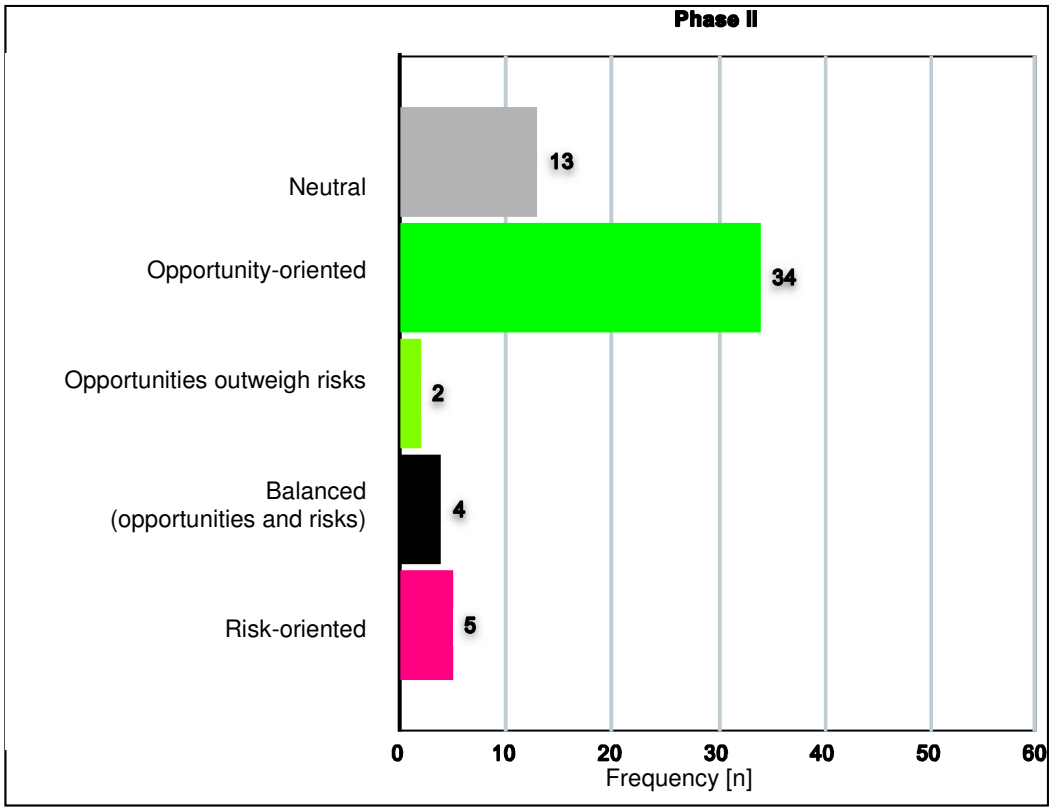
topic structure within the three phases. Fig. 12 gives a comparative assessment of nanotechnology in the different time phases.

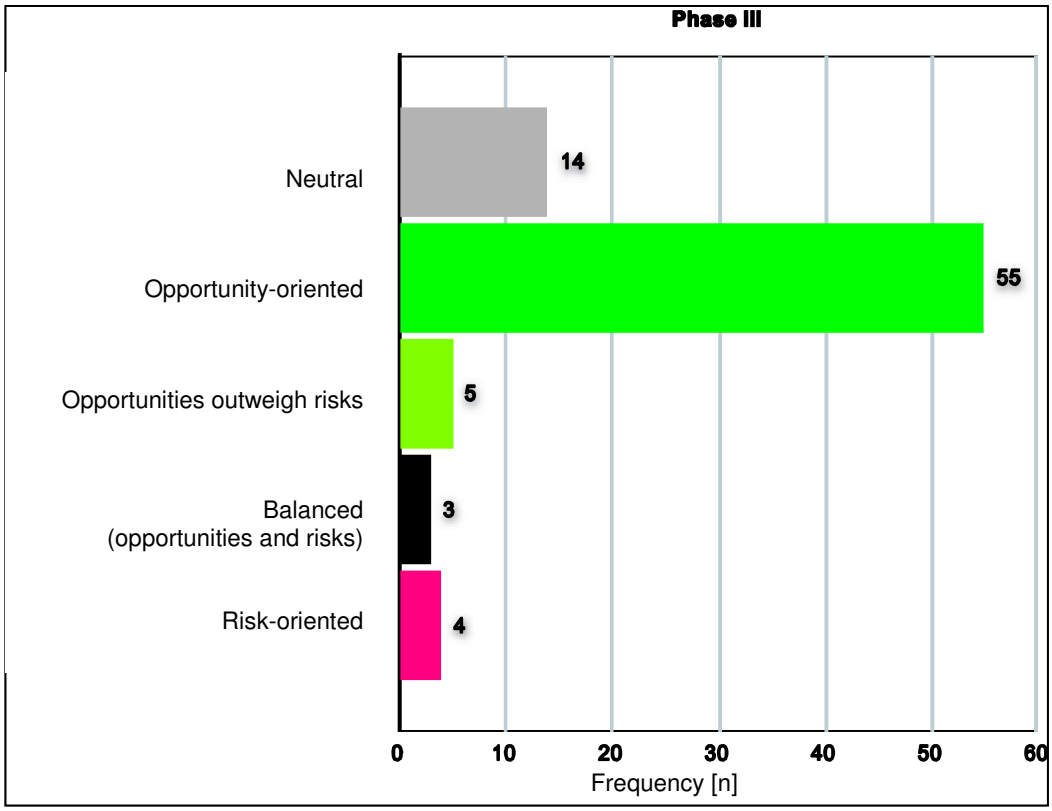
Table 20: A comparison of the topic structure during the three coverage phases of the Magic Nano case

	Phase I (01.01.2006-29.03.2006)	Phase II (30.03.2006-30.06.2006)	Phase III (01.07.2006-30.10.2006)	Σ
Fundamental research or nanotechnology in general	20	15.5	23.5	20.1
Application: Health care	8.9	8.6	1.2	5.4
Consumer-related applications	2.2	5.2	4.9	4.3
Application: Information and communication technologies	20	13.8	17.3	16.8
Not consumer-related applications	13.3	17.2	13.6	14.7
Nanobiotechnology	8.9	6.9	4.9	6.5
Politics	2.2	1.7	6.2	3.8
Economy	15.6	17.2	14.8	15.8
Other	4.4	8.6	1.2	4.3
Overview of nanotechnology	4.4	5.2	12.3	8.2
Total	100 n=45	100 N=58	100 n=81	100 N=184

Fig. 12: Evaluation of nanotechnology in the three coverage phases of the Magic Nano case




Phase II
Neutral
Opportunity-oriented
Opportunities outweigh risks
Balanced
(opportunities and risks)
Risk-oriented
13
34
2
4
5
0
10
20
30
40
50
60
Frequency [n]


Phase III
Neutral
Opportunity-oriented
Opportunities outweigh risks
Balanced
(opportunities and risks)
Risk-oriented
14
55
5
3
4
0
10
20
30
40
50
60
Frequency [n]

4.2.3 Comparison of the various publications

Almost all the newspapers and magazines examined dedicate most articles to the topic fundamental research, the only exception being *Focus*. It pays the most attention to the application healthcare. However, the weighting of and, by extension, the importance attributed to other nanotechnology topics varies considerably in some cases. The newspapers *Frankfurter Allgemeine Zeitung* and *Süddeutsche Zeitung* are very similar in terms of content. Both focus their coverage heavily on news and reports from the field of fundamental research (FAZ: 46.5 %, n=553; SZ: 40.5%, n=168), followed by the application information and communication technologies (FAZ: 10.5%; SZ: 15.5%) as the second most important, and not consumer-related applications (FAZ: 8.9%; SZ: 10.7%) as the third most important topic. General overview articles about nanotechnology account for 6.1% (FAZ) and 6.5% (SZ) of coverage in these print media. The two publications only differ in the fifth place of the ranking of main topics: the *Frankfurter Allgemeine Zeitung* centres its debates about nanotechnology on general and ethical aspects (5.8%) and the *Süddeutsche Zeitung* on the economy (6.0%). Overall this ranking – with the exception of the fifth ranking – correlates with the overall distribution over all media.

There was also common ground in the focus adopted by the *Financial Times Germany* and *Die Welt*. Their coverage mostly concentrates on fundamental research (FTD; 26.3%, n=293; Welt: 27.2 %, n=379), the application information and communication technologies (FTD; 18.8%; Welt: 16.4%) and not consumer-related applications (FTD; 12.6%; Welt: 12.1%). The economy comes next in both publications with approximately 10% of coverage. The fifth most important topic in *Die Welt* is the application healthcare (8.7%) and in the case of the *Financial Times Deutschland* general articles about nanotechnology.

Coverage in the *Frankfurter Rundschau*, the *taz* and *Die Zeit* deviates from the previously outlined distribution of topics and focus of daily newspapers and from the overall distribution. Table 21 presents an overview.

Table 21: Five most important topics in the *tageszeitung, Frankfurter Rundschau* and *Die Zeit* (2000–2007)

	Tageszeitung		Frankfurter Rundschau		Die Zeit		Total	
	%	Ranking	%	Ranking	%	Ranking	%	Ranking
Fundamental research on nanotechnology in general	25.7	1	25.2	1	27.4	1	34.1	1
Application: Health care	11.4	3	7.8	5	6.5	3	7.4	5
Consumer-related applications	2.9		7		4.8		4.1	
Application: Information and communication technologies	8.6	4	18.3	2	4.8		14.2	2
Not consumer-related applications	14.3	2	9.6	4	4.8		11	3
Debates about nanotechnology in general and ethical aspects	8.6	4	6.1		3.2		3.7	
Nanobiotechnology	5.7		0.9		6.5	3	4.4	
Politics	5.7		5.2		6.5	3	4.1	
Economy	-		4.3		6.5	3	7.2	
Other	8.6	4	4.3		1.6		1.7	
Overview of nanotechnology	8.6	4	11.3	3	27.4	1	8.2	4
Total	100		100		100		100	

In its minimal coverage (35 articles in 8 years), the *taz* places the emphasis on not consumer-related applications (14.3%, ranking 2). The *Frankfurter Rundschau* concentrates, alongside the *Financial Times Deutschland,* very much on the application information and communication technologies (18.3%, n=115)[22]. Two main topics can be identified in coverage in *Die Zeit*: "fundamental research" (27.4%, n=62) and "overview of technology" (27.4%).

The two news magazines *Der Spiegel* (ranking 3, 12.8%, n=47) and *Focus* (ranking 1, 18.2%, n=44) place the greatest emphasis on the application healthcare. This can be interpreted as a greater orientation towards human interest and service topics than in the daily newspapers. Particularly for *Focus* this orientation towards 'news to use' is characteristic for its journalistic profile.

In conjunction with the topic structure of coverage of nanotechnology, it is interesting to look at which actors shape the debates or events in the individual areas, how they position themselves and how they evaluate nanotechnology. The following section presents results for these aspects before taking a detailed look in Chapter 4.4 at the assessment of the opportunity and risk aspects of nanotechnology in general and of special applications in particular. Chapter 4.5 then analyses the demands made and actions recommended in the media.

4.3 Analysis on the spokesperson level

The assessment of content depends not least on the interpretation and evaluation of the topic by the main actors. To qualify as a main actor, an individual or cooperative stakeholder has to express him/herself in direct speech or through the presentation of the gist of his/her statements. A journalist can also qualify as the main actor of a written contribution if he makes a clearly evaluative statement about nanotechnology. Besides individual and corporate actors, diffuse collectives (e.g. "the critics", "we") are also covered by this category. In contrast, actors who were only mentioned but did not say anything themselves are not deemed to be main actors. In this survey up to three main actors per article could be taken into account.

According to this operational definition 14.4% of the articles (n=1696) can be described as purely descriptive. In these articles no actor voices his/her opinion directly or indirectly. Most of the articles (47.4%) have *one* main actor, i.e. the focus of the article is on one individual actor or group which expresses its opinion on nanotechnology or its position on this topic is outlined. There are relatively few cases of two or three main actors (25% and 13.2% respectively) voicing their opinions in one article. Table 22 gives the overall distribution of spokespersons. As up to three main actors could be recorded and examined for each article, the total value deviates from the number of articles analysed.

Overall, the attitudes and statements of scientific actors (46.6%, n=2154) and economic actors (19.6%) - aside from the journalists (17.5%) - dominate coverage of nanotechnology. This is plausible against the backdrop of the evaluations of the main topics, the dominant perspective of coverage and the positioning of the articles. The media discourse is hence "dominated" by the scientists engaged in research and development activities in the field of nanotechnology and actors who market or hope to market nanotechnology applications. Scarcely any actors who are critical of the technology are found in the publications examined. In this study they are classed in the categories "social groups" and "public figures".[23]

[22] One reason may be that Hessen, the main circulation area of the *Frankfurter Rundschau*, is an excellent location for information and communication technologies. With around 90,000 employees, sales revenues of €32 billion (2006) and 10,000 companies, this sector - the strongest by far in Hessen - enjoys a leading position in Germany and Europe. Furthermore, almost one-fifth of all German nanotechnology companies have their registered office in Hessen.

[23] Table 25 in Annex A indicates which actors are included in the upper categories scientific actor, economic actor and public figures.

Table 22: Main actors in the coverage of nanotechnology (multiple responses: three mentions per article were possible)

	Answers	
	n	Percent
Political actors	31	1.4
Political institutions	85	3.9
Central bodies, institutions, associations	64	3
Scientific institutions, research groups, scientists	1003	46.6
Economic actors	422	19.6
Public figures	106	4.9
Social groups, group designations	27	1.3
Journalists	377	17.5
Foundations, science support	17	0.8
Other actors	22	1
Total	2154	100

If a person or institution from science and research is mentioned as the first main actor, then in 31.2% of cases there is a second actor (II) who, in the majority of cases, comes from the field of science. There is a parallel picture in the case of economic actors who in 12.2% of cases are joined by a further actor (II) from the economy. In most cases "public figures" (47.4%, n=57) and "social groups" (50%, n=14) occur most frequently in conjunction with a second or third actor. In the first case they are further public figures or actors from science, in the second case mainly central institutions. Table 23 shows by way of example for the mention of actors I and II, the actors who occurred together in one article. What should be noted here is that the occurrence of several actors in an article cannot be interpreted as an indication of a conflict or contradictory views: 95.8% of all spokespersons' statements on nanotechnology (n=2154) are not contradicted. It was far more the case that several actors support an argument or an attitude towards the topic.

If one looks at the entire analytical period, the discussion dynamic examined in Chapter 4.2 is reflected in the structure of actors (cf. Tables 14-16); scientific institutions, research groups and scientists dominate coverage over the entire study period (2000–2007). In 2000 – especially during the Bill Joy debate (cf. section 4.2.2) – public figures play an important role in coverage with a share of 18% and even overtake economic actors (13.9%). In 2004, in contrast, political actors and "political institutions" with 2.6% and 10.6% respectively shape the media agenda, particularly about questions of educational policy and research support. Economic actors take on greater importance with shares in 2006 of 29.5% and 2007 of 23.6%. This can be taken as a sign of the growing economic use of nanotechnology products and increasing economic activities by companies in this segment (cf. Table 24a).[24]

In the coverage in the newspapers and magazines examined, no significant differences are observed in the composition of the actors' structure. That is why no detailed description is given here. Table 24b gives an overview.

[24] The percentages presented in this section refer to the total number of main actors (n=2154).

Table 23: Joint occurrence of actors (mentions I and II) (as %)

	Not applicable	Political actors	Political institutions	Central institutions, etc.	Scientific institutions etc.	Economic actors	Public figures	Social groups etc.	Journalist	Foundations, science support	Other actors
Not applicable	100	70	61	59	68.8	65.4	52.6	50	72.5	10	91.7
Political actors	-	-	-	2.6	0.1	0.7	-	-	0.5	10	-
Political institutions	-	-	6.8	7.7	1.2	-	-	-	-	10	-
Central bodies, institutions, associations	-	-	-	5.1	0.4	2.1	-	14.3	0.9	10	-
Scientific institutions, research groups, scientists	-	20	15.3	7.7	12.5	9.8	15.8	7.1	11.8	20	8.3
Economic actors	-	-	6.8	12.8	4.6	12.2	1.8	7.1	4.7	30	-
Public figures	-	-	3.4	2.6	0.7	0.7	12.3	-	4.7	-	-
Social groups, group designations	-	5	3.4	-	0.5	0.3	1.8	7.1	-	-	-
Journalists	-	5	3.4	-	10.8	7.3	14	14.3	3.3	-	-
Foundation, science support	-	-	-	2.6	0.1	0.3	-	-	0.5	-	-
Other actors	-	-	-	-	0.3	1	1.8	-	0.9	10	-
Total	100 n=244	100 n=20	100 n=59	100 n=39	100 n=744	100 n=286	100 n=57	100 n=14	100 n=211	100 n=10	100 n=12

Table 24 a: Distribution of main actors over time (as %)

	2000	2001	2002	2003	2004	2005	2006	2007	∑
Political actors	0.7	1.9	0.4	1.8	2.6	0.4	1.9	1.4	1.4
Political institutions	1.9	2.9	1.9	2.1	10.6	4.5	3.1	3.8	3.9
Central bodies, institutions, associations	1.9	3.2	0.7	3.9	2.3	2.4	5.4	4.2	3
Scientific institutions, research groups, scientists	45.7	51	47.2	51.9	35	53.3	45	44.3	46.6
Economic actors	13.9	16.6	19.9	14.7	22.8	17.1	29.5	23.6	19.6
Public figures	18	5.2	7.1	4.2	1.9	1.6	-	0.5	4.9
Social groups, group designations,	1.1	0.6	1.1	2.1	1	1.6	0.4	2.4	1.3
Journalists	15	16.2	21	16.8	21.9	17.1	13.6	17.9	17.5
Foundations, science support	0.7	0.6	-	1.8	1.3	0.8	-	0.9	0.8
Other actors	1.1	1.6	0.7	0.7	0.6	1.2	1.2	0.9	1
Total	100 n=267	100 n=308	100 n=267	100 n=285	100 n=311	100 n=246	100 n=258	100 n=212	100 N=2154

Table 24 b: Distribution of main actors within coverage in the publications examined (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
Political actors	2.3	1.4	-	0.6	1.3	0.8	2.1	1.6	-	1.4
Political institutions	3.1	5.5	11.5	6.1	4.6	2.9	3.1	-	1.6	3.9
Central bodies, institutions, associa-tions	1.8	4.1	3.8	3.9	3.1	4	4.1	-	1.6	3
Scientific institutions, research groups, scientists	50.4	47.3	44.2	36.7	42.7	49.9	46.4	52.4	37.1	46.6
Economic actors	15	23.2	7.7	18.3	25.8	20.6	16.5	12.7	29	19.6
Public figures	6.6	3.6	7.7	5	3.1	1.9	9.3	12.7	6.5	4.9
Social groups, group designations,	1.2	0.5	5.8	1.7	1.3	0.8	2.1	-	1.6	1.3
Journalists	18.2	12.3	17.3	22.8	16.7	17.4	15.5	17.5	22.6	17.5
Foundations, science support	0.5	0.5	-	1.7	1.1	0.8	1	1.6	-	0.8
Other actors	0.9	1.8	1.9	3.3	0.2	0.8	-	1.6	-	1
Total	100 n=653	100 n=220	100 n=52	100 n=180	100 n=454	100 n=373	100 n=97	100 n=63	100 n=62	100 N=2154

After first clarifying which actors shape coverage of nanotechnology overall and over the course of time, the question was raised in the second step about which topics they comment on and how they assess nanotechnology in general. The following comments refer first and foremost – unless stated otherwise – to the first actor mentioned (n=1452). Coverage of topics from science and research – in particular nanotechnology developments which are not yet used in industrial production – is dominated by scientific institutions, research groups and individual scientists. They mainly serve as the experts of choice for topics from the field of fundamental research (80 % of the spokespersons' contributions on the topic, n=579), nanobiotechnology (75.4 %, n=75) and the application healthcare (73.8 %, n=126). In the case of topics that permit economic applications at the present time and are, therefore, closely linked to companies' activities, the actors from science and the economy share the field: actors' statements on not consumer-related applications can be attributed in 52.2 % of the cases to scientific (n=186) and in 26.4 % of cases to economic actors. Economic actors have the highest spokesperson share particularly for topics from consumer-related applications (48.1 %) (compared to 30.8 % for economic actors, n=69) and from the application information and communication technologies (44 %, n=241).

Aside from topics from science and research or the economic use and application of nanotechnology, other actors shape the media agenda: on politics – in particular research policy – representatives of political institutions commented in 55.2 % of cases (n=69). The social debate about nanotechnology in general and ethical-moral aspects of nanotechnology is, by contrast, shaped in 58.6 % (n=62) of cases by "public figures". In general in articles on nanotechnology (n=139), journalists are the dominant actors with a share of 39.3 %. The choice of topic is, therefore decisive for the question about which actors commented. Overall there is a highly significant association which can be described as moderate (Cramer's V[25] = .363, $p < .001$) between the topic and the main actor in the article. This remains unchanged when examining each of the years (Table 26 provides an overview of which actors commented on which topics).

Almost all the actors who shape coverage of nanotechnology rate it as rather positive or very positive (total 70.4 %, n=1452) (Cramer's V = .240, $p < .001$). Nanotechnology is rated as very positive particularly by political actors (40 %, n=20) and institutions (52.5 %, n=59), journalists (45 %, n=211) and science support foundations (50 %, n=10) in the examined comments and paraphrases (see Table 27).

Scientific actors evaluate nanotechnology in a slightly less differentiated manner. Nonetheless, in 71.5 % (n=744) of the cases they give it a very/rather positive rating. In 25.5 % of cases scientists do not make any assessment of nanotechnology at all and only 1 % of their ratings are rather/very negative. Almost the same picture is observed in the assessment by economic actors. Only "public figures" have a critical attitude towards nanotechnology. 22.8 % of them rate it as rather and 17.5 % as very negative (n=57). This negative attitude is set against a considerable proportion of spokesperson's comments in which nanotechnology is seen as rather (14 %) and very positive (17.5 %). This means that overall there is a balanced assessment of technology even in this group of actors.

[25] Cramer's V is a measure of the strength of the association between two or more nominally scaled variables when (at least) one of the two variables has more than two variants. The range is between 0 und 1; an association of 0.6 is deemed to be strong.

Table 26: Which actors expressed an opinion on which topics? (as %)

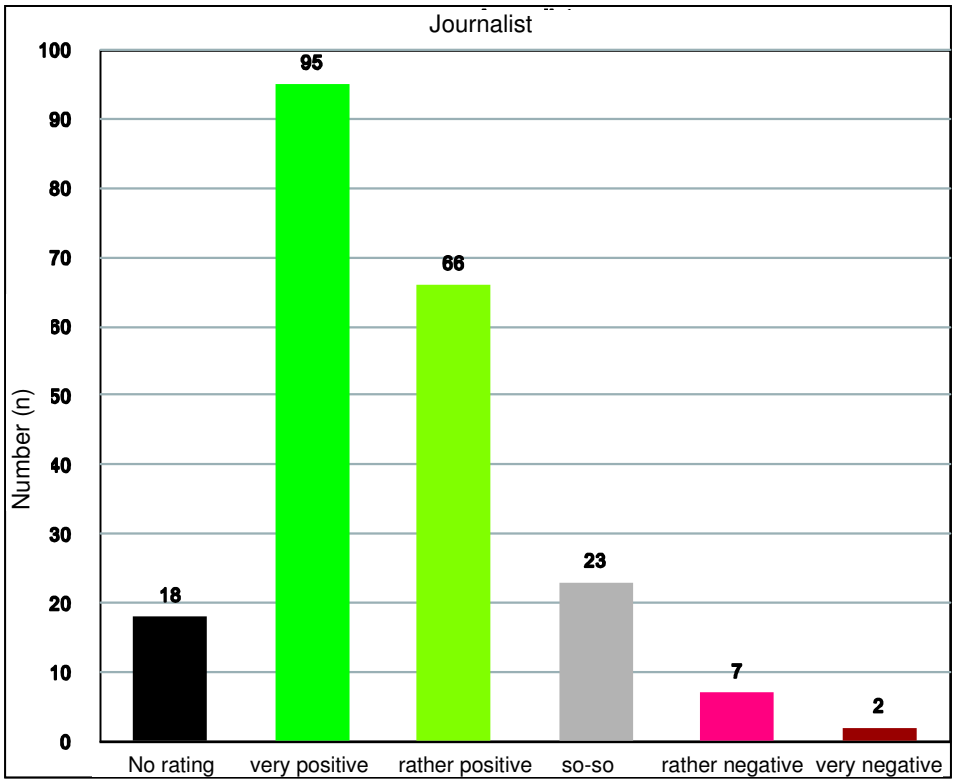
	Basic research	Application: Healthcare	Consumer-related applications	Application: information and communication technology	Not consumer-related applications	Debates about nanotechnology in general and ethical aspects	Nanobiotechnology	Politics	Economy	Other	Overview of nanotechnology	∑
Political actors	0.5	-	-	-	-	3.4	-	11.9	2.7	-	4.5	1.4
Political institutions	1.4	-	1.9	0.9	0.6	1.7	-	55.2	4.4	4.5	4.5	4.1
Central bodies, institutions, associations	0.7	0.8	-	3.2	1.1	1.7	-	7.5	8.8	18.2	4.5	2.6
Scientific institutions, research groups, scientists	80.8	73.8	30.8	39	52.2	13.8	75.4	13.4	2.7	18.2	25	51.2
Economic actors	4.1	5.7	48.1	44	26.4	-	6.2	6	62.8	9.1	10.7	19.7
Public figures	0.5	0.8	-	0.9	2.2	58.6	4.6	-	-	9.1	8	3.9
Social groups, group designations,	0.7	-	-	0.5	1.1	3.4	-	-	1.8	13.6	0.9	1
Journalists	11.1	18	19.2	11	13.5	13.8	12.3	1.5	13.3	27.3	39.3	14.6
Foundations, science support	0.2	0.8	-	-	1.7	-	-	3	2.7	-	-	0.7
Other actors	0.2	-	-	0.5	1.1	3.4	1.5	1.5	0.9	-	2.7	0.8
Total	100 n=443	100 n=122	100 n=52	100 n=218	100 n=178	100 n=58	100 n=65	100 n=67	100 n=113	100 n=22	100 n=112	100 N=1452

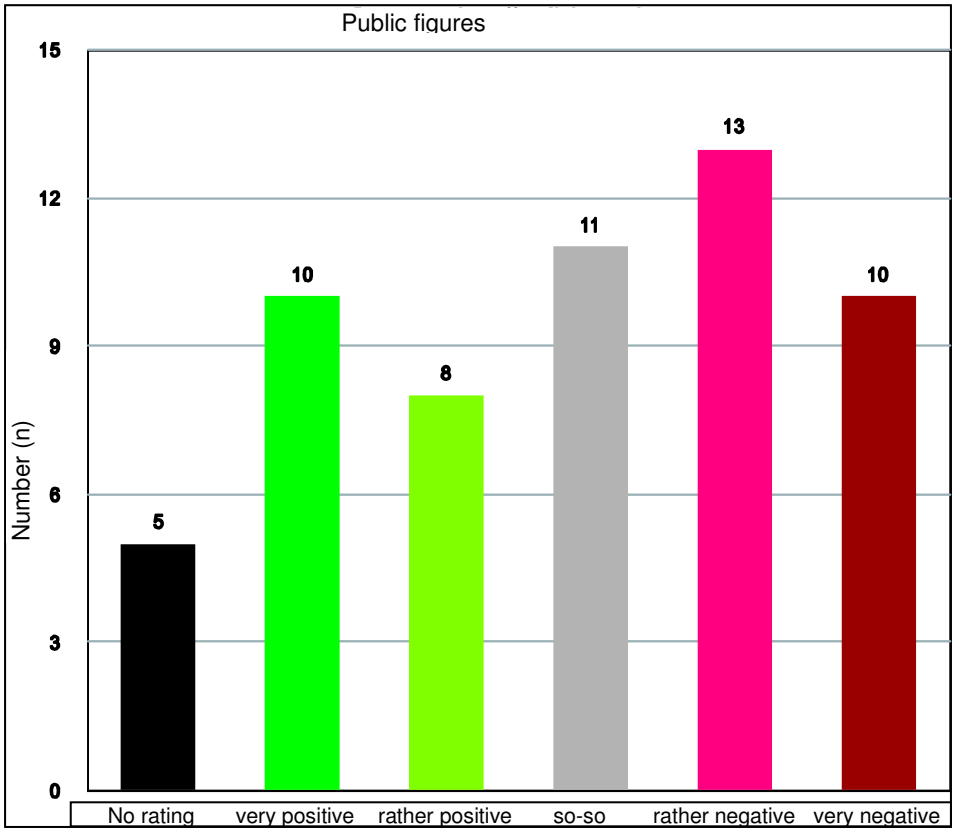
Table 27: How did actors rate nanotechnology? (as %)

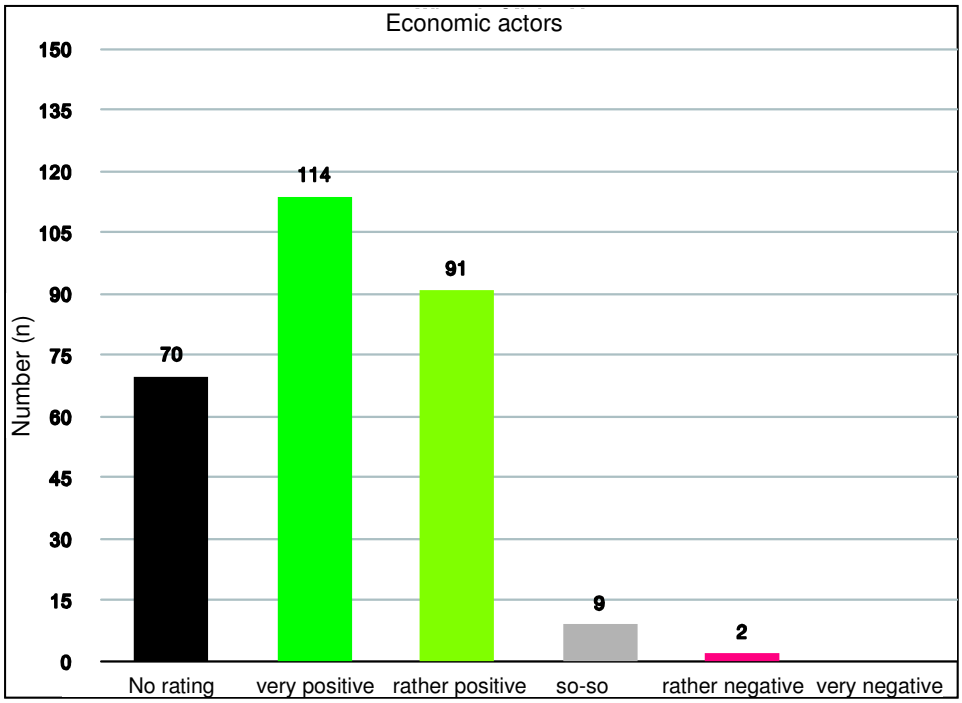
	Political actors	Political institutions	Central bodies, institutions, associa-tions	Scientific institutions, research groups, scientists	Economic actors	Public figures	Social groups, group designa-tions	Journalists	Founda-tions, sci-ence sup-port	Other actors	∑
No rating	10	10.2	7.7	25.5	24.5	8.8	21.4	8.5	40	16.7	20.9
Very positive	40	52.5	38.5	39.8	39.9	17.5	21.4	45	50	41.7	40.1
Rather positive	40	23.7	25.6	31.7	31.8	14	28.6	31.3	10	16.7	30.3
So/so	-	6.8	10.3	2	3.1	19.3	21.4	10.9	-	8.3	4.8
Rather negative	10	6.8	15.4	0.7	0.7	22.8	7.1	3.3	-	16.7	2.9
Very negative	-	-	2.6	0.3	-	17.5	-	0.9	-	-	1
Total	100 n=20	100 n=59	100 n=39	100 n=744	100 n=286	100 n=57	100 n=14	100 n=211	100 n=10	100 n=12	100 N=1452

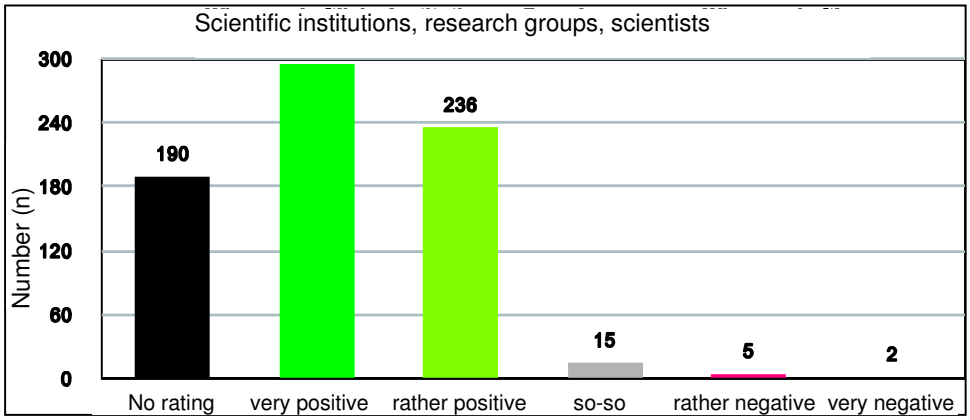
Fig. 13 shows the rating by the dominant actors in the coverage of nanotechnology.

Fig. 13: Rating of nanotechnology by dominant actors









If one also looks at the ratings over the course of time (cf. Table 28) it is clear that they shifted again in 2006 and 2007 in favour of nanotechnology. 42.7 % (n=199) and 45.5 % (n=154) of the ratings are very positive (compared to 2000): 35.3 %, n=170) and 1 % and 0 % are very negative (compared to 2000: 3.5 %). Hence, they are higher than the average ratings over the entire study period.

In the comparison of the various publications, *taz* and *Die Zeit* are the two publications which still allow critical voices to be heard the most frequently. But there is no trend towards negative coverage in these publications either, rather the contrary is the case (for a detailed overview, see Table 29).

Finally, this raises the question whether the general rating of nanotechnology is linked to the reference topic of the respective actor (cf. Table 30). Actors who voice their opinions on the debate about general and ethical aspects of nanotechnology, rate nanotechnology as rather or very negative in 21.4 % and 17.2 % of the cases, respectively (n=58). The only other area in which a cluster of negative assessments of this kind can still be identified is “other” topics (n=22) with 18.2 % and 13.6 %. This encompasses in particular articles on the “Magic Nano” case (intoxication cases and product recalls) (n=7) and articles on the topics health and safety at work (n=1) and consumer protection (n=3).

Based on these figures the image of nanotechnology in the print media examined during the period 2000-2007 is largely and unreservedly positive (in only 3.9 % of cases is a rather/very negative judgement handed down). In more than 95 % of the cases the estimation of the main actor is not contradicted. Hence, there are no signs of a controversial discussion or even a negative view of the topic in the news media.

In 35.9 % of the cases (article with actor, n=1452) the estimation of the main actor is presented as the conclusion to that article. It could very well be that this final judgement is what readers will remember. Hence, it is worth noting that in 80.6 % of the cases this assessment is very/rather positive (Cramer's V =.205, p< .001).

Besides the general rating of the topic by various actors, it is also interesting to know more about what this is based on. What opportunities and risks are associated with nanotechnology in general and with individual applications by the various actors? Which actors are deemed responsible for these opportunities and risks and how likely is their occurrence deemed to be? The following chapter answers these questions first in conjunction with the discussion of opportunities (Chapter 4.1.1) and then for the risk discussion (Chapter 4.4.2). Chapter 4.4.3 draws these considerations together.

Table 28: Rating of nanotechnology (actor I) over the course of time (as %)

	2000	2001	2002	2003	2004	2005	2006	2007	∑
No rating	23.5	19.4	21.8	24.7	25.1	16.8	11.6	25.3	20.9
Very positive	35.3	39.8	36.3	34.6	45.2	41	42.7	45.5	40.1
Rather positive	27.6	32.7	34.1	31.9	21.6	35.8	34.2	24	30.3
So-so	6.5	5.1	5.6	4.4	3	3.5	7	3.2	4.8
Rather negative	3.5	3.1	1.1	2.2	4.5	2.9	3.5	1.9	2.9
Very negative	3.5	-	1.1	2.2	0.5	0	1	-	1
Total	100 n=170	100 n=196	100 n=179	100 n=182	100 n=199	100 n=173	100 n=199	100 n=154	100 N=1452

Table 29: Rating of nanotechnology (actor I) by news media (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
No assessment	23	20.3	19.4	20.4	22.8	14.6	16.7	28.9	22	20.9
Very positive	32.7	48.6	29	38.9	44.4	45.7	31.5	39.5	48.8	40.1
Rather positive	37	20.9	25.8	25	27.8	31.2	35.2	21.1	22	30.3
So-so	3.9	6.1	12.9	8.3	2.5	5.3	9.3	7.9	2.4	4.8
Rather negative	2.4	3.4	12.9	3.7	2.2	2.4	5.6	-	4.9	2.9
Very negative	1.1	0.7	-	3.7	0.3	0.8	1.9	2.6	-	1
Total	100 n=465	100 n=148	100 n=31	100 n=108	100 n=320	100 n=247	100 n=54	100 n=38	100 n=41	100 N=1452

Table 30: Rating of nanotechnology by main topic in the article (as %)

	Funda-mental research	Application: Healthcare	Consumer-related applications	Application: information and com-munication technolo-gies	Not con-sumer-related applica-tions	Debates about nanotech-nology in general and ethical aspects	Nanobio-technology	Politics	Economy	Other	Overview of nanotech-nology	∑
No rating	27.1	17.2	30.8	22	20.2	6.9	20	16.4	16.8	27.3	6.3	20.8
Very positive	36.8	50	48.1	33.5	44.9	3.4	49.2	56.7	48.7	31.8	41.1	40.1
Rather positive	28.9	32	21.2	43.6	29.8	20.7	23.1	19.4	27.4	4.5	37.5	30.3
So-so	4.7	0.8	-	0.5	3.9	27.6	4.6	3	5.3	4.5	10.7	4.8
Rather negative	2.3	-	-	0.5	1.1	24.1	3.1	4.5	1.8	18.2	3.6	2.9
Very negative	0.2	-	-	-	-	17.2	-	-	-	13.6	0.9	1
Total	100 n=434	100 n=122	100 n=52	100 n=218	100 n=178	100 n=58	100 n=65	100 n=67	100 n=113	100 n=22	100 n=112	100 N=1450

4.4 Opportunities and risks of nanotechnology as depicted in the media

4.4.1 Assessment of the opportunities of nanotechnology

In line with the generally positive rating of nanotechnology by the various main actors, 84.7 % of all cases of coverage focus on the opportunities of nanotechnology (n=1696) – 27.5 % even mention several different benefits. Only 259 articles do not mention any benefit (15.3 %) (cf. Table 31).

Table 31: Number of benefits mentioned per article

	Frequency	Percent
No mention of benefit	259	15.3
Mention of one benefit	970	57.2
Mention of two benefits	295	17.4
Mention of three benefits	172	10.1
Total	1696	100

In 2000 and 2006 the proportion of articles that did not mention any benefits, 19.5 % (n=200) and 21.4 % (n=215) was far higher than the mean (cf. Table 32). Nevertheless, coverage in 2000 can be described as very benefit-oriented as three benefits were mentioned in 14.5 % and two benefits were mentioned in 18 % of the articles. In 200 articles a total of 255 benefits are identified (m=1.27). The fewest opportunities (226 in 215 articles) – but still roughly one per article (m=1.05) – are mentioned in 2007 in coverage of nanotechnology.

Table 32: Number of benefits mentioned per article over time (as %)

	2000	2001	2002	2003	2004	2005	2006	2007	∑
None	19.5	11.2	14.9	14.1	14.9	13	21.4	13.5	15.3
1	48	62.7	59.5	54.3	56.5	61.1	57.2	57.1	57.2
2	18	14.6	14	19.6	19.4	17.6	16.3	20.6	17.4
3	14.5	11.6	11.6	12.1	9.3	8.3	5.1	8.8	10.1
Total	100 n=200	100 n=233	100 n=215	100 n=199	100 n=248	100 n=216	100 n=215	100 n=170	100 N=1696
Number of benefits mentioned	255	295	263	258	305	262	226	212	2076
Average (m)	1.27	1.26	1.22	1.29	1.22	1.21	1.05	1.24	1.22

Minor differences can be identified between the publications (see Table 33). With on average 1.48 benefits mentioned per article *Die Zeit* is far higher than the average (m=1.22) and, therefore, presents nanotechnology in an extremely positive manner. The *Süddeutsche Zeitung* is the publication with the fewest mentions of benefits, on average 1.08.

Table 33: Number of benefits mentioned per article in the publications examined (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
None	19.2	19.6	22.9	12.2	12.4	9.9	16.1	17	9.1	15.3
1	55.2	58.9	51.4	52.2	63.6	57.7	41.9	53.2	61.4	57.2
2	16.5	14.3	11.4	22.6	16.4	21.8	19.4	17	9.1	17.4
3	9.2	7.1	14.3	13	7.7	10.6	22.6	12.8	20.5	10.1
Total	100 n=553	100 n=168	100 n=35	100 n=115	100 n=379	100 n=293	100 n=62	100 n=47	100 n=44	100 N=1696
Number of benefits mentioned	640	183	41	157	452	390	92	59	62	2076
Average (m)	1.15	1.08	1.17	1.36	1.19	1.33	1.48	1.25	1.4	1.22

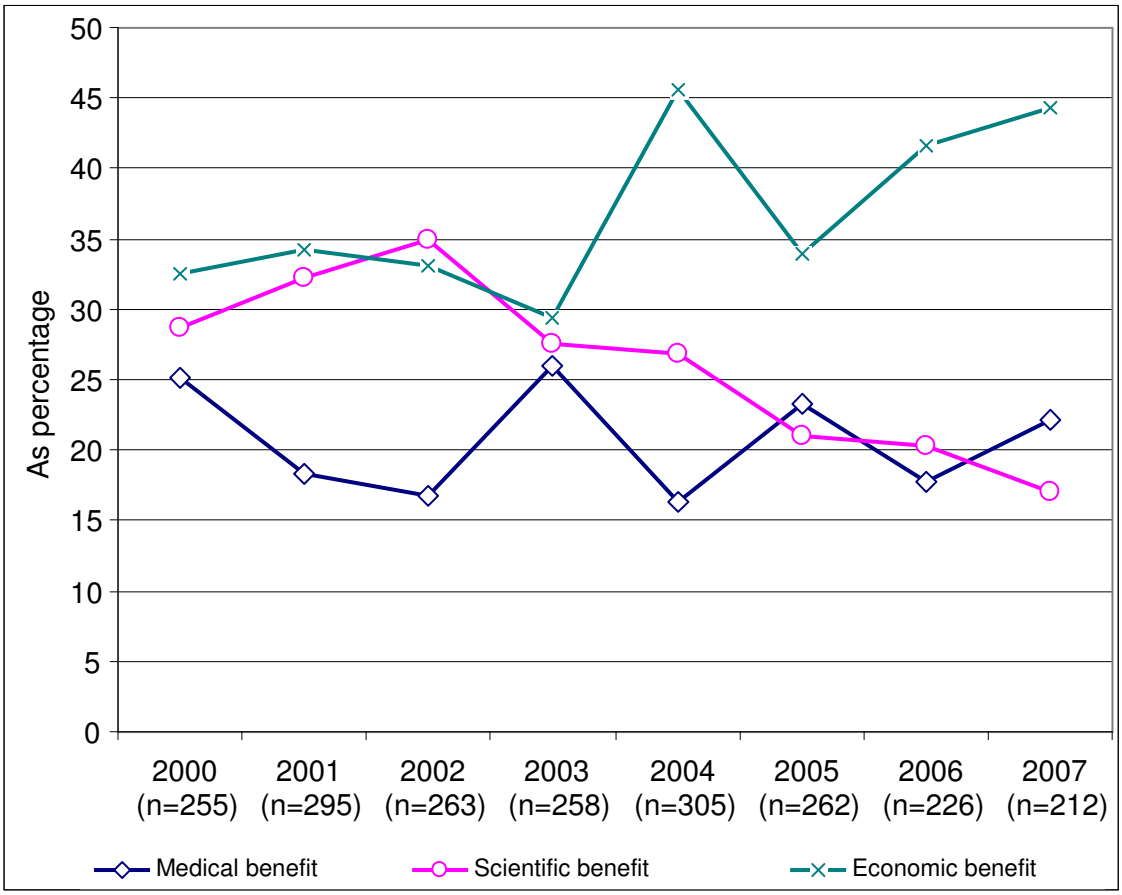
As up to three benefits could be mentioned per article, a total of 2076 mentions were identified. The main opportunities of nanotechnology are seen in the economy (36.8%, n=2076),

science (26.5%) and medicine (20.6%) (see Table 34). All positive comments about progress in knowledge through nanoresearch were recorded as “scientific benefit” which refers to a self-benefit from scientific research that is not described in any more detail.

Table 34: Distribution of benefits I-III

	Frequency	Percent
Diffuse benefit	37	1.8
Medical benefit	427	20.6
Scientific benefit	550	26.5
Economic benefit	763	36.8
Legal benefit	4	0.2
Individual benefit	61	2.9
Military benefit	55	2.6
Public/social benefit	99	4.8
Ecological benefit	66	3.2
Other benefits	14	0.7
Total	2076	100,0

Fig. 14: The relative weight of the three most important types of benefit over time



These three central potential benefits of nanotechnology are also predominant in the consideration over time (cf. Fig. 14). Between 2000 and 2002 coverage of nanotechnology is dominated by the depiction and naming of scientific opportunities and it peaks in 2002 with 35 % (n=263). After that opportunities became less and less important in the scientific area – in 2007 only 17 % (n=212) – whereas assessments highlighting the benefits of nanotechnology in the economic and medical areas grow in importance. 2004 can, therefore, be described as the year of the mentions of the economic opportunities and benefits (45.6 %, n=305). The

medical benefit is particularly to the fore in 2003 with a share of 26 % (n=258) and in 2005 with 23.3 % (n=262).

A comparison of the main focus in the publications reveals (cf. Table 35) that only the *Frankfurter Allgemeine Zeitung* places the greatest emphasis on the scientific benefit (35.5 %, n=640) whereas the *Süddeutsche Zeitung* (37.7 %, n=183), the *Frankfurter Rundschau* (36.3 %, n=157) and *Die Welt* (38.1 %, n=452) stress in the majority of cases the economic potential of nanotechnology. In its presentation of benefits (41.3 %, n=390), *The Financial Times Deutschland* concentrates very much on the economic aspect which corresponds to its overall journalistic orientation (cf. Chapter 2.3). The *taz* (31.7 %, n=41), *Der Spiegel* (32.2 %, n=59) and *Focus* (32.3 %, n=62) place the medical benefit aspect centre stage of their coverage. This can be explained particularly in the case of *Der Spiegel* and *Focus* by their concentration on human interest and service topics.

Table 35: Presentation of benefits by publication (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
Diffuse benefit	2.3	3.8	2.4	1.3	0.7	1	5.4			1.8
Medical benefit	17.2	16.4	31.7	17.8	21	22.3	27.2	32.2	32.3	20.6
Scientific benefit	35.5	24	17.1	27.4	24.8	19.7	13	30.5	16.1	26.5
Economic benefit	34.8	37.7	29.3	36.3	38.1	41.3	41.3	22	29	36.8
Legal benefit	0.2	-	2.4	-	0.4	-	-	-	-	0.2
Individual benefit	2.2	2.7	2.4	3.2	3.5	3.6	2.2	1.7	4.8	2.9
Military benefit	1.7	2.7	12.2	2.5	2.9	2.1	3.3	6.8	3.2	2.6
Public/social benefit	3.6	5.5	2,4	8.3	4.2	4.9	3.3	5.1	12.9	4.8
Ecological benefit	2	5.5	-	3.2	4	4.1	3.3	-	1.6	3.2
Other benefits	0.5	1.6	-	-	0.4	1	1.1	1.7	-	0.7
Total	100 n=640	100 n=183	100 n=41	100 n=157	100 n=452	100 n=390	100 n=92	100 n=59	100 n=62	100 N=2076

Besides the general benefit dimension, concrete mentions of benefits were also recorded.[26] In the case of economic benefits (n=763) they are primarily:

- new materials (38.1 %)
- important sales revenue potential (17.5 %)
- miniaturisation (16.2 %)
- new jobs (3.8 %)

Articles which discuss a benefit in the scientific area (n=550) do not offer any further details of that benefit in 29.8 % of the cases. This can be interpreted as a sign that the scientific development/scientific progress presented in the article is even described as beneficial for society when presented in a general context. In addition “new materials” (33.6 %) constitute an important benefit for science. Other concrete opportunities of nanotechnology, which could be considered as both scientific and economic benefits, are identified in miniaturisation in the computer field (184 net mentions, corresponds to 11.5 %, n=1601), “improving performance in the computer field” (135 mentions, corresponds to 8.4 %) and the development of “high performance data storage media” (42 mentions, corresponds to 2.6 %).

For the medical area (n=427) four special aspects of benefits are dominant:

- Medical treatment (37.4 %)
- Cancer treatment (21.3 %)
- Medical diagnostics (17.3 %)
- New medicinal products (7.4 %)

[26] An overview of concrete mentions of benefits is given in Table 38 in Annex A.

As far as the likelihood of a benefit is concerned, 20.2 % of the cases (n=2076) discuss an existing benefit (cf. Table 36). This share increases particularly in the second half of the study period. Hence in 2006 current opportunities are presented in 32.3 % (n=226) and in 2007 in 24.5 % (n=212) of the cases. Opportunities, whose occurrence is deemed to be very likely and rather likely, are mentioned in a further 39.1 % and 28.8 % of the articles whereby above all the proportion of opportunities rated as "very likely" is very high in the second half of the study period (2000: 48.2 %, n=255; 2001: 44.4. %, n=295) (cf. Table 36). Only 1.3 % of the benefits mentioned are described as relatively unlikely. A similar distribution of the assessment of likelihood is observed in all the publications examined aside from the *taz* which describes "rather likely" opportunities in 46.3 % (n=41) of cases. At least 50 % of the cases report a very likely or already existing benefit (cf. Table 37).

Finally, this raises the question about the depicted causes for potential or already existing benefits. In this context a rough distinction can be made between "internal" attributions to concrete individuals and "external" attributions to circumstances, situations or objects. The evaluation clearly shows that the public media depiction of a benefit of nanotechnology is dominated by external attributions. In the majority of cases the benefit is not attributed to personal actors but rather "the nanotechnology" (48.2 %, n=1877) itself seems to be responsible for its benefits. Only then do we see scientific (36.5 %) and economic actors (13.6 %) being mentioned as the people responsible for the opportunities mentioned. In particular in 2000 (60.8 %, n=227) and in 2007 (58.7 %, n=201) "the nanotechnology" itself is named as the responsible agent. By contrast, scientific actors play a particularly important role as the people behind the benefits of nanotechnology (42.5 %, n=263) in 2003 (43 %, n=235) and in 2005 (43.8 %, n=210) (cf. Table 41).

In all the publications "The nanotechnology" comes first in the attribution of responsibility for potential and concrete benefits (cf. Table 40). The highest importance is attributed to it in the *taz* (72.2 %, n=36), *Die Zeit* (62 %, n=71) and *Focus* (56.9 %, n=58). The *Frankfurter Allgemeine Zeitung* (41.5 %, n=583) and *Der Spiegel* (50 %, n=50) also attribute major importance to actors and scientific institutions. With a share of around 17 %, economic actors play a role in the *Süddeutsche Zeitung*, the *Frankfurter Rundschau*, *Die Welt* and the *Financial Times Deutschland.*

The attributions of responsibility are undertaken by the journalists themselves in 34.6 % of cases (n=1877). In 47.3 % of their attributions of responsibility they name scientific actors (n=838). In 17.7 % actors attribute responsibility to themselves. Firstly, they pay tribute to a colleague and secondly they stress their own achievements (39.3 %, n=333). In particular they present "the nanotechnology" as the source of the benefit (55.8 %). Economic actors name "the nanotechnology" in as many as 63.3 % of their attributions of responsibility (n=142) for benefits.

The time-based consideration reveals that journalists claim power over the definition of attributions of responsibility with 72.3 % (n=173) of the mentions in 2002. By way of comparison in 2000 the proportion was 47.3 % (n=184) and in 2007 it was 37.7 % (n-159) (cf. Table 41). Scientific actors mainly appear in 2000 (29.3 %) and 2007 (30.2 %) as authors of attributions of responsibility. Towards the end of the study period economic players take on more importance (2006: 15.3 %; 2007: 18.9 %). There is a special situation in 2000. Here "public figures" (for explanations on content reference is made here to the Bill Joy debate) assume greater relevance with a share of 14.1 % in all attributions of responsibility. The same picture emerges in the *Frankfurter Allgemeine Zeitung* (4.4 %, n=413) and in *Die Zeit* (9.4 %, n=53).[27]

[27] For an overview of authors of attributions of responsibility in the various publications see Table 39 in Annex A.

Table 36: Expectation of the occurrence of the benefit by year (n=2076; as %)

	2000	2001	2002	2003	2004	2005	2006	2007	∑
No mention	6.7	10.8	11.8	13.2	11.8	11.5	6.6	11.8	10.6
Unlikely	0.8	-	-	-	-	0.4	0.9	-	0.2
Rather unlikely	-	1.7	0.8	0.4	1.6	1.1	1.8	0.9	1.1
Rather likely	25.9	27.1	31.6	29.5	26.6	34	29.6	26.4	28.8
Very unlikely	48.2	44.4	39.2	41.1	37	35.9	28.8	36.3	39.1
An existing benefit	18.4	15.9	16.7	15.9	23	17.2	32.3	24.5	20.2
Total	100 n=255	100 n=295	100 n=263	100 n=258	100 n=305	100 n=262	100 n=226	100 n=212	100 N=2076

Table 37: Likelihood of the occurrence of a benefit by print media (n=2076; as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
No mention	12.8	7.7	9.8	7	9.1	11.3	14.1	10.2	8.1	10.6
Unlikely	0.2	-	2.4	-	-	0.3	1.1	1.7	-	0.2
Rather unlikely	0.3	3.3	-	1.3	0.4	1.5	2.2	1.7	1.6	1.1
Rather likely	26.3	30.6	46.3	28	27.7	33.8	21.7	22	33.9	28.8
Very unlikely	39.1	41	29.3	46.5	40.9	35.1	32.6	47.5	35.5	39.1
An existing benefit	21.4	17.5	12.2	17.2	21.9	17.9	28.3	16.9	21	20.2
Total	100 n=640	100 n=183	100 n=41	100 n=157	100 n=452	100 n=390	100 n=92	100 n=59	100 n=62	100 N=2076

Table 40: Attribution of responsibility for the opportunities of nanotechnology by print media (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
Federal government	0.2	0.6	-	-	0.2	0.3	-	-	-	0.2
Political institutions	0.2	-	-	1.3	-	-	-	-	-	0.2
Central bodies/institutions and associations	0.3	-	2.8	0.7	-	0.3	-	-	-	0.3
Scientific actors/ groups/institutions	41.5	35.8	22.2	25.3	38.1	33.9	26.8	50	29.3	36.5
Economic actors	9.9	17.3	2.8	16	17.4	16.1	11.3	4	8.6	13.6
Public figures	-	1.2	-	-	-	-	-	-	-	0.1
Science journalists	-	-	-	0.7	-	-	-	-	-	0.1
Journalists	0.2	-	-	-	-	-	-	-	-	0.1
Foundation/ science support	0.3	-	-	-	-	-	-	-	-	0.1
Other actors	0.3	0.6	-	0.7	-	2.1	-	-	5.2	0.7
“The nanotechnology” (object)	47	43.9	72.2	55.3	44.3	47.3	62	46	56.9	48.2
External circumstances/situation	-	0.6	-	-	-	-	-	-	-	0.1
Total	100 n=583	100 n=173	100 n=36	100 n=150	100 n=420	100 n=336	100 n=71	100 n=50	100 n=58	100 N=1877

Table 41: Attribution of responsibility for the opportunities of nanotechnology over time (n=1877, as %)

	2000	2001	2002	2003	2004	2005	2006	2007	∑
Federal government	-	-	-	-	0.7	0.5	0.5	-	0.2
Political institutions	0.4	-	0.4	0.4	-	-	-	-	0.2
Central bodies/institutions and associations	-	-	0.4	-	0.7	-	0.5	0.5	0.3
Scientific actors/groups/institutions	30.8	37	42.5	43	27.4	43.8	38.6	30.8	36.5
Economic actors	7.5	13	16.7	8.9	17.5	12.4	22.9	9	13.6
Public figures	-	-	-	0.9	-	-	-	-	0.1
Science journalists	0.4	-	-	-	-	-	-	-	0.1
Journalists	-	-	0.4	-	-	-	-	-	0.1
Foundation/science support	-	-	-	-	-	1	-	-	0.1
Other actors	-	0.7	1.3	-	1.4	0.5	1	1	0.7
"The nanotechnology" (object)	60.8	49.3	38.2	46.8	52.3	41.9	36.2	58.7	48.2
External circumstances/situation	-	-	-	-	-	-	0.5	-	0.1
Total	100 n=227	100 n=276	100 n=233	100 n=235	100 n=285	100 n=210	100 n=210	100 n=201	100 N=1877

4.4.2 Risk assessment of nanotechnology

In contrast to the extensive discussion of opportunities in the coverage in the publications examined, the discussion of risks is less extensive. Only in 13.9 % of the articles examined (n=1696) is there any discussion of the risks associated with nanotechnology. In total two or three risks are only mentioned in 3.3 % and 1.5 % of all articles.

Table 42: Number of mentions of risk

	Frequency	Percent
No mention of risk	1461	86.1
Mention of one risk	153	9
Mention of two risks	56	3.3
Mention of three risks	26	1.5
Total	1696	100

The most mentions of risks occurred in 2000 (in total 74). Nanotechnology risks are discussed in 22.5 % of all articles (n=200). Coverage in 2002 and 2005 can, in contrast, be described as the least critical. Only 26 (n=215, m=0.12) and 29 (n=216, m=0.13) mentions of risks were counted (cf. Table 43).

Table 43: Mentions of risk over time (as %)

	2000	2001	2002	2003	2004	2005	2006	2007	∑
No mention of risk	77.5	88.4	91.2	86.4	85.1	89.4	82.8	88.2	86.1
1	12	6	6	8.5	8.9	7.9	14.9	8.2	9
2	6.5	3.9	2.3	2.5	4.4	2.8	2.3	1.2	3.3
3	4	1.7	0.5	2.5	1.6	-	-	2.4	1.5
Total	100 n=200	100 n=233	100 n=215	100 n=199	100 n=248	100 n=216	100 n=215	100 n=170	100 N=1696
Number of risks mentioned	74	44	26	42	56	29	42	30	343
Mean (m)	0.37	0.18	0.12	0.21	0.22	0.13	0.19	0.17	0.2

A comparison of the newspapers and magazines examined reveals (cf. Table 44) that in the *taz* (19 mentions of risks in 35 articles, m=0.54) and in *Die Zeit* (32 mentions in 62 articles, m=0.51) there is above-average mention of the risks of nanotechnology. The least attention is paid to risks in the coverage in *Die Welt* (46 mentions in 379 articles, m=0.12), the *Finan-*

cial Times (45 mentions in 293 articles, m=0.15) and the *Süddeutsche Zeitung* (27 mentions in 168 articles, m=0.16). The *Frankfurter Allgemeine Zeitung*, which sets the tone of coverage of nanotechnology, is in the lower range with 121 mentions of risks in 153 articles. (m=0.21).

Table 44: Number of mentions of risk by publication (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
No mention of risk	86.3	86.9	60	81.7	91	89.1	64.5	80.9	88.6	86.1
1	7.8	10.7	31.4	13	6.3	6.8	24.2	8.5	6.8	9
2	3.8	1.8	2.9	1.7	2.1	3.8	6.5	10.6	2.3	3.3
3	2.2	0.6	5.7	3.5	0.5	0.3	4.8	-	2.3	1.5
Total	100 n=553	100 n=168	100 n=35	100 n=115	100 n=379	100 n=293	100 n=62	100 n=47	100 n=44	100 N=1696
Number of risks mentioned	121	27	19	31	46	45	32	14	8	343
Average (m)	0.21	0.16	0.54	0.26	0.12	0.15	0.51	0.29	0.18	0.2

Even although up to three risks could be recorded per article, only 343 mentions of risks were identified in the 1696 articles analysed. In terms of content there is a focus on “health” risks (28.9 %, n=343). Other important risks are “ethical-moral” (13.1 %) and “public/social” ones (11.4 %) which cover the social discussion and acceptance of nanotechnology. Military risks (share of 18.1 % in all mentions) are also mentioned comparatively frequently. They are also the dominant types of risk over time (2000 up to 2007) (see Fig. 15).

Fig. 15: The relative weighting of the four most important types of risk over time

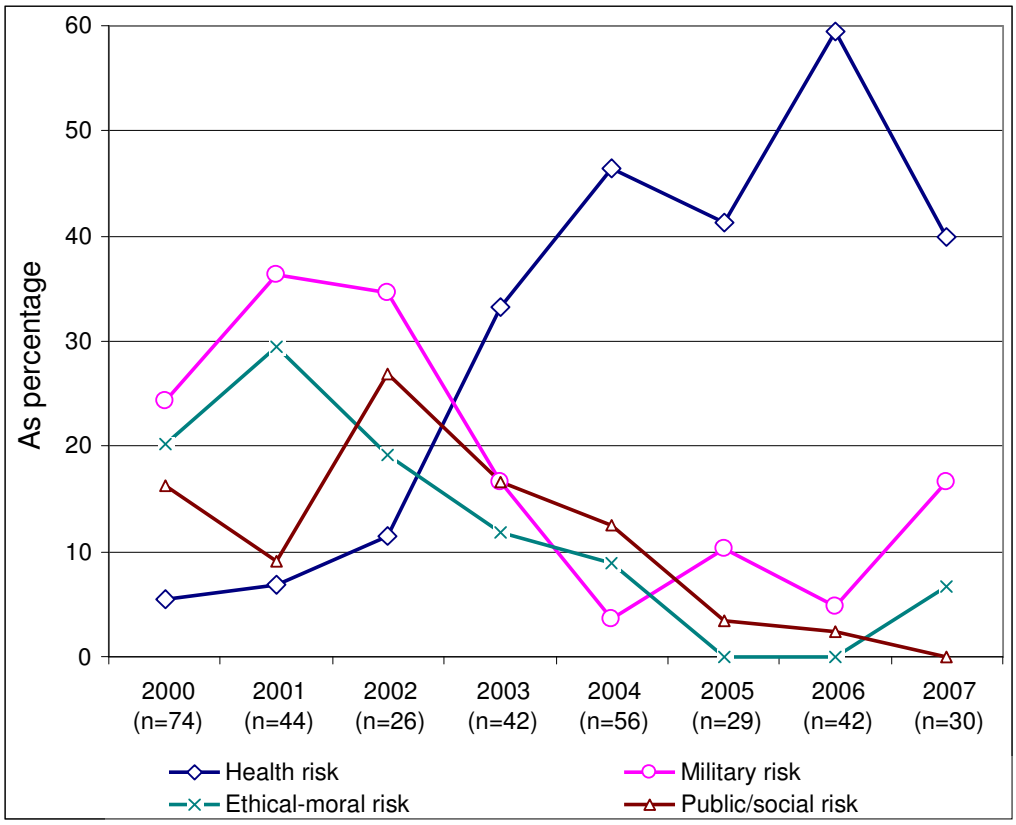


Fig. 15 shows that health risks become increasingly important over time. In 2000 they account for only 5.4 % (n=74) of all mentions of risk whereas in 2006 (n=42) they account for more than half of all mentions of risks (59.5 %). Ethical-moral (2000: 20.3 % (n=74); 2001: 29.5 % (n=44)) and public-social risks (2000: 16.2 % (n=74); 2002: 26.9 % (n=26)) are, by contrast mainly discussed during the first half of the study period. In 2001 and 2002 mentions of risks with a military reference are dominant with a share of 36.4 % (n=44) and 34.6 % (n=26).

The individual publications also differ in respect of their main focus. For instance in *Focus* (50 %, n=8), the *taz* (47.4 %, n=19) and the *Financial Times Deutschland* (40 %, n=45), the emphasis is mainly on risks in the health sector. *Die Zeit* (18.8 %, n=32) and *Der Spiegel* (28.6 %, n=47) which mention "ethical-moral" risks, and the *Frankfurter Rundschau* (32.3 %, n=31) which mentions "public/social" risks focus first and foremost on the social risks of nanotechnology. Military risks are discussed most in *Die Welt* with a proportion of 28.3 %. In the coverage by the *Frankfurter Allgemeine Zeitung* all three types of risks are discussed more or less to the same degree.

Besides the general risk dimension concrete mentions of risk[28] were recorded in order to be able to describe the individual categories in more detail. In the health field (n=99) the potential disadvantages of nanotechnology are mainly:

- intake of nanoparticles through the skin and lungs (56.5 %),
- fine dust (16.1 %) and
- possible damage to genetic information (5.5 %).

Besides "transcending" human beings (other key words: posthumanism, transhumanism) (23.8 %) other ethical-moral and public/social risks (n=84) mentioned refer to potential harm through artificial intelligence (13.1 %) and self-assemblers (30.9 %), the creation of artificial organisms (7.1 %) and the possibility of a "nano-divide". The military risks mentioned most frequently in the coverage are:

- nanorobots (54.8 %),
- misuse of technology (30.6 %) and
- the possibility of knowledge-driven mass destruction.

The general probability of the above risks (n=343) is deemed to be rather likely in 38.5 % of the cases and as very likely in a further 21.6 %. However, only in 3.5 % of the cases are concrete risks – i.e. manifest damage – discussed (cf. Table 45). Between 2004 and 2006 this share is 5.4 % (2004, n=56) and 7.1 % (2006, n=42)[29]. Particularly in 2000 the proportion of risks deemed to be "very likely" is high (41.9 %). Risks that can generally be described as utopian, whose occurrence is rather or very unlikely, are discussed in a total of 18.4 % of cases. Their proportion is very high in 2000 (a total of 31.9 %).

A comparable distribution of the assessment of probability is found in all newspapers and magazines examined. Topicality-fixated print media report– if at all – in the majority of cases about technical risks which they classify as rather or very unlikely (cf. Table 46). One exception here is *Focus* that also reports on very unlikely cases of damage. However, the percentages must be treated with caution because of the low number of cases (n=8).

[28] Table 47 in Annex A provides an overview of the concrete mentions of risks.

[29] In this context reference should be made once again to the coverage of the Magic Nano case which may explain the high proportion of risks that have already occurred.

Table 45: Likelihood of risks over time (n=343; as %)

	2000	2001	2002	2003	2004	2005	2006	2007	∑
No assessment	6.8	31.8	15.4	16.7	21.4	17.2	21.4	20	18.1
Unlikely	5.4	11.4	3.8	11.9	8.9	6.9	7.1	3.3	7.6
Rather unlikely	9.5	20.5	19.2	7.1	5.4	10.3	9.5	10	10.8
Rather likely	33.8	27.3	38.5	40.5	33.9	41.4	50	5.,3	38.5
Very likely	41.9	9.1	23.1	21.4	25	17.2	4.8	10	21.6
Risk already occurred	2.7	-	-	2.4	5.4	6.9	7.1	3.3	3.5
Total	100 n=74	100 n=44	100 n=26	100 n=42	100 n=56	100 n=29	100 n=42	100 n=30	100 N=343

Table 46: Likelihood of risks by print medium (n=343; as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
No assessment	20.7	11.1	26.3	12.9	17.4	22.2	15.6	7.1	12.5	18.1
Unlikely	6.6	7.4	10.5	9.7	13	2.2	3.1	14.3	12.5	7.6
Rather unlikely	10.7	11.1	-	12.9	10.9	8.9	18.8	-	25	10.8
Rather likely	40.5	48.1	26.3	51.6	23.9	42.2	34.4	35.7	37.5	38.5
Very likely	20.7	18.5	36.8	6.5	28.3	20	25	35.7	-	21.6
Risk already occurred	0.8	3.7	-	6.5	6.5	4.4	3.1	7.1	12.5	3.5
Total	100 n=121	100 n=27	100 n=19	100 n=31	100 n=46	100 n=45	100 n=32	100 n=14	100 n=8	100 N=343

Here again the attribution of responsibility for potential damage (cf. Table 48) is interesting. It is worth noting that regarding the scale of damage, diffuse external attributions are dominant. In 86.6 % of all cases (n=298) “the nanotechnology” is held responsible for any risks that occur, not nameable actors. In 2001 this proportion is 97.1 % and in 2007 even as high as 100 %. Actively involved actors from the economic sector, scientists or scientific institutions scarcely play any role at all with a share of just 6.4 % and 4 % respectively. The sole exception is coverage from 2006. In 25.6 % of all cases economic actors are held responsible for risks that have occurred whereby once again the Magic Nano case (03/2006–06/2006) can perhaps explain this. In the coverage of the individual publications a similar distribution can be observed.

The attributions of responsibility are undertaken in 33.1 % of cases (n=284) by “public figures” and in a further 27.5 % of cases by “scientific actors/institutions” (cf. Table 49). Journalists are another group with major influence when it comes to causal stories about risk potential. They crop up in 18 % of cases as the authors of attributions of responsibility. The time-based consideration reveals that in 2000 – the year of the Bill Joy debate discussed in Chapter 4.2.2 - public figures shape the risk discussions: 77.4 % of all attributions of responsibility (n=74) are undertaken by this group. By contrast, scientific actors take on more importance in the second half of the study period. In 2006 scientists undertook 44.4 % and in 2007 40 % of all attributions of responsibility.

A comparison of the publications reveals the following differences: whereas in the coverage by the *taz* (42.9 %, n=19) and the *Frankfurter Allgemeine Zeitung* (42.7 %, n=121) public figures mainly occur as the spokespersons, it was mainly actors from science who appear in the *Financial Times Deutschland* (45.2 %, n=45) and the journalists themselves in the case of the *Frankfurter Rundschau* (36.7 %, n=31).

Table 48: Actor responsible for the risk over time (as %)

	2000	2001	2002	2003	2004	2005	2006	2007	∑
Other political actors	-	-	-	-	1.9	-	-	-	0.3
Political institutions	-	-	-	-	-	8	-	-	0.7
Central body/institutions	-	-	-	2.9	-	-	2.6	-	0.7
Scientific actors	5.1	-	12.5	2.9	5.7	8	-	-	4
Economic actors	10.2	-	-	2.9	1.9	4	25.6	-	6.4
Other actors	3.4	2.9	-	-	-	-	-	-	1
"The nanotechnology" (object)	79.7	97.1	87.5	91.4	90.6	80	71.8	100	86.6
External circum-stances/situation	1.7	-	-	-	-	-	-	-	0.3
Total	100 n=59	100 n=35	100 n=24	100 n=35	100 n=53	100 n=25	100 n=39	100 n=28	100 N=298

Table 49: Actor responsible for the risk by print medium (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
Other political actors	-	-	-	-	-	-	4.5	-	-	0.3
Political institutions	1	-	-	-	-	2.4	-	-	1	0.7
Central body/institutions	1	-	5.6	-	-	-	-	-	1	0.7
Scientific actors	6.8	-	-	-	-	7.1	-	20	6.8	4
Economic actors	3.9	19.2	5.6	6.5	5	2.4	18.2	-	3.9	6.4
Other actors	-	-	5.6	-	2.5	-	4.5	-	-	1
"The nanotechnology" (object)	87.4	80.8	83.3	90.3	92.5	88.1	72.7	80	87.4	86.6
External circum-stances/situation	-	-	-	3.2	-	-	-	-	-	0.3
Total	100 n=103	100 n=26	100 n=18	100 n=31	100 n=40	100 n=42	100 n=22	100 n=10	100 n=103	100 N=298

4.4.3 General tenor of coverage of nanotechnology

Consideration of the evaluations of opportunities and risks by individual actors is presented below. Overall a highly differentiated discussion of opportunities can be observed in the coverage of nanotechnology: 74.5 % of all articles (n=1696) only report on the potential or real benefits of the technology. By contrast, the discussion of risk is almost marginal. The risks alone of nanotechnology are only discussed in 3.7 % of the articles. Some articles (10.3 %) discuss both the opportunities and risks – but to varying degrees. A further 11.6 % can be described as neutral – they do not contain any evaluations of opportunities or risks.

Table 50 gives an overview of the distribution of the assessments of opportunities and risks (between 0 and 3 mentions were possible) in the overall coverage. The percentages given refer to the number of articles (n=1696).

Table 50: Assessment of opportunities and risks in the coverage of nanotechnology (as %)

Mention of benefit Mention of risk	0	1	2	3	Total
0	11.6	53.7	15	5.8	86.1
1	2.6	2.6	1.4	2.5	9
2	0.8	0.6	0.7	1.2	3.3
3	0.3	0.3	0.3	0.6	1.5
Total	15,3 n=259	57,2 n=970	17,4 n=295	10,1 n=172	100 N=1696

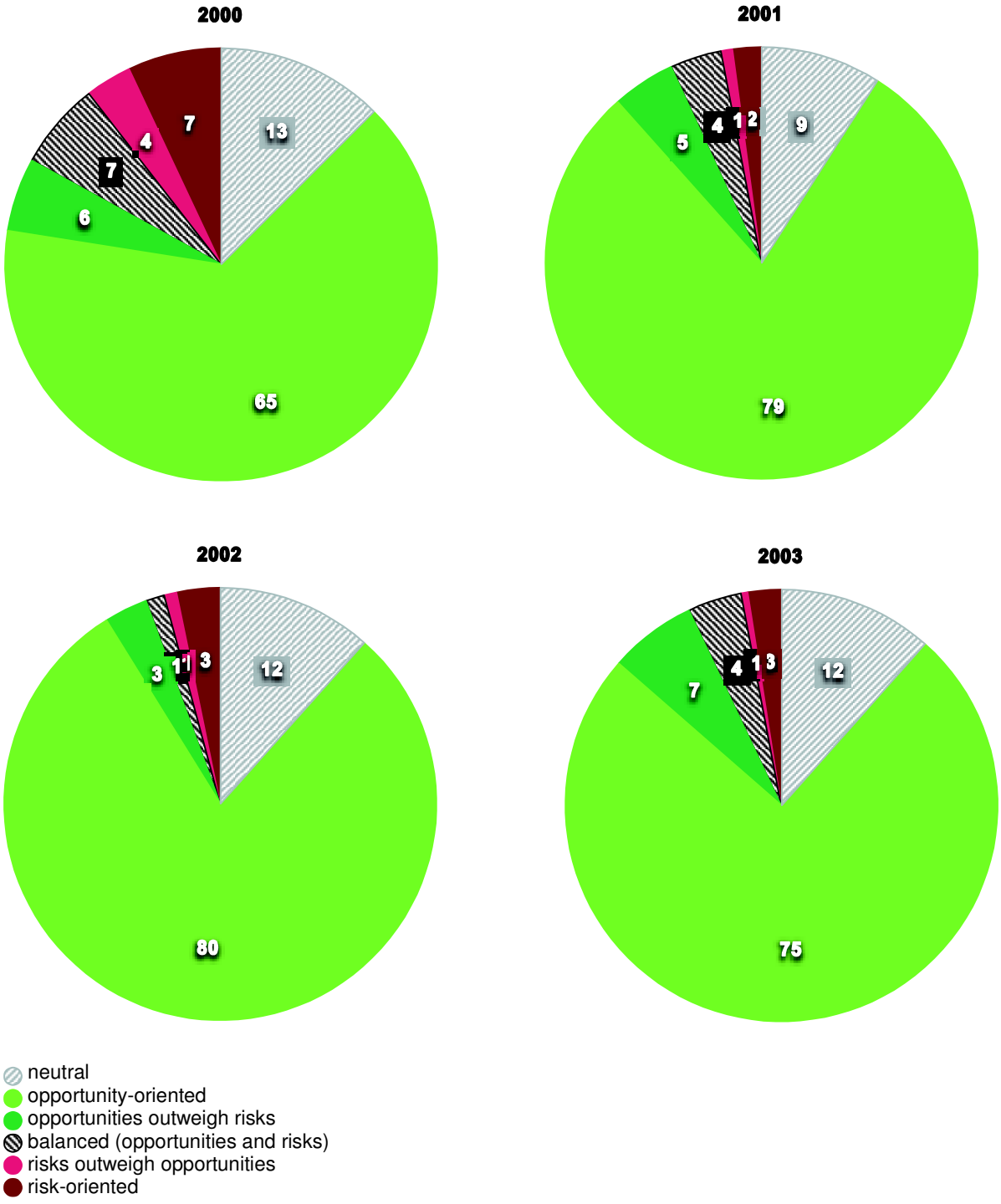
As, however, even in those cases in which both opportunities and risks are discussed, there is not always a balance, a distinction can be made in addition to pure risk or opportunity-oriented articles between rather opportunity-oriented (i.e. more mentions of opportunities than risks) and rather risk-oriented (i.e. more mentions of risks than opportunities) and balanced articles which pay equal attention to opportunities and risks. Table 51 shows how the examined articles are distributed over these categories.

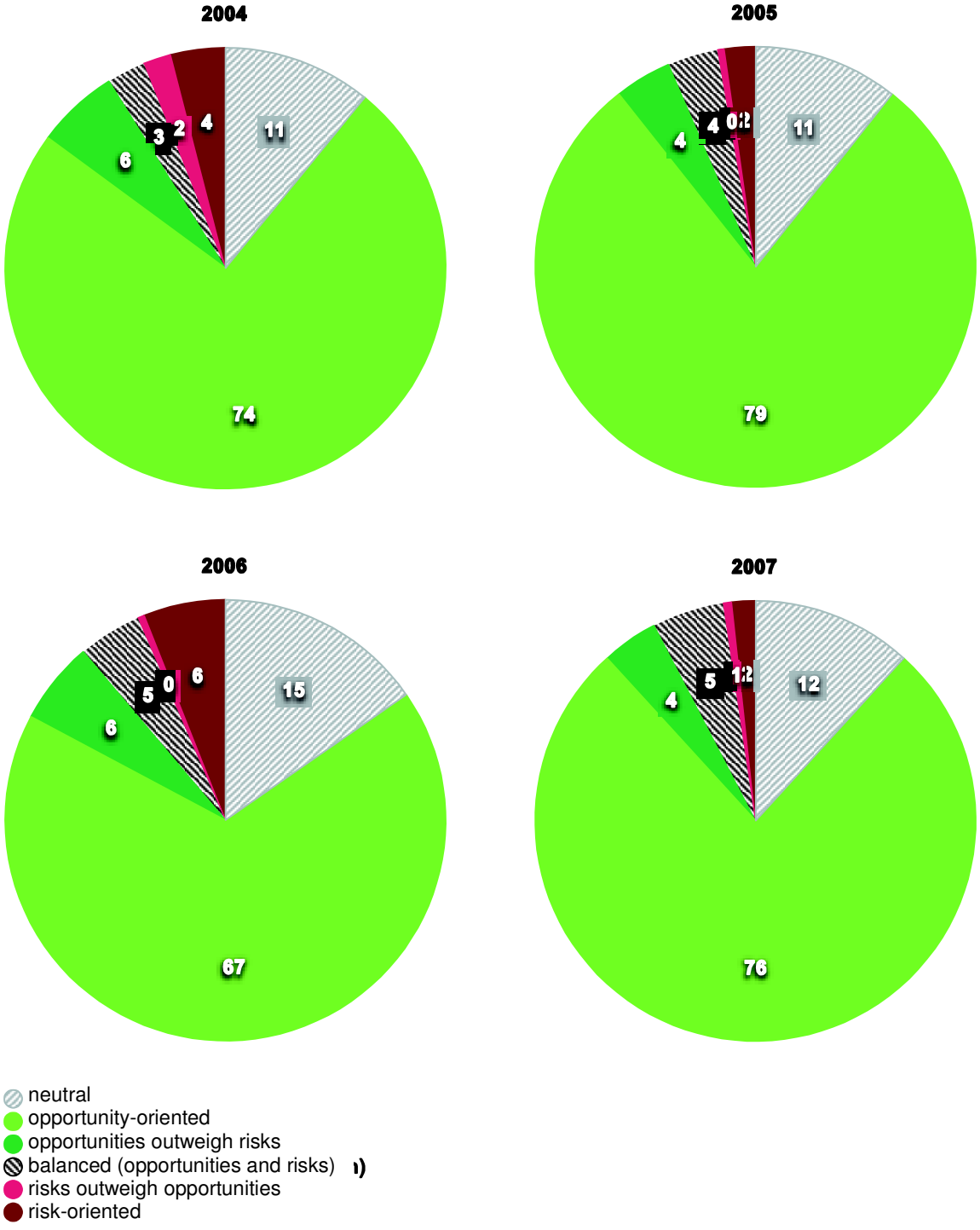
Table 51: Opportunity-risk orientation in coverage of nanotechnology

	Frequency	Percent
Neutral	197	11.6
Opportunity-oriented	1264	74.5
Opportunities outweigh risks	86	5.1
Balanced (opportunities and risks)	67	4
Risks outweigh opportunities	20	1.2
Risk-oriented	62	3.7
Total	1696	100

Although the coverage over all the years in the study period can mainly be described as opportunity-oriented (in 2001 and 2002 79.4 % and 79.5 % of all articles are purely opportunity-oriented), relevant shifts can be identified in the time-based comparison (see Fig. 16). In 2000 (n=200) the share of purely risk-oriented (7 %) and rather risk-oriented (3.5 %) articles is far higher than average. In 2006 as well we observe a weak discussion of risks: 6 % of all articles in that year (n=215) are risk-oriented. Overall, it cannot be said that there is no extensive risk debate or anything coming close to negative coverage of nanotechnology in any of the years.

Fig. 16: Comparison of the opportunity-risk orientation of coverage in the various years

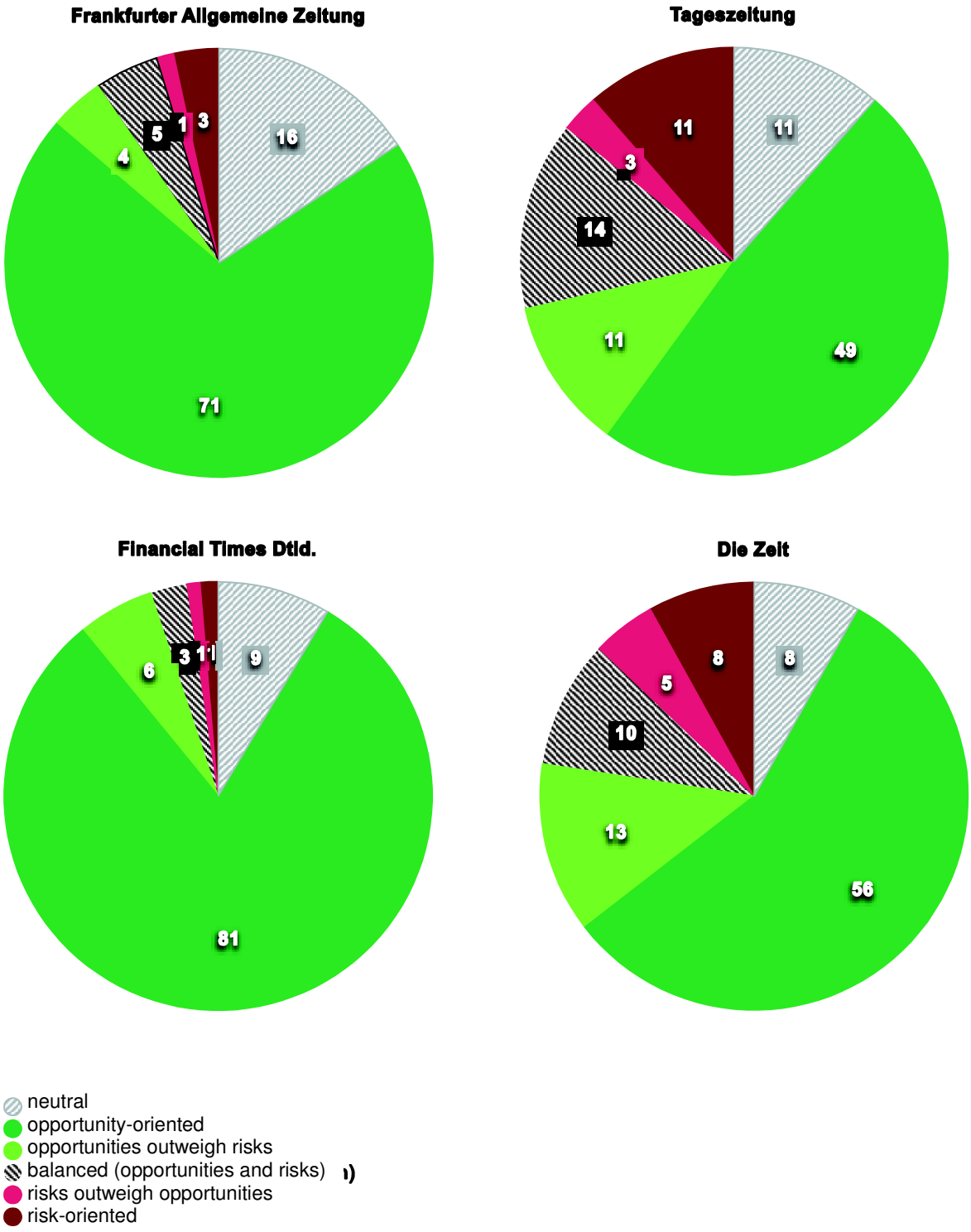




In the comparison of the publications studied the coverage of the *Financial Times Deutschland* (86.3 % opportunity-oriented/rather opportunity-oriented and 2.4 % risk-oriented/rather risk-oriented, n=293) of *Focus* (86.4 % opportunity-oriented/rather opportunity-oriented and 4.5 % risk-oriented, n=44) and of *Die Welt* (84.7 % opportunity-oriented/rather opportunity-oriented and 3.4 % risk-oriented/rather risk-oriented, n=379) can be most clearly described as “pro-nanotechnology”. Although all newspapers and news magazines mainly discuss the opportunities, the *taz* with a proportion of 14.3 % (n=35), *Die Zeit* with 12.9 % and the *Frankfurter Rundschau* with 10.4 % are particularly noticeable with rather or purely risk-oriented articles. The highest percentage of balanced articles, which focus equally on opportunities and risks, is found in the *taz* (14.3 %, n=35). In contrast, the *Süddeutsche Zeitung* (16.7 %, n=168) and the *Frankfurter Allgemeine Zeitung* most frequently adopt a neutral form of reporting in the overall comparison (cf. Table 52). Fig 17 presents by way of example the op-

portunity/risk orientation in the coverage of the *Frankfurter Allgemeine Zeitung*, which also holds for the distribution in the *Süddeutsche Zeitung*, and the *taz*, the *Financial Times Deutschland*, whose distribution is comparable with *Die Welt* and *Die Zeit*.

Fig. 17: Opportunity- risk orientation in the coverage of selected publications



Furthermore, this raises the question about how to assess the opportunities and risks in the main topic areas (cf. Table 53).

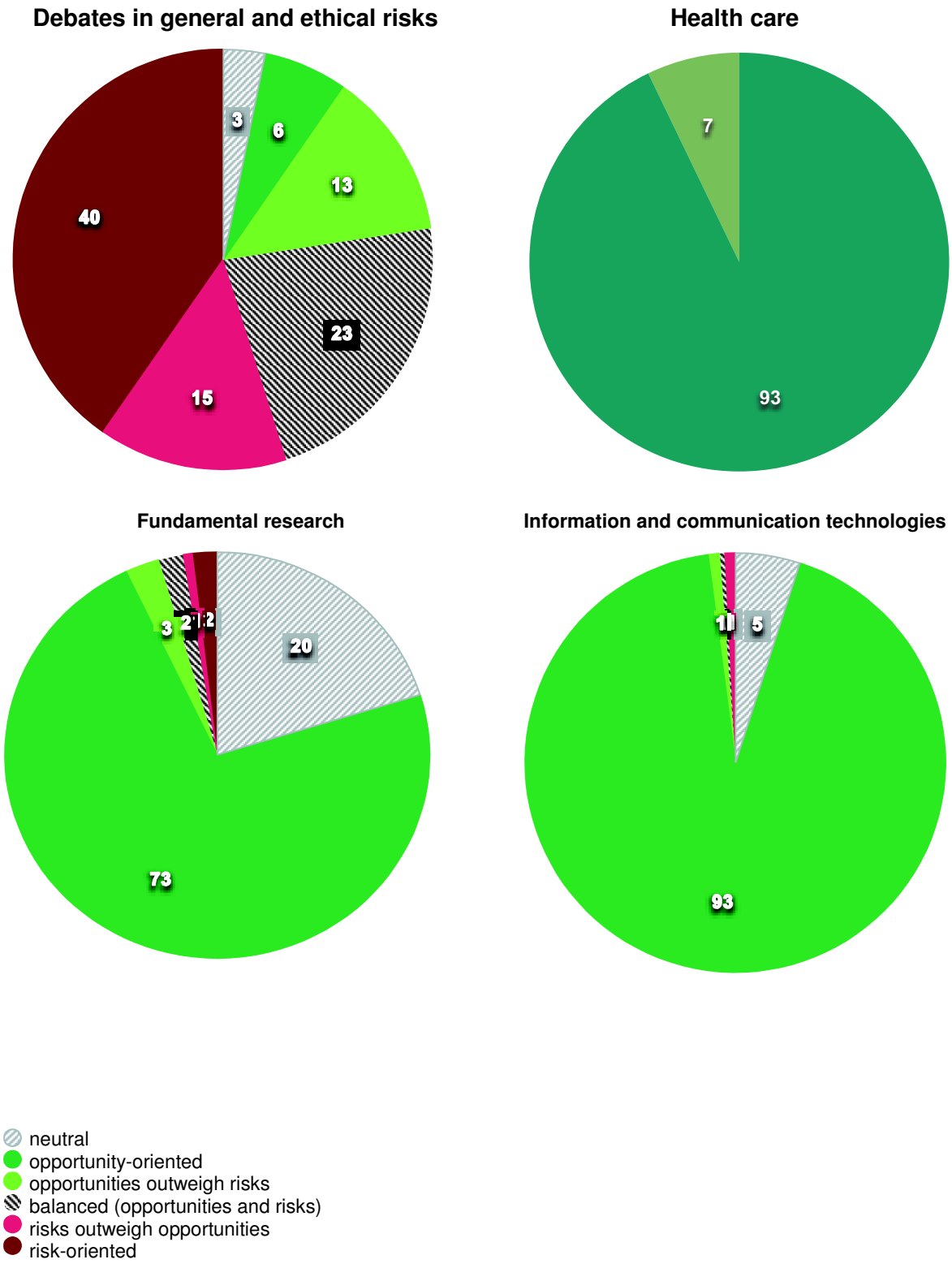
Table 53: Assessment of the opportunities and risks of selected topics covered (n=1696, as %)

Main topic	Neutral	Opportunity oriented	Opportunities outweigh risks	Balanced (opportunities and risks)	Risks outweigh opportunities	Risk-oriented	n
Fundamental research	20.2	72.7	2.6	1.9	0.7	1.9	579
Application: Healthcare	-	92.9	7.1	-	-	-	126
Consumer-related applications	2.9	87	4.3	5.8	-	-	69
Application: information and communication technologies	5	92.9	0.8	0.4	0.8	-	241
Not consumer-related applications	4.8	87.6	2.2	1.1	0.5	3.8	186
Debates about nanotechnology and ethical aspects	3.2	6.5	12.9	22.6	14.5	40.3	62
Nanobiotechnology	10.7	86.7	1.3	-	-	1.3	75
Politics	31.9	52.2	5.8	5.8	-	4.3	69
Economy	13.1	72.1	5.7	4.1	1.6	3.3	122
Other	7.1	42.9	3.6	14.3	3.6	28.6	28
Overview of nanotechnology	5	53.2	23	15.8	0.7	2.2	139
Total	11.6	74.5	5.1	4	1.2	3.7	n= 1696

Coverage of the application healthcare/medicine is purely opportunity-oriented in all publications examined (n=126). 92.9 % are opportunity-oriented as against only 7.1 % which are rather opportunity-oriented articles. The coverage of the application information and communication technologies (n=241) is also similarly positive. Once again 92.9 % of the articles are purely opportunity-oriented as against only 1.2 % which focus on the risks of nanotechnology. At 20.2 % the proportion of neutral articles is highest in the case of fundamental research (n=579). In 72.7 % of the cases here the coverage can be described as purely opportunity-oriented as against 2.6 % of the articles on this topic that are rather or purely opportunity-oriented. A very different picture emerges in the coverage of the “debate about nanotechnology in general and ethical aspects” (n=62) which is mainly shaped by the Bill Joy debate (cf. Chapter 4.2.2). In more than half the cases discussion of this topic largely concentrates on risks (14.5 % rather risk-oriented and 40.3 % purely risk-oriented). Furthermore, a comparatively high proportion (22.6 %) reports in an equal manner about opportunities and risks whereas only 18.4 % of the articles highlight the opportunities. Coverage of the “Magic Nano” case is similar; for a detailed examination please refer to Chapter 4.2.2. Overall, a weak association between main topic and assessment can be observed (Cramers V=.31; p<.001). This means that as long as there is discussion of applications and fundamental research, the articles are positive.

Fig. 18 shows the opportunity-risk orientation of the three most important topic areas on the subject of nanotechnology – fundamental research, the applications healthcare and information and communication technologies – and on “debates about nanotechnology in general and ethical aspects”.

Fig. 18: Opportunity-risk orientation in the coverage of selected main topics



4.5 Arguments used by the actors concerning the opportunities and risks of nanotechnology

In conjunction with analysis of the actor level, in particular consideration of risk-opportunity assessments and the attribution of responsibility by individual actors, the question is raised about the way in which they present their arguments concerning nanotechnology and how they assess the technical development.

As in the case of opportunities and risks, up to three demands were coded. Only in 7.8 % of all articles could demands – 199 in total – be identified. Demands are mainly advanced when risks are discussed (Cramer's V=.58, p< .001) (cf. Table 54).

Table 54: Demands in conjunction with the opportunity-risk orientation of an article

	Neutral	Opportunity-oriented	Opportunities outweigh risks	Balanced (opportunities and risks)	Risks outweigh opportunities	Risk-oriented	∑
None	98.5	98.2	57	49.3	25	67.7	92.2
Demand	1.5	1.8	43	50.7	75	32.3	7.8
Total	100 n=197	100 n=1264	100 n=86	100 n=67	100 n=20	100 n=20	100 N=1696

Cramer's V=.58, p< .001

One in two articles that depict the opportunities and risks to an equal same degree (n=67) also contain demands. This proportion increases in articles that are rather risk-oriented (n=20) to as much as 75 %. Overall, the majority of articles, in which actors express demands, only contain one (in 63.6 % of the 132 articles with demands). Two (21.9 %) or even three (14.3 %) demands in an article are, in contrast, found less frequently comparatively speaking. Tables 55 and 56 show how the articles with demands are spread over the individual years and publications.

In 2000 (n=200) and 2006 (n=215), the years in which the most risk assessments were also undertaken, the highest number of articles is found (11 % and 9.8 % respectively) in which demands are made. A comparison of the various newspapers and magazines shows that the *taz* with 17.1 % and *Die Zeit* with 19.4 % publish articles with demands the most frequently.

Demands are made in 51.8 % of the cases (n=199), the foremost being "risk regulation[30]" (cf. Table 57). If one includes amongst demands concerning the handling of nanotechnology, demands which calls both for the "regulation of the risk and the promotion of the benefit " (6 %), "ethical standards" (4.5 %) and "improved information or a better dialogue" (11.1 %), then this proportion increases to 73.4 %. Promotion of the benefit is called for, by contrast, in only 11.6 % of the demands.

Table 55: Demands about nanotechnology over time (as %)

	2000	2001	2002	2003	2004	2005	2006	2007	∑
No demand	89	95.3	95.8	91.5	91.1	92.6	90.2	91.8	92.2
1	5.5	2.6	3.3	6	4	5.6	7.4	5.9	5
2	3.5	1.7	0.9	1	2.8	0.5	2.3	0.6	1.7
3	2	0.4	-	1.5	2	1.4	-	1.8	1.1
Total	100 n=200	100 n=233	100 n=215	100 n=199	100 n=248	100 n=216	100 n=215	100 n=170	100 N=1696

[30] The regulation of a risk is primarily understood to be the containment of a risk (risk reduction, risk minimisation); this could also encompass regulation in the true meaning of the word for example by political circles (e.g. legislation).

Table 56: Demands about nanotechnology in the individual news media (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
No demand	91.5	91.1	82.9	87	96.6	92.8	80.6	97.9	95.5	92.2
1	4.5	6.5	11.4	7	2.4	6.1	11.3	2.1	2.3	5
2	2	1.8	2.9	4.3	0.8	1	3.2	-	2.3	1.7
3	2	0.6	2.9	1.7	0.3	-	4.8	-	-	1.1
Total	100 n=553	100 n=168	100 n=35	100 n=115	100 n=379	100 n=293	100 n=62	100 n=47	100 n=44	100 N=1696

Table 57: Demands concerning the handling of nanotechnology

	Frequency	Percent
Regulation of the risk	103	51.8
Promotion of the benefit	23	11.6
Both regulation of the risk and promotion of the benefit	12	6
Research/studies	25	12.6
Ethical standards	9	4.5
Improved information/dialogue	22	11.1
Other demand	5	2.5
Total	199	100

In 30.6 % of the cases demands are made by scientific actors and institutions. Other important actors, who make demands in the print media examined, are “political actors” (14.8 %)[31] in addition to “public figures” (20.6 %). The following overview shows which demands concerning the handling of nanotechnology are made by the various groups.

Table 58: Which actors formulate which demands?

Group of actors	Demand	Frequency	Percent
Scientific actors	Regulation of the risk	29	50.8
	Promotion of the benefit	6	10.5
	Both regulation of the risk and promotion of the benefit	5	8.7
	Research/studies	8	14.4
	Ethical standards	2	3.5
	Improved information/dialogue	7	12.2
	Total	57	100
Public figures	Regulation of the risk	26	66.7
	Promotion of the benefit	1	2.5
	Both regulation of the risk and promotion of the benefit	3	7.6
	Research/studies		-
	Ethical standards	5	12.8
	Improved information/dialogue	3	7.6
	Other demand	1	2.5
	Total	39	100
Political actors	Regulation of the risk	8	28.5
	Promotion of the benefit	7	25
	Both regulation of the risk and promotion of the benefit	3	10.7
	Research/studies	7	25
	Ethical standards		- -
	Improved information/dialogue	3	10.7
	Total	28	100

If one compares the individual years in the study period, this shows that public figures are the authors of demands especially in 2000 (64.9 %, n=37) and 2002 (54.5 %, n=11). In contrast,

[31] In this context a distinction can be made between the federal government (2.4%), other political actors (8.4%) and political institutions (4.7%).

political actors voice their demands more in the media-driven debate about nanotechnology (43.6 %, n=39). In 2006 (45.5 %, n=22) and 2007 (42.1 %, n=19) demands by public figures and scientific institutions are predominant.[32]

The above demands (n=199) are directed at a specific target group in 54.7 % of the cases (this corresponds to 109 mentions of target groups). The authors direct their demands first and foremost at scientific actors (61.5 %, n=109), economic actors (15.6 %) and persons and institutions from the field of politics (13.7 %).

Besides demands it was also recorded whether the individual authors formulate concrete instructions on how these demands could be met. In 89.45 % of the cases, a demand is linked to a concrete instruction. Overall 178 recommended actions were identified. Table 60 gives the breakdown.

Table 60: Instructions on handling nanotechnology

Instruction	N	Percent
Health and safety at work measures	5	2.8
Toxicological assessment (test methods, classification, limit values)	3	1.7
Safety research	6	3.4
Moratorium or renunciation of the development and use of nanotechnology	17	9.6
(Internationally) standardised test methods	5	2.8
Mandatory product labelling	5	2.8
International codes of conduct	10	5.6
Appointment of independent research bodies on risk assessment	2	1.1
Setting up of a central information office	1	0.6
Creation of a legal framework	9	5.1
Call for nanoethics	7	3.9
Product recall/removing possibly harmful products from the market	1	0.6
Risk research	35	19.7
Fair participation	1	0.6
Other instructions on risks (regulation)	17	9.6
Innovation research	7	3.9
Public research support	3	1.7
Fundamental research	7	3.9
Technical democracy	1	0.6
Improving scientists' ability to communicate	7	3.9
Other instructions about opportunities (support)	10	5.6
Nanodiscussion platform	3	1.7
Social debate/setting up of citizen's fora	14	7.9
Other not clearly classifiable instructions	2	1.1
Total	178	100

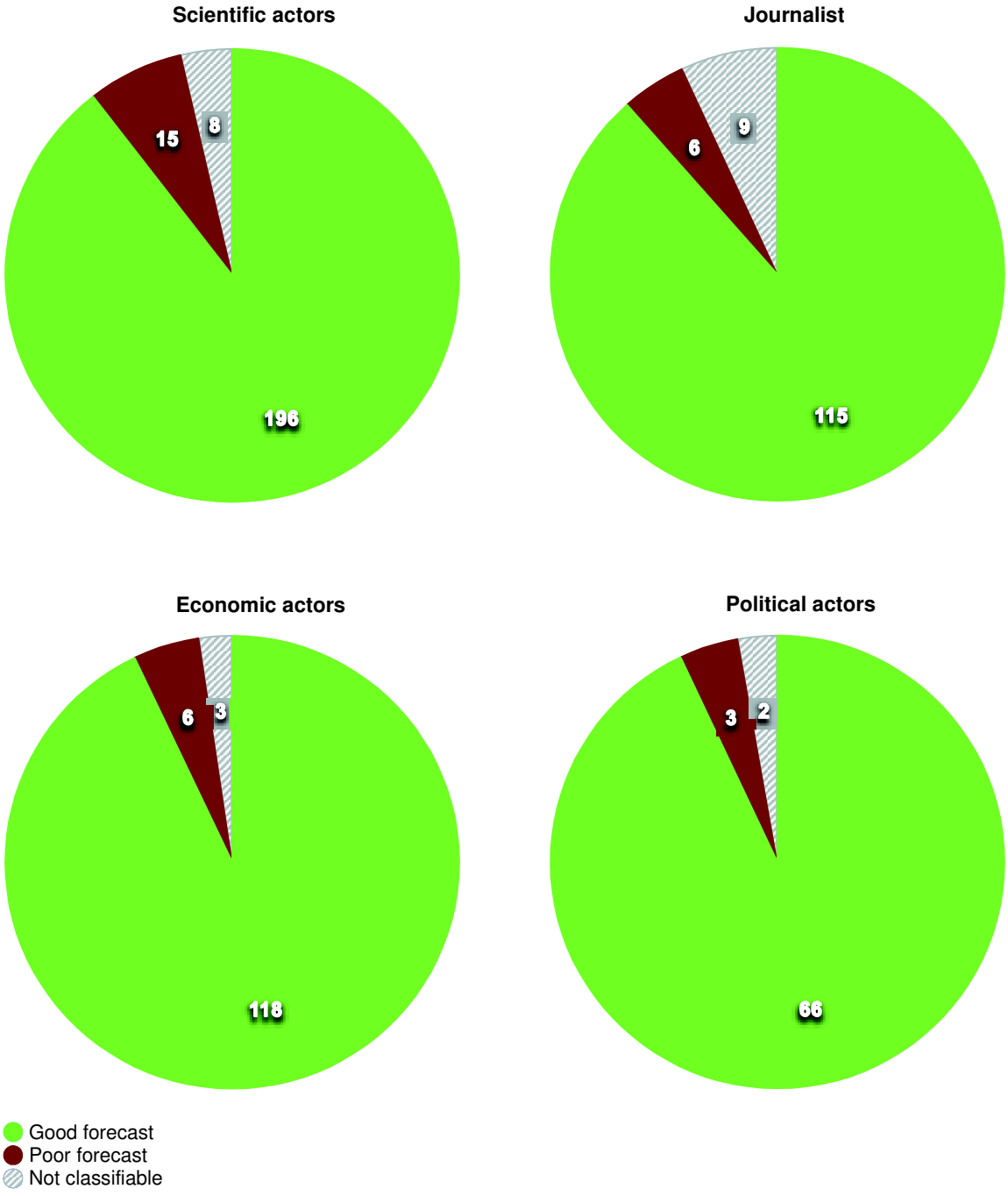
The initiation of additional risk research (19.7 %, n=178) can be highlighted as the most frequent recommendation concerning opportunities to regulate the risks of nanotechnology. The recommendation of a moratorium is mentioned 17 times in the media in the course of the seven years. In addition, the recommendation to launch a broad social dialogue with the participation of the public at large also plays a role.

Besides the assessments of opportunities and risks, attributions of responsibility and demands were investigated which formulate forecasts[33] concerning the future opportunities and development of nanotechnology. Forecasts were identified in only 25.8 % of all articles (n=507). In 89.9 % of the cases they describe a positive development. Only 5.3 % present a pessimistic view of the future. The main actors who appear as forecasters are scientists (34.9 %, n=475), journalists (21.9 %) and economic actors (18.5 %). They are followed by

[32] Table 59 in Annex A provides details of which actors appear as the authors of demands in individual publications.
[33] Here, too, up to three forecasts per article were recorded in order to reflect the situation that each of the three main actors could make forecasts about the future opportunities of nanotechnology.

actors from the political arena (10.8 %). Figure 19 shows how the above-mentioned groups of actors publicly voice their opinions about the future of nanotechnology.

Fig. 19: Forecasts of the opportunities and risks of nanotechnology



The time-based analysis shows that although coverage in all years can be seen as positive, there is a particularly high number of very positive forecasts in 2005 (93.7 %, n=48) and there is not one single negative estimation of the future. Low proportions of pessimistic forecasts were mainly recorded at the beginning of the study period in 2000 (7.7 %, n=78) and 2002 (14.2 %, n=56) (cf. Table 61). These can be linked to the Bill Joy debate (2000) and coverage of "The Prey" by Michael Crichton (2002).

In the comparison of the various publications, negative estimation*s* of the future are published the most frequently in the *taz* (27.3 %, n=11). In the *Frankfurter Rundschau*, in contrast, the actors frequently express positive forecasts on an above-average scale (95.1 %, n=41) (cf. Table 62).

Table 61: Forecasts about the development of nanotechnology over time (as %)

	2000	2001	2002	2003	2004	2005	2006	2007
Good forecast	85.9	93.2	82.1	91.7	89.9	93.8	91.5	92.7
Poor forecast	7.7	3.4	14.3	6.3	5.8	-	3.2	1.8
Not classifiable	6.4	3.4	3.6	2.1	4.3	6.3	5.3	5.5
Total (N=507)	100 n=78	100 n=59	100 n=56	100 n=48	100 n=69	100 n=48	100 n=94	100 n=55

Table 62: Forecast of the development of nanotechnology in the print media (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus
Good forecast	91.4	83.3	63.6	95.1	94.9	89.4	80	91.3	94.1
Poor forecast	3.1	13	27.3	2.4	3	4.8	10	4.3	-
Not classifiable	5.5	3.7	9.1	2.4	2	5.8	10	4.3	5.9
Total (N=507)	100 n=128	100 n=54	100 n=11	100 n=41	100 n=99	100 n=104	100 n=30	100 n=23	100 n=17

4.6 Processing and conveying the topic

The previous chapters contain an extensive analysis of the characteristics of coverage of the topic nanotechnology – *i.e.* the *what?* We now turn our attention to the *how? o*f coverage. How is the complex area of nanotechnology, which is not socially accessible or perceivable for most people, processed and conveyed in the media? Here we are particularly interested in the identifiable classification of the reported events or incidents concerning nanotechnology and their stylistic interpretation (4.6.1), the figures of speech (4.6.2) and, last but not least, the visualisation of the subject matter (4.6.3).

4.6.1 Stylistic analysis

The first entry point into an article, besides the images which may attract the reader's attention, is the headline. Frequently, headlines are scanned by readers in order to quickly obtain an overview of topical subjects. In 72.2 % of all analysed articles (n=1696) which deal with nanotechnology as the main topic, this subject cannot be identified on the basis of the headline (cf. Table 63). Only 27.8 % of the articles reveal this link in the headline whereby the subject matter is only explicitly assessed in just under half (46.5 %) of these cases (n=471). When explicit evaluations of this kind are made in headlines, only roughly one in seven is negative. This means that only 1.8 % of the analysed articles mention nanotechnology in the headline in a recognisably negative manner.

Table 63: Clear link and explicit assessments of nanotechnology in the article headline

	Frequency	Percent
No link to nanotechnology	1225	72.2
Positive assessment of nanotechnology	189	11.1
Neutral	252	14.9
Negative assessment of nanotechnology	30	1.8
Total	1696	100

It can be concluded that the virtual reader, who only pays attention to the headlines of an article, would have to gain a potentially positive impression of this technology. The coverage in 2004 provides the best preconditions for this with a share of 13.3 % of positive assessments within all headlines. This corresponds to a share of 44.5 % of headlines with a discernible link. By contrast in 2006 most of the article headlines – calculated as a percentage - have negative evaluations (3.7 %, n=215) (cf. Table 64, Annex A). These minor fluctuations on an overall low level would probably be below the perception threshold of a normal reader. In the comparison of the publications the *taz* (n=35) with a proportion of 30.1 % and *Die Welt* (n=379) with 37.1 % evaluative headings are the most prominent. Furthermore, the most positive (50.8 %, n=114) article headlines are found in *Die Welt* and the most negative (23.3 %, n=13) in the *taz* (cf. Table 65, Annex A).

Fig. 20: Examples of headlines with a link to nanotechnology

For nanotechnology	• **"Bonanza for nanotech companies" *(Die Welt*, 03.08.2006)** • **"With nanoparticles directly to the cancer cell" *(taz*, 23.03.2007)** • **"Nanomotor: tiny but powerful" *(Financial Times Deutschland*, 14.03.2006)** • **"Nanotechnology: the smallest particles – the biggest prospects" (*Die Welt*,17.03.2007)** • **"Nanotechnology becomes innovation leader" *(Financial Times Deutschland*, 11.01.2007)**
Neutral	• "Axle for nanocar" *(Frankfurter Allgemeine Zeitung*, 26.03.2007) • "Insect eye from the nanolab"*(Frankfurter Allgemeine Zeitung*, 08.05.2006) • "Nanotools from the tip" *(Financial Times* Deutschland, 12.09.2006)
Against nanotechnology	• "Risky nanoparticles" *(taz,* 14.10.2006) • "Invasion of nanoparticles" (*Frankfurter Allgemeine Zeitung*, 12.01.2007) • "US agency imposes limits on nanotechnology products" (*Financial Times Deutschland*, 24.11.2006) • "Hungry nanobots"*(Frankfurter Allgemeine Zeitung*, 29.11.2002) • "Experts worried about nanotechnology" *(Frankfurter Rundschau,* 27.11.2007) • "Useful nanoparticles can damage cells" *(Die Welt*, 22.02.2005)

Furthermore, clear classification of the processes described and scientific results is of major importance when it comes to shaping the opinions of readers. Only when the article contents could also be assigned to the subject matter area, nanotechnology, by a lay person did they take on informative and evaluative importance for the topic. This condition is met for example by articles that directly mention "nanotechnology". Overall, this classification is considerably more difficult in 17.3 % of the 1696 articles and hence is scarcely identifiable by the non-expert reader. Vice versa this also means that in more than four-fifths of cases the article contents can clearly be classified under nanotechnology. In this context, there is no discernible indication of a link with any initial familiarisation with the subject matter that may be necessary by editorial boards or individual journalists. This identifiability varies considerably. In 2001 (n=233) 85.4 % of the article contents can be clearly classified but in 2002 (n=215) only

77.7 %. The same applies for instance between 2005 (n= 216, 83.8 % identifiable) and 2006 (n=215, 76.7 % identifiable).

If we look at the identifiability of a link to the subject matter in association with the main topic of the article, then articles which focus on the "debate about nanotechnology in general and ethical aspects" (93.5 %, n=62) or questions of "research policy" (98.6 %, n=69) are found to very clearly stress the link to nanotechnology. This classification is slightly more difficult for the application health care (22.2 % of the articles are not clearly classifiable), information and communication technologies (23.2 %, n=241) and not consumer-related applications (25.8 %, n=186) (see Table 66).

Table 66: Identifiability of a link to nanotechnology for the selected topic areas (as %)

	Fundamental research	Application: health care	Consumer-related applications	Application: information and communication technologies	Not consumer-related application	Debates about nanotechnology in general and ethical aspects	Politics	Overview of nanotechnology	Total
No	21.1	22.2	13	23.2	25.8	6.5	1.4	0.7	17.3
Yes	78.9	77.8	87	76.8	74.2	93.5	98.6	99.3	82.7
Total	100 n=579	100 n=126	100 n=69	100 n=241	100 n=186	100 n=62	100 n=69	100 n=139	100 N=1696

In the comparison of the news media the clearest classification for the reader is undertaken by the *Financial Times Deutschland*: 87.7 % (n=293) of the articles explicitly link the contents to nanotechnology. This proportion is far lower for *Der Spiegel* (78.7 %, n=47) and *Focus* (77.3 %, n=44).

In the majority of courses, the journalistic style of the individual articles corresponds to what is expected. More than 90 % of the articles appear as news or reports. Consequently, the journalistic style is descriptive and factual in 90.8 % of the cases (n=1696) (cf. Table 67).

Table 67: Journalistic style in the various forms of coverage

	News	Report	Commentary/column/ editorial	Interview	Portrait	Essay	Total[34]
Descriptive/factual	98	92.6	30.2	60.5	72.7	42.9	90.8
Interpretative/ evaluative/opinionoriented	2	7.4	69.8	39.5	27.3	57.1	9.2
Total	100 n=541	100 n=1031	100 n=63	100 n=38	100 n=11	100 n=7	100 N=1696

Cramer's V=.48, p<.001

If one compares the individual coverage years, then 2000 (n=200) has an above average number of articles (14.5 %) with an interpretative or evaluative style. This can be attributed first and foremost to the Bill Joy debate in the *FAZ*. Within the news media examined coverage by the *taz* (22.9 %, n=35) and *Die Zeit* (25.8 %, n=62) can be described as interpretative and opinion-oriented to an above average degree (cf. Table 68).

In terms of time orientation 91.7 % of all articles (n=1696) refer to the present-day as is to be expected from daily newspapers and topical news magazines. Only 3.3 % focus on events from the past whereas 4.2 % concentrate on the near and 0.8 % on the distant future.

[34] The category "other" (n=5) was not included in this table for technical reasons.

Table 68: Coverage style in the various publications (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
Descriptive/ factual	91.7	89.3	77.1	88.7	94.7	91.1	74.2	89.4	90.9	90.8
Interpretative/ evaluative/ opinion-oriented	8.3	10.7	22.9	11.3	5.3	8.9	25.8	10.6	9.1	9.2
Total	100 n=553	100 n=168	100 n=35	100 n=115	100 n=379	100 n=293	100 n=62	100 n=47	100 n=44	100 N=1696

Besides journalistic style and time orientation, the use of technical terms can also be selected as a descriptive characteristic for the type of coverage. 90.1 % of all articles use technical terms requiring an explanation. 6.7 % even use more than three.[35] In 46.4 % of cases (n=1465) they are explained at least in part. This shows that technical terms are always explained when major recourse is made to technical jargon (Cramer's V=.65, p<.001) (see Table 69). In particular articles on fundamental research make extensive use of technical terms (approximately 970 in 579 articles).

Table 69: Explanation of the technical terms used

	Use of technical terms					Total
	None	1	2	3	>3	
Are not used	100	5.6	3.6	1.6		13.6
Yes, are explained (at least in part)		29.2	49	74	93.9	40.2
No, are not explained		65.2	47.5	24.4	6.1	46.2
Total	100 n=168	100 n=786	100 n=535	100 n=123	100 n=114	100 N=1696

Cramer's V=.65, p<.001

In the comparison of the individual newspapers and magazines technical terms from the technical world are used most frequently in the coverage by *Die Zeit* (m= 2.1; a total of 132 in 62 articles) and *Die Welt* (m= 1.77; 673 in 379).

Besides the use of technical terms comparisons, metaphors as well as positive or negative adjectives can be described as language strategies for depiction. The following section presents the results of the language analysis of the subject nanotechnology.

4.6.2 Language analysis

In order to enable readers to better understand the new technology, several rhetorical devices are used. Comparisons with external reference objects, especially with other technologies like genetic engineering or technological products like asbestos, are designed to permit a fundamental classification and assessment of nanotechnology. Comparisons of this kind were, however, only identified in 4.4 % of all articles. Overall 105 comparisons of this kind were counted[36]. The objects used for comparison are:

- genetic engineering (25.7 %, 27 mentions),
- asbestos (19 %, 20 mentions),
- nuclear age or nuclear power (17.1 %, 17 mentions),
- Internet (7.6 %, 8 mentions),
- thalidomide scandal (4.7 %, 4 mentions),
- BSE (1.9 %, 2 mentions) and
- DDT (1.9 %, 2 mentions).

[35] For an overview see list "Glossary of technical terms" (Annex C).
[36] Three comparisons could be coded per article.

Further comparisons are recorded in an open form. Figure 21 lists all other comparisons which were only identified once.

Fig. 21: Nanotechnology is a.../is like...

Information technology, biscuit industry, constructivistic programme of the creation of a world, lasers, microsystems technology, perpetual motion, the plague, scholarly efforts, black magic, science fiction, sports competitions, Star Trek, Chernobyl, biological weapons, computers, garden hose (nanotubes), industrial revolution, snow flake, transistor, tuberculosis

Table 70 gives the distribution of the individual comparisons over the various years of coverage. Comparisons with asbestos only began in 2003 with an average mention of four per year. 2006 – the coverage year in which the magic nano case is located – reveals a small cluster of comparisons with asbestos, DDT and tuberculosis.

Table 70: Objects of comparison with nanotechnology over time (frequency)[37]

	2000	2001	2002	2003	2004	2005	2006	2007	∑
Genetic engineering	6	1	1	5	5	5	1	3	27
Asbestos	-	-	-	4	4	4	5	3	20
Thalidomide scandal	-	-	-	1	2	-	-	1	4
DDT	1	-	-	-	-	-	1	-	2
Nuclear age/nuclear power	5	2	-	2	5	1	-	2	17
Internet	-	2	1	-	4	-	1	-	8
Other comparison	4	2	7	-	5	2	3	4	27
Total	16	7	9	12	25	12	11	13	105

The most comparisons are used in coverage in the *taz*. Out of 35 articles on nanotechnology there are 5 articles with a total of nine comparisons (see Table 71). If one looks, by contrast, at the frequency of certain comparisons, this reveals that far more frequent use is made of comparisons with genetic engineering in the *Frankfurter Allgemeine Zeitung* (13 out of 27 mentions were found in the *FAZ*) and in the *Financial Times Deutschland* of comparisons with asbestos (7 out of 20 mentions).

Table 71: Objects of comparison with nanotechnology in the individual publications (frequencies)[38]

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
Genetic engineering	13	1	3	2	3	3	2	0	0	27
Asbestos	3	2	2	3	0	7	0	1	2	20
Thalidomide scandal	1	0	1	0	0	1	1	0	0	4
DDT	1	0	1	0	0	0	0	0	0	2
Nuclear age/nuclear power	7	1	1	2	2	2	1	1	0	17
Internet	1	0	1	0	1	2	0	3	0	8
Other comparison	10	4	0	0	7	1	2	3	0	27
Total	36	8	9	7	13	16	6	8	2	105

Besides these somewhat global comparisons with other technologies, figures of speech like comparisons, metaphors or images are mainly used to explain nanotechnological dimensions, processes and methods, and to qualify the future importance attributed to nanotechnology in the overall technological spectrum (cf. Fig. 22). In the analysed coverage a total of 612 explanatory and qualifying comparisons, metaphors, images and analogies were identified in 24.5 % of all cases (corresponds to 415 articles). They endeavour above all to explain to the reader the – in the truest sense of the word - unfathomable size dimension “nano” (35.9 %) Furthermore, definitions are given of the foreign word “nanotechnology” itself in or-

[37] Multiple mentions (3) were possible.
[38] Multiple mentions (3) were possible

der to facilitate more direct understanding of technology and science. In most cases the journalists draw on a direct translation of the word nano “dwarf” (11.4 %). Moreover, certain attributes, comparisons or images aim to qualify the fundamental position of nanotechnology within all technologies by working for instance with a key metaphor or the term revolution (24.3 %).

Fig. 22: Examples of metaphors and images in conjunction with nanotechnology

Upper category	Examples	Frequency
Size comparison	“One thousand times smaller than a body cell”	6
	“A million times thinner than a human hair” (size comparison with the thickness of a hair)	90
	“If one compares the size of a nanoparticle with a football, this corresponds to the ratio between the ball and the earth”	15
	“One nanometre is the millionth part of a millimetre. This corresponds to the size ratio between a hot air balloon and earth”	3
	Mathematical sizes: nanoparticle – no bigger than 10^{-9}	101
Size-related description	“Nanos = Ancient Greek for dwarf”	24
	“Dwarf science”	5
	“Kingdom of dwarves”	16
	“World of the microcosm”	2
Qualification of technology	“Key technology”	40
	“Future technology”	29
	“Cross-sectional technology”	12
Comparisons to revolution/innovation and future viability	“The fabric the future is made of”	1
	“Third industrial revolution”	12
	“Revolution”	25

The above-mentioned figures of speech - comparisons and images – can indeed be understood as neutral or positive. A small share of the identified images (3.9 %, n=612) does, however, refer to the risks of nanotechnology. They are: horror scenario (1.6 %), Pandora's box (1 %, corresponds to 6 mentions), dust (0.3 %) and the designation risk technology.[39]

The time-based analysis shows that the figures of speech listed are used the most at the beginning of the study period (2000: 104 out of 612). Their use steadily declines: in 2007 there are not even half as many (51) as in 2000. In relation to the total number of articles published in the individual magazines and newspapers, no noticeable concentration of one or more publications on a specific figure of speech is observed (Table 72 in Annex A contains the breakdown).

Besides comparisons, metaphors, images and analogies, adjectives are also used to characterise nanotechnology.[40] Whereas positive adjectives are consciously used to an identifiable degree in 21.3 % of the articles, this only happens with negative adjectives in 4 % of the cases (total 102 mentions).

[39] Table 73 in Annex A gives an overview of all images.
[40] Annex B, section b.3 contains a few articles that use figures of speech.

Table 74: Positive and negative adjectives for nanotechnology

	N	Percent
Cheaper	62	11.1
Faster	54	9.7
Scratch-resistant	47	8.4
Intelligent	44	7.9
More efficient	40	7.2
Lighter	32	5.7
More robust	32	5.7
Self-cleaning	30	5.4
Higher perform-ance/stronger	24	4.3
More effective	7	1.2
More environmentally compatible	6	1.1
Self-disinfecting	1	0.2
Magical	1	0.2
Other	177	31.7
Total	557	100

	N	Percent
Other	36	35.3
Dangerous	29	28.4
Artificial	15	14.7
Poisonous/ toxic	13	12.7
Risky	7	6.9
Scary	2	2
Total	102	100

The 177 words described in the table as “other” were openly recorded in a separate variable. Here, further adjectives were identified which are frequently linked to nanotechnology, nanoparticles or products made possible by them: dirt-repellent (4), promising, flexible (3), fine (3), ultra-hard (2), resistant (2) and future-centric (2).

Other negative adjectives were also openly recorded in a separate variable. In their case only (health) impairing (4 mentions), radical (3), threatening (2) and uncontrollable (2) occurred in more than one case.

4.6.3 Image analysis[41]

Besides the language underscoring and visualisation of nanotechnology, images may also be used to render visible a technology which operates in the range of the invisible. This happens in 28.4 % of all articles (n=1696). For the individual articles we found between one and 21 images.[42] The majority, however, contains only one image. Table 75 indicates how many diagrams and images are contained in articles which use visualisation of this kind (n=481).

When it comes to the use of illustrations and images, a major difference is observed, as expected, between the types of media included: news magazines use more visualisation in their articles than daily and weekly newspapers. Whereas in the daily newspapers one or more figures were only identified in one in four articles (26.1 %, n=1605), this proportion is 68.2 % (n=91) in magazines. Furthermore, magazine articles have far more images per article with an average 2.5 diagrams than newspapers per article (m=1.13). In the comparison of newspapers the *Financial Times Deutschland* (in 35.8 % of articles, n=293) and *Die Welt* (25.6 %, n=379) make the most frequent use of images to depict nanotechnology.

[41] It should be pointed out here that the basis for the individual evaluations presented here (figure, image, topic and visualisation) differs even if it refers to the same situation. This is due to the quality of the respective analytical material. In the archive of the *Financial Times Deutschland* figures are depicted as white boxes which means that the topic of the image could in some cases be ascertained from the image caption but no indication could be given of the actual image content. The situation is similar in the case of the archive printouts of *FAZ* from 2000, the *taz* and *Die Zeit*.

[42] 21 images for *Der Spiegel* article “Immersion in the nanocosm” which was longer than 5 pages

Table 75: Number of images/illustrations used per article (n=481)

	Frequency	Percent
1	419	87.1
2	29	6
3	21	4.4
4	4	0.8
5	2	0.4
6	1	0.2
7	2	0.4
10	1	0.2
15	1	0.2
21	1	0.2
Total	481	100

"Fundamental research" was determined as the subject of the images in 38.5 % of cases (566 images). It is followed by not consumer-related applications (12 %) and images which relate to the "application information and communication technologies" (11.1 %).

The most popular image contents are microscope images (42.5 % of the 534 images) which endeavour to render the nanorange of 10^{-9}m visible. Besides that, people (24.3 %) from the sciences or the economy as well as technical devices (12.5 %) and everyday objects (6.2 %) are the preferred objects of visualisation. The above-mentioned image topics are presented in the following way:

Table 76: Overview of the most important visualisation forms of selected image topics

Image topic	Visualisation	Frequency	Percent
Fundamental research	Microscope images	127	58.3
	People	30	13.7
Not consumer-related applications	Microscope images	15	22.1
	Technical devices	14	20.6
	Everyday objects	13	19.1
	People	11	16.2
Application information and communication technologies	Microscope images	26	41.3
	People	19	30.2
	Technical devices	12	19.5

Whereas the *Frankfurter Allgemeine Zeitung* uses microscope images for visualisation in 61.1 % of cases (126 images in the *FAZ*), people are the main focus of images in *Der Spiegel* (31.6 %, n=57), *Focus* (37 %, n=46) and *Die Welt* (30.9 %, n=110). In the comparison of the individual coverage year no noticeable priorities or shifts can be observed[43].

4.7 Framing "nano": Generic and issue-specific framing

4.7.1 Generic framing

Generic media frames are formal-stylistic media frames which are used independently of the respective topic in order to give a specific "face" to the media text which is recognisable by the recipient. In the overview of several of the individual studies a few frames appear that can claim to have a certain degree of "universality" as they can be identified again and again independently of one another in a majority of studies on various media topics. They include conflict framing (each problem always has two antagonistic sides), human interest framing (abstract and general problems are illustrated using individual cases), morality framing (the subject of coverage has a moral dimension), economic framing (there is a concentration on

[43] Examples of images from the analysis of the publications are given in Annex B, B.5.

economic consequences, profits and losses) and attribution of responsibility framing (in conjunction with conflict-ridden topics an attribution of responsibility is undertaken). In order to identify whether, and, if so which of these established frames was adopted in the coverage of nanotechnology, this study drew on the most advanced methods for recording media frames. Using a set of variables developed by Semetko and Valkenburg (2000), which at the same time is designed as a questionnaire consisting of 20 yes-no questions[44] on the text, the five above-mentioned generic frames were operationalised using several individual items. After that sum indices were formed on the basis of the item complex identified by Semetko and Valkenburg (2000: 100) which represented one frame per content. In order to be able to talk about a frame, there had to be at least two items in the sum index concerned. Table 77 presents the results of this two-phase method.

Table 77: Sum indices[45] for the identification of generic frames:

	Frame designation				
	attribution of responsibility	human interest	conflict	morality	economic
Frame *not p*resent	88.3	93.9	97.3	99	90.7
Frame present	11.7	6.1	2.7	1	9.3
Total	100 N=1696	100 N=1696	100 N=1696	100 N=1696	100 N=1696

As can be seen from Table 77, conflict framing and morality framing are only used on a limited scale in the coverage of nanotechnology. The conflict frame can only be attributed to 2.7 % of all articles and the morality frame to 1 %. For the determination of the morality frame, questions were asked about, for example, moralising terms or statements and references to God or religious attitudes.

The conflict frame is observed for the very first time in 2000, the same year as the Bill Joy debate, with a share in coverage of 8 % (n=200). The *taz* (8.6 %, n=35) and *Die Zeit* (8.1 %, n=62) use this framing the most frequently in the comparison of the media examined.

In 2000 – the year in which the subject "debates about nanotechnology in general and ethical aspects" was on the media agenda - the morality frame is used most with a share of 3 % (n=200) in coverage in the time-based comparison. In the individual publications morality framing is used the most frequently in F*ocus* (4.5 %, n=44).

With a proportion of 6.1 % of overall coverage, the human interest frame is scarcely more important. One exception is the time-based comparison. In 2000 (n=200) 17 % of all articles could be assigned to this frame. In particular articles on the topic "debates about nanotechnology in general and ethical aspects" (n=31) were processed in 41.9 % of cases in this form. In the comparison of individual publications this frame can be observed in particular in the coverage of *Die Zeit* (17.7 %, n=62) and *Der Spiegel* (17 %, n=47).

Economic framing does not yet seem to an established form for framing nanotechnology. It is only used in 9.3 % of all articles. This frame is – even if only marginally – observed more frequently in the second half of the study period (2004–2007). In 2004, the coverage year in which the topic nanotechnology and "the economy" had a proportion of 10 %, it even reached a share of 14.1 % (n=248). What should be noted at this point is that the frame-related items focus first and foremost on financial gains or losses and economic consequences. It is, therefore, to be expected that this frame will grow in importance in coverage as a consequence of the increase in ready-to-market applications and products as well as the economic activities of companies in the field of nanotechnology.

[44] The formulation of the items is based on a meta-analysis by the authors of the available framing literature.

[45] For the purposes of operationalisation four items were used for the attribution of responsibility frame, five for the human interest frame, four for the conflict and economic frames and three items for the morality frame.

Table 78: Proportion of the economic frame in coverage over time

		2000	2001	2002	2003	2004	2005	2006	2007	∑
None	Number	189	218	202	184	213	191	188	153	1538
	% of year	94.5	93.6	94	92.5	85.9	88.4	87.4	90	90.7
Economic frame	Number	11	15	13	15	35	25	27	17	158
	% of year	5.5	6.4	6	7.5	14.1	11.6	12.6	10	9.3
Total	Number	200	233	215	199	248	216	215	170	1696
	% of year	100	100	100	100	100	100	100	100	100

The attribution of responsibility frame, with a coverage share of 11.7 % can be described as the most important frame. It was mainly used in 2000 (16.5 %, n=200). The topic "debate about nanotechnology in general and ethical aspects" (58.1 %, n=31) is largely presented in this form. Another main focus is coverage in 2006 (14.4 %, 215) where, for instance, the "Magic Nano" case (37.5 %, n=8) is partly processed in this way.

Overall the individual frames are not used in a clearly distinctive manner or are used as a combination within an article. For instance the morality frame is used in 52.9 % of cases (n=17) in conjunction with the conflict frame and the human interest frames in 44.7 % (n=103) of cases together with the attribution of responsibility frame. Furthermore, not one of the five frames examined could be identified in 78.7 % of all articles (n=1696).

What these results reveal is that coverage of nanotechnology at the present time is only similar in part to the frames that we are familiar with for other topics. This can be taken as an indicator for a social view of nanotechnology which is still emerging and as yet undecided. Established frames like the morality, human interest and conflict frame are found in particular in articles about the topic "debates about nanotechnology in general and ethical aspects" (n=62) in which technology is the subject of a public dispute and hence in just over 3.7 % of the texts. An increase in social discussion could also lead to an increase in these frames. Also the economic frame may grow in importance with the increase in the application orientation and the number of ready-to-market products. As nanotechnology is still currently seen as an emerging technology – both in respect of its maturity and familiarity with it within the population[46] – coverage mainly involves progress and development in the field of research. Hence at the present time the coverage can be described as scientific-technological-descriptive.

4.7.2 Issue-specific framing

Identification of the frames

Besides issue-specific frames, a component model (cf. Chapter 1.2; 2.5.5) – consisting of four frame elements (problem definition, attribution of cause, recommended action and moral assessment) which were each operationalised through several variables – was used to examine the specific frames that can describe coverage of nanotechnology. The frame element – problem definition – is operationalised using the variables "main actor" and "main topic" in the article. This is based on the assumption that an actor places a subject on the media agenda and determines which aspect of nanotechnology is discussed. For the operationalisation of the second frame element – the attribution of cause or causal interpretation – use is made of the variables "actor responsible for the benefit" and "actor responsible for the risk". The third frame element "recommended action" is operationalised through the coded "demands" about handling nanotechnology and the "forecasts" of future developments. Finally, the variable "assessment of nanotechnology" encompasses the fourth frame element

[46] A telephone survey of 1000 people (September-October 2007) on behalf of BfR revealed that around 50% of the respondents did not know anything or anything concrete about the terms nanotechnology or nanomaterials. The other 50% had at least some idea and could further specify the terms (cf. Zimmer/Hertel/Böl 2008: 14).

"(moral) evaluation". In the two-step cluster analysis only those variables are considered which have a frequency of more than 5 % and, by extension, relative importance for the media discussion. Table 79 depicts the operationalisation of the main elements including the variables taken into account.

A two-step cluster analysis[47] (cf. Chapter 2.5.5) was used to determine which variables occur in an above-chance manner in the same article. The above-chance frequency of these characteristics in articles is interpreted as a typical frame. The analysis identified five typical clusters of this kind to which the designations given in the first row are attributed in order to characterise their content. The last two rows in Table 80 show in how many articles in the investigated texts they occurred. In this context each articles only clearly assigned one frame. This (relative) proportion gives an impression of the weight of a frame in the public media discussion of nanotechnology.

Table 79: Operationalisation of the frame elements

Frame elements	Variables	Variables used in the analysis [a]
Problem definition	Main actor	Scientist/scientific institutions Economic actor Journalist
	Main topic	Fundamental research Application medicine/health care Application information and communication technologies Economy Overview of nanotechnology
	Evaluation of benefit	Medical benefit Scientific benefit Economic benefit
	Evaluation of damage	Health risk
Causal interpretation/ Attribution of cause	Responsibility for benefit	Scientist/scientific institutions Economic actor The nanotechnology
	Responsibility for risk	The nanotechnology
Attribution of solution/ Recommended action	Demand Forecast	Regulation of risk Positive forecast Negative forecast
Moral evaluation	Evaluation of nanotechnology	Positive acceptance/evaluation Negative acceptance/evaluation

[a] Only those variables were included in the cluster analysis which have a frequency (valid percentage) of more than 5 %.

In order to examine the content quality of the five-cluster solution, F values, which can serve as the yardstick for homogeneity within the individual clusters and t values, which can serve as the yardstick for heterogeneity between the clusters, were calculated (cf. Backhaus 2003: 533-535). Secondly, discriminance analysis was undertaken with a view to forecasting the affiliation of individual articles to the clusters. Overall 91.2 % of cases could be clearly assigned to the previously determined clusters. This is seen as an acceptable value for its accuracy (cf. Table 81).

Besides the statistical calculation, the cluster solution was also tested in a selection of ten articles which were assigned to each of the individual clusters. This was how content plausibility was confirmed.

[47] The log likelihood measurement, Bayesian information criterion (BIC), was used as the distance measurement for the automatic determination of the number of clusters.

Table 80: Clusters of coverage of nanotechnology

Forms included in the analysis[a]	Cluster I "Research and development" %	Cluster II "Progress in the field of information and communication technologies" %	Cluster III "Economic use" %	Cluster IV "Medical benefit" %	Cluster V "Risk-opportunity discussion" %
Main actor					
Scientist/scientific institutions	**71.5**	33.2	3.2	**58.7**	27.3
Economic actor	2.4	8.6	**73.9**	4.9	9.3
Journalist	-	29.4	7.1	20.3	16.7
Main topic					
Fundamental research	**70.7**	18.5	3.2	4.2	18.5
Application medicine	-	-	-	**83.2**	3.2
Application information and communication technologies	-	**32.5**	**34.6**	-	2.3
Economy	-	-	**39.3**	0.7	5.1
Overview of nanotechnology	-	21	0.4	-	**22.2**
Evaluation of benefit					
Medical benefit	7.9	4.7	3.9	**95.8**	21.8
Scientific benefit	**45.2**	24.5	6.4	3.5	7.4
Economic benefit	11.1	**46.5**	**73.2**	-	22.7
Evaluation of damage					
Health risks	-	-	-	-	**36.1**
Actor responsible for benefit					
Scientist	**51.5**	24.3	3.2	**60.1**	9.3
Economic actor	0.3	0.7	**62.9**	1.4	4.6
The nanotechnology	14.6	**57.9**	22.5	29.4	**44.4**
Actor responsible for risk					
The nanotechnology	-	**6.5**	1.8	1.4	**65.7**
Demands					
Regulation of risk	0.2	-	0.4		**50**
Forecast					
Positive forecast	11.3	**36.9**	27.9	24.5	26.9
Negative forecast	-	-	-	-	**7.9**
Evaluation of nanotechnology					
Positive acceptance/evaluation	**54.4**	**74.1**	**66.1**	**76.2**	31.9
Negative acceptance/evaluation	-	-	0.7	-	**57.9**
N (=1696)	629	428	280	143	216
% (=100)	37.1	25.2	16.5	8.4	12.7

[a] The variables in bold are interpreted as relevant for the respective cluster along the lines of an ideal type.
Please note: the percentages given are column percentages. In cluster 1 "research and development" the persons and institutions from science are, consequently, the main actors in 71.5% of the articles.

Table 81: Classification result of discriminance analysis concerning validation of the cluster solution

	Number of the two-step cluster	Predicted group affiliation					Total
		Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	
Number	Cluster 1	629	0	0	0	0	629
	Cluster 2	49	376	3	0	0	428
	Cluster 3	3	34	243	0	0	280
	Cluster 4	11	12	1	119	0	143
	Cluster 5	14	10	6	7	179	216
%	Cluster 1	100	-	-	-	-	100
	Cluster 2	11.4	87.9	0.7	-	-	100
	Cluster 3	1.1	12.1	86.8	-	-	100
	Cluster 4	7.7	8.4	0.7	83.2	-	100
	Cluster 5	6.5	4.6	2.8	3.2	82.9	100

[A] 91.2 % of the grouped cases were correctly classified.

Content characterisation of the five frames

The first cluster or frame, which has a proportion of 37.1 % in overall coverage and is, therefore, the most important is described here *as "research and* development" (n=629). In the articles that can be assigned to this frame, the main focus of coverage is "fundamental research" whereby scientists are the main actors in 71.5 % of these articles. A further 20.5 % of articles do without a main actor. Mentions of benefits, which occur less frequently in this frame than in others (23.2 % of the articles with *no* mention), describe the scientific findings obtained as the main benefit of nanoresearch. In particular actors from science are deemed responsible for this benefit. Risks (0.7 %, n=629) and demands (0.6 %) concerning the handling of nanotechnology are almost non-existent in this frame. The main actors of this frame evaluate nanotechnology in 68.4 % of cases as very or rather positive. In the other 31.6 % of cases they do not give any evaluation. Overall in this frame the coverage is science-oriented; it only highlights the progress character of research and does not undertake any or scarcely any social contextualisation of nanotechnology which goes beyond that. This type of coverage can also be found in early coverage of genetic engineering (Hampel/Ruhrmann/Kohring/Görke 1998). Annex B.5.1 contains the articles which are deemed to be typical for this frame.

One quarter (25.2 %, a total of 428 articles) of the examined coverage focus on the "application information and communication technologies" from the scientific angle which is why the corresponding frame is called "*progress in the field information and communication technologies*". The main actors here who appear on a significant scale are journalists who evaluate nanotechnology and people from science. Mentions of benefits refer both to the scientific and economic benefits of nanotechnology. "The" nanotechnology is deemed to be responsible for these benefits in more than half of all cases (57.9 %). Risks (7.5 %) and demands (3.3 %) do not play a significant role in this frame either. The evaluation of nanotechnology by the main actors is positive. 87.5 % of the statements by actors (n=362) describe nanotechnology as very positive (48.6 %) or rather positive (38.9 %). In 36.9 % of the articles in this frame forecasts are also made which are 100 % positive. The illustrations in Annex B.5.2 show the article examples selected to illustrate this frame.

The third cluster (16.*5 %, total 280 articles)* is very similar to the frame "*progress in information and communication technologies*". This third frame examines the topic albeit from an economic angle. Hereinafter this frame is called "*economic use". The main a*ctors in 73.9 % of these articles are economic actors. The benefits of nanotechnology are seen in economic improvements (73.3 %, n=280) like new jobs or sales revenue potentials. Various actors (62.9 %) as well as nanotechnology itself (22.5 %) are deemed responsible for this. Similar to the case for frames one and two, there are scarcely any mentions of risks (4.3 % - they are seen above all in the economic area) or demands (1.4 %). General evaluations of nanotechnology and estimates of its future prospects, if undertaken at all, are almost all 100 % positive (cf. illustration in Annex B.5.3).

The fourth and most consistent frame (8.4 %, a total of 143 articles) can be characterised most accurately as "*medical benefit".* In 83.2 % of all articles which could be assigned to this frame, the "health care" application is the focus of coverage. Hence, the main actors are primarily scientists or scientific institutions. All articles also mention one benefit of nanotechnology which is described in 98.5 % of cases as a medical opportunity. These positive prospects are attributed to the actions of scientific actors (60.1 %) and to the potential of nanotechnology itself (29.4 %). The risks of nanotechnology (1.4 %) and demands (0 %) are not relevant in this frame either. Overall, the coverage in this frame is very positive: 84.5 % of the actors' general evaluations are very or rather positive (in the other cases the actors do not make any evaluation). Furthermore, the forecasts are positive in 24.5 % of cases. For examples of articles assigned to this frame see the illustrations in Annex B.5.4.

The fifth and last frame (12.7 %, a total of 216 articles) differs markedly from the four previous ones. In this frame almost all the articles are located in the topic area "debates about nanotechnology in general and ethical aspects" (51 out of 62 articles). It also contains articles in which the "Magic Nano" case is discussed. Another important topic in this frame encompasses overview articles on the opportunities and risks of nanotechnology (22.5 %). The main groups that comment in this frame are scientific actors (27.3 %), public figures (18.5 %) and journalists (16.7 %). In contrast to the above-mentioned frames, benefits (69.4 %) and risks (85.6 %) on nanotechnology are depicted in this frame whereby the risks outweigh the benefits. Almost all the articles that mention risks are in this frame which is called the "*risk-opportunity debate* for that exact reason. Half of the articles, which frame nanotechnology in this way, include demands for risk regulation. In the context of the general risk orientation of the articles, the evaluation of nanotechnology is also rather negative in 57.9 % of cases. Furthermore, negative forecasts are made in 7.9 % of cases. Examples for articles which use this frame are given in Annex B.5.5.

The issue-specific frames over the course of time

What is discussed below is the question whether the presence of the five frames of nanotechnology coverage presented above change over the course of the study period, and if so, how (cf. Table 82).

Table 82: Distribution of the five issue-specific frames during the study period (as %)

	2000	2001	2002	2003	2004	2005	2006	2007	∑
Frame 1	38	42.5	42.8	42.7	30.2	42.1	28.8	28.8	37.1
Frame 2	27	29.6	24.2	21.6	26.2	22.2	21.9	29.4	25.2
Frame 3	10.5	11.6	16.7	12.1	21.8	12.5	26	20.6	16.5
Frame 4	6	6	7.9	11.6	7.7	12.5	6	10.6	8.4
Frame 5	18.5	10.3	8.4	12.1	14.1	10.6	17.2	10.6	12.7
Total	100 n=200	100 n=233	100 n=215	100 n=199	100 n=248	100 n=216	100 n=215	100 n=170	100 N=1696

The *"Research and development"* frame that influences overall coverage is particularly highly represented in the individual study years, too. After all, most of the activities in the field of the current development of nanotechnology are in the field of research. This frame is dominant particularly from 2001 to 2003 with a share of 42.5 % (2001, n=233) and 42.7 % (2003, n=199). This share falls towards the end of the study period (2006, n=215 /2007, n=170) to 28.8 %.

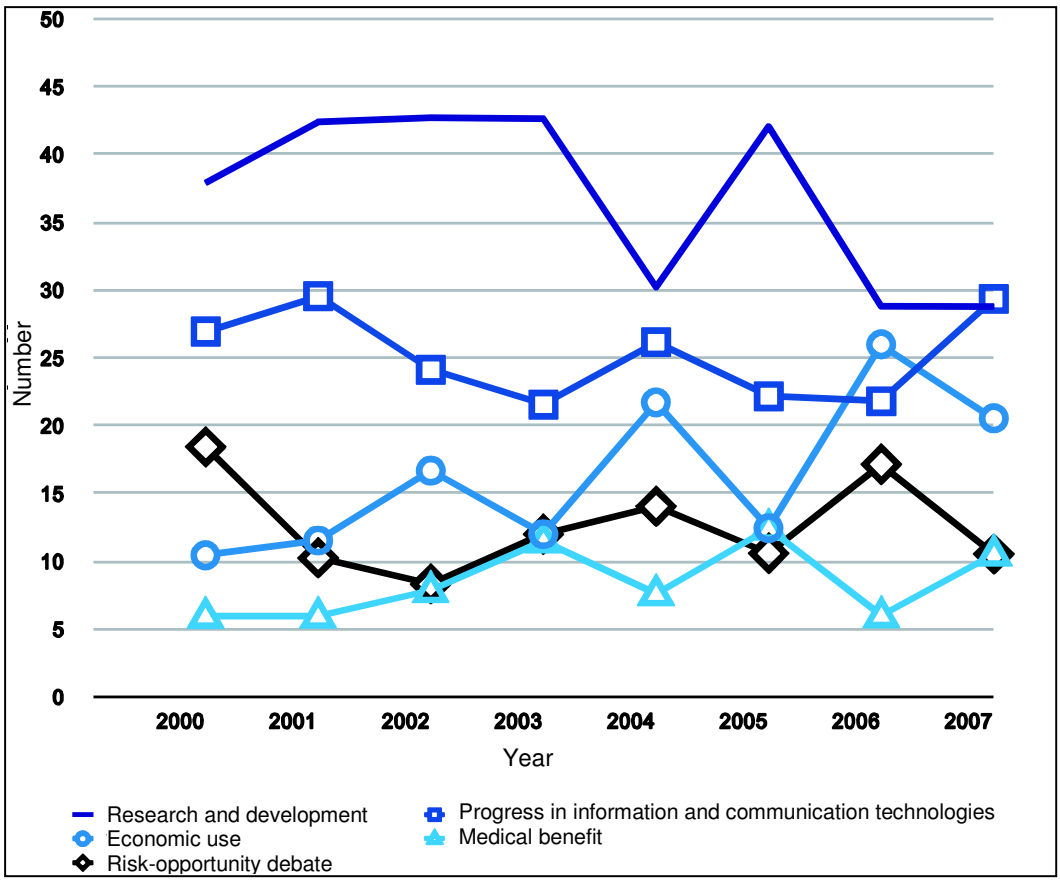
The *"progress in information and communication technologies"* frame is relatively evenly distributed over all coverage years whereby it has the greatest weight in coverage in 2007 (n=170) with 29.4 %. The constant importance of this frame can be attributed to the enormous, publicly visible activities in the field of the computer industry and chip production which points to competition between competing research groups.

Between 2000 and 2005 the *"economic use"* frame - although with far less intensity – shows a similar course to the coverage curve of the previous frame with, however, a time shift compared to the coverage curve of the *"research and development"* frame. This can be explained by the fact that breakthroughs in science and research always trigger discussion about applications and economic importance. Towards the end of the study period and increasing maturity of the technology, this frame seems to stabilise with on average 23 % in 2006 (n=215, 26 %) and 2007 (n=170, 20.6 %).

The presence of the *"medical benefit"* frame runs partially counter to the coverage curve of the two previous frames. In phases of declining coverage in the other two frames, the frame that focuses on the application healthcare and medical benefits records a slight increase (2003: 11.6 %; 2005: 12.5 %; 2007: 10.6 %). In the same way this frame is less important in the peak periods of the other frames. In 2001 its share in coverage is only 6 % and in 2004 7.7 %.

The course of coverage within the frame "risk-opportunity debate*"* can be described as unstable compared to the individual coverage years. The two peaks in the presence of this frame – in 2000 (n=200) with a proportion of 18.5 % and 2006 (n=215) with 17.2 % – can again be attributed to the Bill Joy debate and in part to the "Magic Nano" case. Figure 23 visualises this time-based consideration of the coverage curve of the five frames.

Fig. 23: Coverage curve of the five issue-specific frames (2000–2007)



Issue-specific frames in the individual publications
Differences can also be observed in the comparison of the daily newspapers and magazines examined (cf. Table 83).

Table 83: Distribution of frames in coverage by the individual publications (as %)

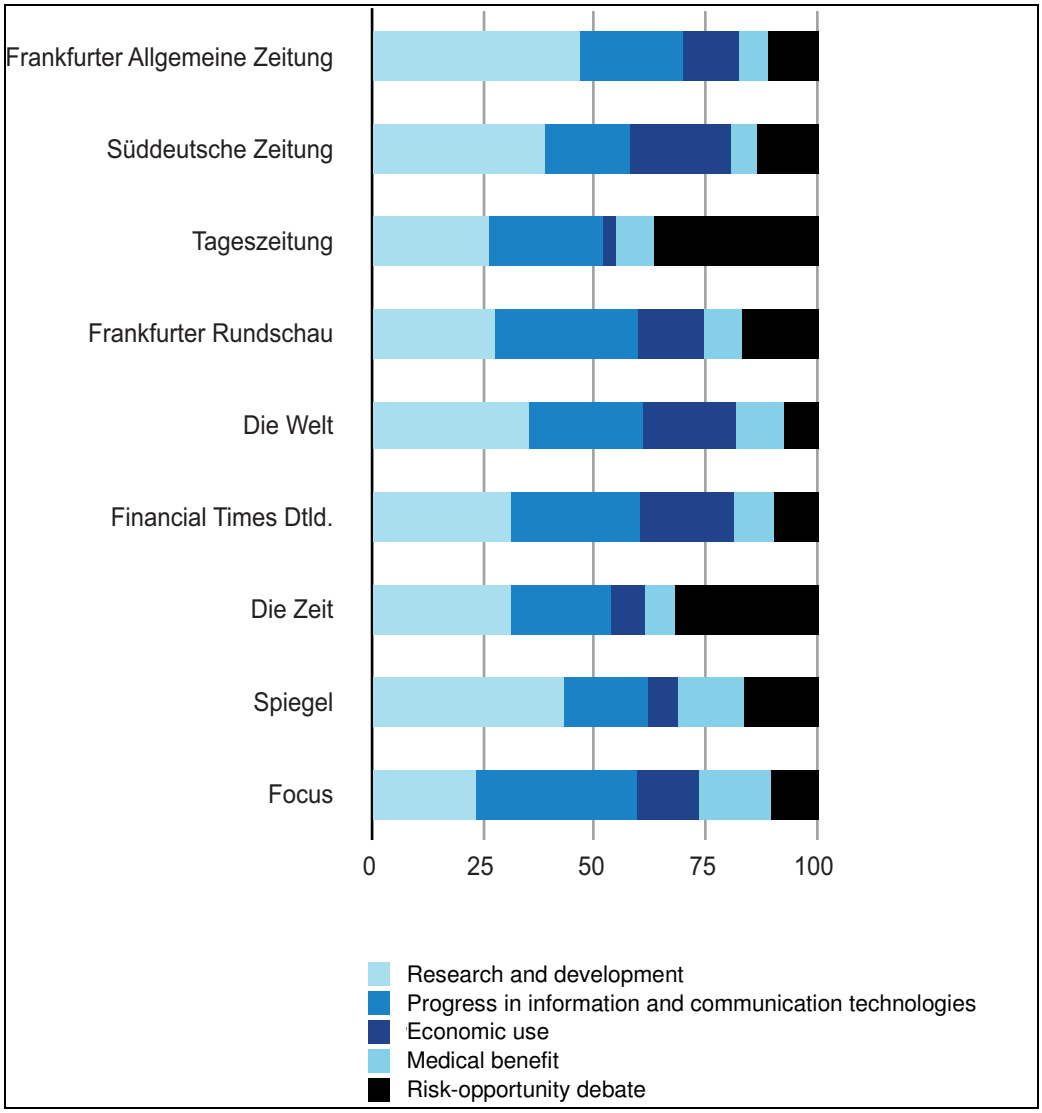
	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
Frame 1	46.1	38.7	25.7	27	34.6	30.4	30.6	42.6	22.7	37.1
Frame 2	23.1	19	25.7	32.2	25.6	29.4	22.6	19.1	36.4	25.2
Frame 3	12.5	22.6	2.9	14.8	21.1	20.8	8.1	6.4	13.6	16.5
Frame 4	6.5	6	8.6	8.7	10.6	8.9	6.5	14.9	15.9	8.4
Frame 5	11.8	13.7	37.1	17.4	8.2	10.6	32.3	17	11.4	12.7
Total	100 n=553	100 n=168	100 n=35	100 n=115	100 n=379	100 n=293	100 n=62	100 n=47	100 n=44	100 N=1696

Out of the daily newspapers the *Frankfurter Allgemeine Zeitung* with a coverage share of 46.1% and the news magazine *Der Spiegel* with 42.6% place the greatest emphasis on the *"research and development"* frame. In these articles which do indeed correspond to the traditional idea of acceptance-oriented communication and popularisation of knowledge (without this necessarily being the journalist's intention), progress in the field of fundamental research is the main focus.

By contrast, the "progress in information and communication technologies" is paid the greatest attention in the coverage of the *Frankfurter Rundschau* (32.2%, n=115) and *Focus* (36.4%, n=44). The economic frame or the "economic use" of nanotechnology frame is present in around one in five articles in the *Süddeutsche Zeitung* (22.6%), *Die Welt* (21.1%) and the *Financial Times Deutschland* (20.8%).

The human and special interest orientation in the two news magazines *Focus* and *Der Spiegel* is reflected in the relatively high proportion of articles which are attributed to the "medical benefit" frame compared to the other publications. *Die Zeit* (32.3%) and the *taz* (37.1%) attract attention above all because they account for around one-third of all reports in the "risk-opportunity debate" frame. Fig. 24 gives the distribution of media frames in nanotechnology coverage in the individual publications.

Fig. 24: Distribution of the media frames in nanotechnology coverage in the individual publications



5 Summary

In our content analysis of "Risk Perception of Nanotechnology in German News Coverage" we examined 1696 articles from seven national dailies and weeklies (*Financial Times Deutschland*, *Frankfurter Allgemeine Zeitung*, *Frankfurter Rundschau, Süddeutsche Zeitung, taz, Die Welt, Die Zeit)* and the two newsmagazines *Focus* and *Der Spiegel* published between 2000 and 2007. The results can be summarised as follows:

- On average, 212 articles on nanotechnology were published per year. The peak value – 248 articles – was reached in 2004. In this respect, the *FAZ* differs significantly from the rest of the media examined. It published 553 articles in total (on average, 69 per year), about 1/3 of our sample. Within the period of our study, there were no major changes in the scale or intensity of media coverage of nanotechnology. After the peak in 2004, there was a slight drop in media attention. These figures can be compared to those of the coverage of genetic engineering: between 1973 and 1985 when genetic engineering was an emerging technology, much like nanotechnology is today. During that period the *FAZ* published on average 24 articles per year. It is interesting to note that in the first year of both study periods: in 1973 and in 2000 there was a call for a moratorium at an early stage in the development of these technologies.
- The predominant form of journalistic presentation is the report. Hence the prevailing tone is factual and descriptive. Articles on nanotechnology are mostly positioned in the science section of the publications (58.5 %); other relevant sections are business and finance (14.2 %) and the feature/arts section (11.6 %). The FAZ is slightly different: almost one-third of the articles were published in its Feuilleton (feature/arts section). This can be interpreted as an indicator for the publication's specific take on nanotechnology that also reflects social and cultural effects. Over the last eight years, nanotechnology only made front page news in one percent of all cases.
- In the majority of cases (82.7%), nanotechnology is discussed in depth. This means that the reader, too, can easily associate all the situations, facts and events with "nanotechnology". In more than a quarter of the articles analysed, the reference to nanotechnology is already identifiable in the headline. If nanotechnology is evaluated in the headline, then this evaluation is generally positive.
- The coverage of nanotechnology focuses in 1/3 of all cases on the results and work in the field of fundamental research. Therefore, coverage of nanotechnology is still largely purely scientific reporting. Another quarter of the articles concentrate on the applications of the new technology, especially in the field of "information and communication technologies" (14.2 %) and other, predominantly not consumer-related applications (11.7 %). Over the entire study period, coverage is dominated by "fundamental research". In the last two years (2006 and 2007) this subject seems to have become less important; this may indicate a shift in the topic structure in future. The year 2000 is the exception. Triggered by the FAZ feuilleton the "Bill Joy Debate" attracted greater attention. However, the "Magic Nano" case, which hit the headlines in March 2006, did not have any impact either on the type or scale of coverage of nanotechnology or on the general evaluation of opportunities and risks.
- We distinguish between the overarching thematic perspective of an article and the choice of individual topics. What is meant is the general perspective used to discuss the diversity of individual articles. Again, our analysis yielded unambiguous results. In 2/3 of all the articles examined, nanotechnology is primarily seen as a field of scientific research. Another quarter of articles consider nanotechnology to be a relevant economic factor. Political and military perspectives are rarely adopted, and in only a few cases are critical ethical or social views expounded.

- In the news media, predominantly scientists (46.6 %) and economic actors (19.6 %) comment on nanotechnology. Another 17.5 % of comments are by journalists themselves. Therefore, published opinion is largely dominated by these three groups of actors. In the context of the "Bill Joy Debate", comments by "public figures" (i.e. representatives of associations, churches, trades unions etc.) are also widely published. Particularly in 2004, political actors made more appearances in debates on educational policy and science support.
- Almost all relevant main actors evaluate nanotechnology as "rather positive" or very positive (70.4 %; n=1452). "Political actors" and "journalists" tend to see nanotechnology as very positive. A more critical stance is adopted by "public figures": 22.8 % of all cases rate nanotechnology as rather negative and a further 17.5 % as very negative (n=57).
- The science coverage of nanotechnology in the narrower sense – particularly of nanotechnology developments that have not yet translated into applications in industrial production – is dominated by scientific institutions, research groups and individual researchers. Topics that cover concrete industrial applications which are, therefore, linked to company activities are dominated by economic players and scientists. Ethical and socio-cultural points of debate are, however, predominantly discussed by representatives of social and other interest groups. The probability of statements by social actors is thus highly dependent on the topic structure of the coverage. In this respect, the media agenda during the study period (2000–2007) clearly favours representatives from the fields of science and the economy.
- So far, coverage has focussed almost exclusively on the opportunities and potential of nanotechnology. Three major types of potential benefits are discussed: "economic" (36.8 % of all mentions), "scientific" (26.5 %) and "medical" (20.6 %). Scientific and economic actors concentrate on the opportunities whereas individual researchers and scientific institutions stress the "scientific" benefits, and economic actors accentuate the "economic" benefits. "Public figures" paint a completely different picture. If they are given an opportunity to voice their opinions – which was rarely the case – they do not mention any benefits in one-third of their comments but do explicitly mention risks in another third, mainly addressing "military", "ethical-moral" and social risks.
- Demands are made first and foremost in combination with risk attributions – this is the case in only 7.8 % of all articles. Around about three-quarters of all claims refer to risk regulation, i.e. the minimization or reduction of potential damages. Demands are mainly advanced by scientific actors (30.6 %). 20.6 % of all demands can be attributed to "public figures" and a further 14.8 % to "political actors". 89.4% of the demands made were generally accompanied by a specific recommended action. The most important recommendation with regard to handling the risks of nanotechnology procedures and products is the "initiation of additional risk research' (19.7 %, n=178).
- The marked research focus in the nanotechnology coverage means that the vast majority of articles (90.1%) use technical terms in need of an explanation. To familiarise a lay audience with the basic concepts of nanotechnology, a small proportion of the articles (4 %) employ comparisons with other technologies (genetic engineering, nuclear power) or technological products (e. g. asbestos). Metaphors, figures of speech and other rhetorical devices are also used to explain nanotechnology itself and to illustrate its general relevance. The imagery used primarily refers to "size", "general qualifications of nanotechnology", "size-based designations" as well as references to innovative processes and the potential inherent in nanotechnology. These rhetorical devices are generally positive; a small proportion use negative associations: "Pandora´s box" (1 %) and "horror scenarios" (1.6 %), for instance. Furthermore, 21.3 % of all articles use adjectives that directly impute positive attributes to nanotechnology; only in 4 % of the articles are negatively connotated adjectives used.

- The central assumption is that the media reduce the complex, diverse phenomenon nanotechnology to a few orientational frames that are found in many individual texts. This assumption was confirmed. Based on the five frames determined in cluster analysis, the analysed articles (N=1696) can be classified as follows: (1) The most important frame is called “Research and development” here. It focuses on the mainly uncritical, descriptive presentation of events and procedures in the field of fundamental research. Here, nanotechnology is an important research field from which important findings can be expected. As a result, the positive evaluation of nanotechnology is associated with the mere scientific knowledge gained; the power of definition remains with the individual researchers. This frame applies to more than one-third of all articles (37%). Two other frames, with a very similar structure, are called “progress in the field of information and communication technologies” (25.2 %) and “economic benefit” (16.5 %). Both frames look considerably beyond mere nanotechnology and focus on specific applications in the field of information and communication technologies or on as yet unspecified economic uses. Both these frames suggest a positive evaluation of nanotechnology by emphasising the opportunities for economic growth and prosperity. In this frame entrepreneurs and managers appear as the “movers and shakers”. They single-handedly dominate the public discussion and claim to be the actors responsible for the economic benefits associated with nanotechnology. Another frame focuses on the application medicine and is very much benefit-oriented. It is, therefore, called “medical benefit”. This frame was identified in around 8 % of the analysed articles. In this context, nanotechnology appears to offer great opportunities for improving medical care and the health of all citizens. The “power of definition” is in the hands of scientists and researchers whose evaluations are extremely positive. Only one out of five frames identified points out that opinions could differ on the subject of nanotechnology. This frame is called the “risk-opportunity debate”. It applies to 12 % of all articles and deals with nanotechnology as a whole instead of addressing specific applications and research fields. According to this frame, the inherent risks are all flatly attributed to “nanotechnology” as such, and not to individual actors. The main criticism is not directed at abstract social risks but at potential concrete dangers for the health of citizens. In this context the demand is advanced for legal regulation in the form of laws and bans.

Outlook

When we finally endeavour to assess the current public perception of nanotechnology, another formerly emerging technology, modern biotechnology, could at least provide some criteria for comparison. Between the early 1970s and the early 1980s, no wide public debate about biotechnology was launched. Media coverage of this technology focused on aspects of technological and social progress. Nevertheless, potential risks were reported right from the outset (cf. Hampel/Ruhrmann/Kohring/Görke 1998; Hampel/Pfenning/Kohring/ Görke/Ruhrmann 2001). This changed when the first (West-)German test-tube babies were born in the mid-1980s. Politicians continued to introduce new research programmes and they also launched several initiatives to prepare for the legal regulation of biotechnology and its impact assessment. A parliamentary commission (Enquete-Kommission), propelled by divergent party interests, conducted a debate on biotechnology that attracted considerable attention in the media. From the mid-1980s until the adoption of the first German law on genetic engineering, a conflict-laden public debate about modern biotechnology took place in the news media. Many influential collective actors participated in this debate, e. g. churches, trade unions and numerous social movements. As no acute biotechnological damages materialised and the first noteworthy economic successes appeared, media coverage from the 1990s onwards focused primarily on the biotechnological benefits. The birth of the cloned sheep Dolly in 1997 did, however, trigger another lively ethical debate. All in all, German coverage of biotechnology by national newspapers can be described as both critical and opportunity-oriented (cf. Görke/Kohring/Ruhrmann 2000; Kohring/Matthes 2002).

Viewed from that angle, nanotechnology can be described as being in the first phase, the progress phase. This phase is still largely oriented towards technological progress and as yet there has been no public debate. At the same time, nanotechnology, unlike biotechnology in the Germany of the 1990s, does not evoke any cultural associations with the National Socialists and their ideology of biological selection, the Frankensteinian problem of scientific hubris as interference with the natural divine order or, simply, the general system of values connected with the Christian idea of divine creation. If it is true that nanotechnology lacks “these characteristics”, then it will not become the subject of critical public debate as long as no large-scale acute damage occurs. “Nano Magic” – the most prominent case of damage in the media coverage between 2000 and 2007 – did not lead to any major swing in the tone of reporting because of its limited impact and because nanotechnology was exonerated of any blame. The incriminated product did not have anything to do with nanotechnology except in name. We will have to wait and see whether a possible future case of damage or the mere reporting of risks could trigger a critical public debate and dent the prevailing, eminently positive general view of nanotechnology. At all events, one frame that was critical of nanotechnology was able to assert itself in the German press. Even if this frame is not at all dominant at the moment, it could recruit new contributors and articles in response to concrete events. In any case it seems advisable to continue monitoring the media coverage and media take on nanotechnology in the future. The news-based “issue attention cycle” will not be completed for some time; in fact it has only just started to develop.

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7 Annex A: Tables

Table 25a: Scientific actors

Scientific actors	Number
Natural scientists	64
(Social) scientists	5
Institut für Nanotechnologie, Karlsruhe	4
Leibniz-Institut für Neue Materialien (INM)	10
Fraunhofer Verbund Nanotechnologie	9
Max-Planck-Institute	50
Royal Society	10
Nano2Life (European Network of Excellence for Nanotechnology)	4
MIT Institute for Technology, Cambridge (Massachusetts)	27
(Group) Harald Fuchs, Münster	5
(Group) Roland Wiesendanger, Hamburg	3
(Group) Hermann Gaub, Munich	10
(Group) Wolfgang Heckl, Munich (LMU, Chair for Nanobiotechnology)	7
Cees Dekker, Dutch physicist (Delfter Institut, NL)	10
Gerd Binnig/Heinrich Rohrer (Inventor of the scanning tunnelling microscope)	6
Günter Oberdörster (nanoexperts/practitioners of environmental medicine)	7
Robert Feynman	92
Physicians/doctors	179
Other scientific institutions/ research groups/scientists	12

Table 25b: Economic actors

Economic actors	Number
Actors on the employer's side	1
Actors on the employee's side	1
Company representatives from the pharmaceutical industry	1
Company representatives from the textile industry	7
Company representatives from the construction industry	6
Company representatives from the chemical industry	25
Company representatives from the automotive industry	9
Company representatives from the information and communication industry	79
Company representatives from the cosmetics industry	2
Company representatives from the food industry (including agriculture)	4
Company representatives from other industrial sectors	6
520	1
BASF	11
Beiersdorf	1
Henckel	4
Nestlé	1
IBM	38
Industry, commerce	2
Other economic actors	61

Table 25c: Public figures

Public figures	Number
Public figures (authors, actors, moderators etc.)	12
Eric Drexler (publicist)	13
Michael Crichton (author)	12
Ray Kurzweil (author)	21
Bill Joy (publicist)	45

Table 38: Concrete mentions of benefits (multiple answers: 3 mentions per article were possible)

	N	Percent
Major sales revenue potential	135	8.4
New jobs	29	1.8
Environmental detoxification	13	0.8
Climate protection	4	0.2
Sustainability effects	3	0.2
Improved efficiency in energy conversion	30	1.9
Reduction of energy consumption	12	0.7
Solving of energy problems	36	2.2
New materials	564	35.2
Medical diagnostics	78	4.9
Medical therapy	169	10.6
Cancer therapy	91	5.7
New medicines	34	2.1
High performance data storage media	42	2.6
Miniaturisation in computers	184	11.5
Improved performance in computers	135	8.4
Individual safety	16	1.0
Superhuman powers	7	0.4
Protection against environmental impact	19	1.2
Total	1601	100

Table 39: Author of the attribution of responsibility by publication (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus
Federal Government	0.2	0.6	-	-	0.2	0.3	-	-	-
Political institutions	0.2	-	-	1.3	-	-	-	-	-
Central body/Institutions and associations	0.3	-	2.8	0.7	-	0.3	-	-	-
Scientific actors/Groups/ Institutions	41.5	35.8	22.2	25.3	38.1	33.9	26.8	50.0	29.3
Economic actors	9.9	17.3	2.8	16.0	17.4	16.1	11.3	4.0	8.6
Public figures	-	1.2	-	-	-	-	-	-	-
Science journalists	-	-	-	0.7	-	-	-	-	-
Journalists	0.2	-	-	-	-	-	-	-	-
Foundations/Science support	0.3	-	-	-	-	-	-	-	-
Other actors	0.3	0.6	-	0.7	-	2.1	-	-	5.2
"Nanotechnology" (object)	47.0	43.9	72.2	55.3	44.3	47.3	62	46	56.9
External circumstances/ Situation	-	0.6	-	-	-	-	-	-	-
Total	100 n=583	100 n=173	100 n=36	100 n=150	100 n=420	100 n=336	100 n=71	100 n=50	100 n=58

Table 47: Concrete mention of risks (Multiple answers: 3 mentions per article were possible)

	Frequency	Percent
Health risk from fine dust	16	5.6
Absorption of nanoparticles through the skin/lungs	56	20.7
Damage to genetic information	5	1.9
Occupational diseases	1	0.4
Nanoparticles in the water cycle	1	0.4
Absorption of nanoparticles by plants	1	0.4
Destruction of the biosphere	5	1.9
Other environmentally damaging effects	5	1.9
Artificial intelligence	11	4.1
Transcending the human/post-humanism/trans-humanism	20	7.4
Nano-divide	1	0.4
Nanorobots/microrobots (Crichton, Prey)	34	12.6
Self-assemblers/replicators	26	9.6
Grey goo	12	4.4
Creation of artificial organisms	6	2.2
Technology abuse	19	7.0
Science-based mass destruction	6	2.2
Other	45	16.7
Total	270	100

Table 52: Comparison of the opportunity-risk orientation between the news media (as %)

Assessment	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
Neutral	15.7	16.7	11.4	3.5	9.8	8.5	8.1	10.6	4.5	11.6
Opportunity-oriented	70.5	70.2	48.6	78.3	81.3	80.5	56.5	70.2	84.1	74.5
Opportunities outweigh risks	4.2	5.4	11.4	5.2	3.4	5.8	12.9	10.6	2.3	5.1
Balanced (opportunities and risks)	4.9	4.2	14.3	2.6	2.1	2.7	9.7	2.1	4.5	4.0
Risks outweigh opportunities	1.3	0.6	2.9	1.7	0.8	1.0	4.8	-	-	1.2
Risk-oriented	3.4	3.0	11.4	8.7	2.6	1.4	8.1	6.4	4.5	3.7
Total	100 n=553	100 n=168	100 n=35	100 n=115	100 n=379	100 n=293	100 n=62	100 n=47	100 n=44	100 N=1696

Table 59: Authors of the demands in the various publications (as %; N=189)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus
Federal Government	-	10.5	-	4.3	-	-	-	-	-
(Other) Political actors	5.4	10.5	11.1	26.1	-	8.7	-	-	50.0
Political institutions	9.5	-	-	-	5.6	-	5.0	-	-
Central body/institutions and associations	9.5	15.8	11.1	-	5.6	13.0	10.0	-	50.0
Scientific actors/groups/institutes	29.7	42.1	-	34.8	38.9	26.1	30.0	-	-
Economic actors	4.1	-	-	4.3	5.6	21.7	10.0	100.0	-
Public figures	24.3	15.8	11.1	13.0	38.9	4.3	30.0	-	-
Environmental associations	4.1	-	11.1	-	-	-	-	-	-
Social groups	5.4	-	33.3	8.7	5.6	4.3	10.0	-	-
Science journalists	1.4	-	-	-	-	-	-	-	-
Journalists	2.7	5.3	22.2	8.7	-	17.4	5.0	-	-
Other actors	4.1	-	-	-	-	4.3	-	-	-
Total (N=189)	74.0	19.0	9.0	23.0	18.0	23.0	20.0	1.0	2.0

Table 64: Annual comparison of the assessment of nanotechnology in article headlines (as %)

	2000	2001	2002	2003	2004	2005	2006	2007	∑
No link to nanotechnology	78.5	74.7	74.0	69.3	70.2	74.5	64.7	72.4	72.2
Positive assessment	9.0	11.2	11.6	12.1	13.3	9.3	9.8	12.9	11.1
Neutral	11.5	13.7	13.5	17.1	14.9	13.4	21.9	12.4	14.9
Negative assessment	1.0	0.4	0.9	1.5	1.6	2.8	3.7	2.4	1.8
Total	100 n=200	100 n=233	100 n=215	100 n=199	100 n=248	100 n=216	100 n=215	100 n=170	100 N=1696

Table 65: Assessment of nanotechnology within the article headings of the publications examined (as %)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
No link to nanotechnology	71.6	75.6	62.9	76.5	69.9	73.4	72.6	72.3	75	72.2
Positive assessment	10.7	6.0	8.6	14.8	15.3	10.2	11.3	2.1	9.1	11.1
Neutral	16.5	14.9	20.0	7.8	13.5	14.7	14.5	25.5	11.4	14.9
Negative assessment	1.3	3.6	8.6	0.9	1.3	1.7	1.6	-	4.5	1.8
Total	100 n=553	100 n=168	100 n=35	100 n=115	100 n=379	100 n=293	100 n=62	100 n=47	100 n=44	100 N=1696

Table 72: Use of images in the individual publications (frequencies)

	FAZ	SZ	taz	FR	Welt	FTD	Zeit	Spiegel	Focus	∑
Size comparisons	58	30	3	31	45	37	6	6	4	220
Reference to materiality and its potential	9	1	0	0	2	2	0	0	0	14
Formulations which illustrate the relationship to nature	4	1	0	1	1	1	2	0	0	10
Size-related description	13	5	2	8	18	13	4	4	3	70
Reference to visibility or sensory perceptibility	1	0	0	1	1	0	0	1	0	4
Reference to revolution, innovation and future viability	13	4	6	9	8	4	7	7	2	60
Negative images or metaphors	8	2	0	3	2	1	1	2	0	19
Designations for nanotechnology as a whole	26	10	1	13	18	13	5	2	1	89
Other descriptive terms	4	0	1	0	0	5	4	1	0	15
Other images	29	15	3	11	16	15	13	2	7	111
Total	165	68	16	77	111	91	42	25	17	612

Table 73: Images used in conjunction with nanotechnology (n=612)

	N	%
Mathematical indications of size (nanoparticles – no larger than 100 x 10^{-9}, millionth of a millimetre)	101	16.5
One million times thinner than a human hair (comparison with the thickness of a hair)	90	14.7
Key technology	40	6.5
Science Fiction	30	4.9
Future technology	29	4.7
Revolutionising/revolution	25	4.1
Nanos = Ancient Greek for dwarf	24	3.9
Kingdom of dwarves	16	2.6
Size comparison: the size of a nanoparticle is compared to a football, corresponds to the ratio between (…)	15	2.5
Third industrial revolution	12	2.0
Cross-sectional technology	12	2.0
Hype word/hype technology	12	2.0
Horror scenario	10	1.6
Learning from nature	8	1.3
One thousand times smaller than a cell in the human body	6	1.0
World of the millionth of a millimetre	6	1.0
Pandora's box	6	1.0
Basic technology of the twenty-first century	6	1.0
True to scale comparison: Moving a molecule with the tip of a microscope is like wanting to (...) with the tip	5	0.8
Dwarf science	5	0.8
Technology of dwarves	4	0.7
The kingdom of atoms (molecules)	4	0.7
A nanometre is the millionth part of a millimetre; this corresponds to the size relationship between a hot air balloon and (…)	3	0.5
Smallest of all worlds	3	0.5
Lilliput	3	0.5
Invisible partners	3	0.5
Bio(-), Nano(-), Info(-)	3	0.5
Scarcely imaginable small world	2	0.3
World of the microcosm	2	0.3
Dust	2	0.3
Risk technology	2	0.3
The stuff the future is made of	1	0.2
Tool box	1	0.2
Formulations which illustrate the relationship to nature	1	0.2
Overcoming dependency on nature and its forms/overcoming nature	1	0.2
Quantum world	1	0.2
Limit of visibility	1	0.2
Gold rush atmosphere	1	0.2
Nano, a future-centric word	1	0.2
Change in paradigms	1	0.2
Miracle	1	0.2
Golden age	1	0.2
Nanoists	1	0.2
Other images/metaphors	111	18.1
Total	612	100

8 Annex B: Examples of articles and illustrations

B 1: Examples of articles which could not be assessed as articles on nanotechnology because they did not mention it all or only mentioned it in passing (I–III) examples of articles which use the partial word “nano*” without any link to nanotechnology

Example I: (…) “The shares of the nanotechnology company Neosino increased by about 170% since the IPO at the beginning of January.” (Die Welt, 27.01.2007, p. 19)

1007 jk

Beteiligungsfirma Bavaria mit Kursplus zum Börsendebüt

Frankfurt/Main –Die Münchener Beteiligungsfirma Bavaria Industriekapital hat am Donnerstag ein Börsendebüt mit steigenden Kursen gegeben. Die im Wachstumssegment Entry Standard für kleine und mittelgroße Unternehmen notierten Bavaria-Papiere stiegen an ihrem ersten Handelstag bis auf 29,87 Euro, ein Plus zum Ausgabepreis von 26 Euro von rund 15 Prozent. Am Nachmittag wurden die Bavaria-Papiere zu 29,40 Euro gehandelt. Damit konnte schon der dritte Börsenneuling im Segment Entry Standard in diesem Jahr Kursgewinne verbuchen. Die Aktien des Nanotechnologie-Unternehmens Neosino sind seit der Erstnotiz Anfang Januar um rund 170 Prozent gestiegen; die Papiere des seit Mitte des Monats notierten Multimedia und SMS-Dienstleisters Convisual gewannen seither rund 50 Prozent.

Bavaria hatte inklusive Mehrzuteilungsoption 575 000 Aktien in einer Spanne von 22 bis 26 Euro zur Zeichnung angeboten. Das Emissionsvolumen beläuft sich auf bis zu rund 15 Mio. Euro. Bei vollständiger Plazierung befinden sich nach dem Börsengang 28,4 Prozent der Bavaria-Anteile im Streubesitz, rund zwei Drittel verbleiben beim Management.

Mit den Einnahmen aus der Aktienplazierung will die Gesellschaft den Kauf größerer Beteiligungen stemmen. Bavaria übernimmt vor allem sanierungsbedürftige Firmen, um sie rentabel zu machen und einige Jahre später gewinnbringend zu verkaufen. Die 2002 gegründete Beteiligungsgesellschaft hat derzeit zehn Firmen im Portfolio, darunter den Autozulieferer Paulmann & Crone und den Küchenhersteller Alma. Der im Oktober gestartete Entry Standard konnte bis Ende 2005 bereits 20 Notierungen auf dem Kurszettel verbuchen. Wegen der niedrigen Transparenzanforderungen im Vergleich zu Prime Standard und General Standard und der oftmals niedrigen Liquidität der notierten Aktien spricht die Deutsche Börse mit dem auf dem Freiverkehr aufbauenden neuen Börsensegment vor allem professionelle Anleger an. *rtr*

Example II: (…) above all in bio- and nanotechnology (FAZ, 06.02.2006, p.4)

SPD setzt auf Nein zu Atomkraft

Wahlparteitag der baden-württembergischen Sozialdemokraten

rso. STUTTGART, 5. Februar. Die baden-württembergische SPD will mit landespolitischen Themen und einem klaren Nein zur Laufzeitverlängerung für Atomkraftwerke im Landtagswahlkampf um Stimmen werben. Die Spitzenkandidatin Ute Vogt wandte sich am Samstag in Stuttgart gegen die EU-Dienstleistungsrichtlinie in ihrer derzeitigen Form, sprach sich dafür aus, freiwillige Vereinbarungen über die Verkehrssprache auf deutschen Schulhöfen zu treffen, und forderte mehr Geld für Bildung und Qualifizierung. „Wir wollen in Bildung investieren und dafür Landesbeteiligungen und die Landesstiftung veräußern“, sagte Frau Vogt. Ministerpräsident Oettinger (CDU) nannte sie einen „Mini-Merz“, der nach der Bundestagswahl nicht begriffen habe, daß die Bürger radikale wirtschaftsliberale Reformen nicht wollten. Die SPD sei die politische Kraft, die den „sozialen Zusammenhalt“ organisiere. Die Parteitagsdelegierten verabschiedeten am Samstag einstimmig das „Regierungsprogramm“ mit dem Titel „Mehr Gerechtigkeit“. Darin wird in Anlehnung an den früheren sozialdemokratischen Landesminister Spöri eine „dialogorientierte Wirtschaftspolitik“ sowie ein stärkerer Wissenstransfer in die Wirtschaft gefordert – vor allem in der Bio- und Nanotechnologie. Zur Energiepolitik heißt es: „Wir werden den Atomkonsens ohne Abstriche umsetzen. Mit uns wird es keine Verlängerung der Laufzeiten von Atomkraftwerken geben.“ Eine Aussage zur Kontingentübertragung von Kraftwerkskapazitäten gibt es nicht. Die Landesregierung möchte die Laufzeit für den Kraftwerksblock Neckarwestheim I über das Jahr 2009 hinaus verlängern. Die SPD hatte in der vergangenen Woche auch mit einer Unterschriftensammlung gegen den „Ausstieg aus dem Atomausstieg“ begonnen.

Die SPD fordert in ihrem Wahlprogramm auch die Einführung der sechsjährigen Grundschule. Außerdem spricht sie sich deutlich gegen Gebühren im Erststudium aus. Die CDU-FDP-Koalition hatte kürzlich beschlossen, 500 Euro Studiengebühren pro Semester zu erheben. Zur Wahlkampfstrategie heißt es in der SPD, daß die Partei darauf setze, sowohl im „linksbürgerlichen Milieu“ als auch im „Facharbeitermilieu“ Stimmen zu gewinnen. Mit ihrer eindeutigen Ablehnung von Studiengebühren hofft die SPD auf die Stimmen von Wählern in den Universitätsstädten Tübingen, Freiburg oder Konstanz, die zwischen SPD und Grünen schwanken. Mit Kritik an der EU-Dienstleistungsrichtlinie und an den geplanten Entlassungen bei Daimler-Chrysler will die SPD Facharbeiter ansprechen, die von der wirtschaftlichen Entwicklung und der Globalisierung verunsichert sind.

Von der Bundespolitik der SPD in der großen Koalition könne man angesichts der guten Umfragewerte der Bundeskanzlerin kaum profitieren, heißt es in der Landespartei. Deshalb gelte es, mit „Landesthemen einen Landtagswahlkampf“ zu führen.

Nach der jüngsten Meinungsumfrage würde die SPD 29 Prozent der Stimmen erhalten, die CDU 45 Prozent. Im Jahr 2001, als Frau Vogt gegen den früheren Ministerpräsidenten Teufel antrat, bekam sie 33,3 Prozent. Auf die Frage, wen die Bürger in Baden-Württemberg zum Ministerpräsidenten wählen würden, nannten 39 Prozent den amtierenden Ministerpräsidenten Oettinger und 33 Prozent die SPD-Spitzenkandidatin. Der geringe Vorsprung Oettingers bei den Persönlichkeitswerten führt im SPD-Landesverband zur Annahme, daß sie ihren Stimmenanteil noch steigern kann. Die Delegierten feierten Ute Vogt auf dem Parteitag über fünf Minuten mit tosendem Applaus – dafür hatte auch die Parteitagsregie gesorgt, weil Ministerpräsident Oettinger vor einer Woche in Offenburg nur mäßigen Beifall bekommen hatte.

Example III: Mere mention (taz, 25.01.2006, p. 18)

Elite-Favoriten: Was sie forschen 1010 jk

Die Exzellenzinitiative besteht aus drei Förderlinien. Graduiertenschulen, Exzellenzclustern und Zukunftskonzepten, sprich: Elite-Unis. Die folgende Liste nennt die Kategorie, die Uni, die Zahl der favorisierten Schools beziehungsweise Cluster und deren Themen.

Graduiertenschulen:
RWTH Aachen (4) – Aachen Institute for Computational Engineering Science; Graduate School (GS) for Applied Informatics; Engineered Materials Unlimited; Medically- and Bio-Engineered Materials; **FU Berlin,** GS of North American Studies. **HU Berlin,** GS of Mind & Brain. **TU Berlin,** Berlin Mathematical School. **Uni Bielefeld** (2) – Int. GS in History, Sociology and Politics, GS of Education and Capabilities. **Ruhr-Uni Bochum,** Ruhr Research School. **Uni Bonn** (2) – GS of Economics, GS in Physics and Astronomy. **TU Braunschweig,** Int. GS of Metrology. **Uni Bremen** (2) – Int. GS of Social Sciences; Marine Realm. **TU Dresden,** Int. GS for Biomedicine and Bioengineering. **Uni Erlangen-Nürnberg,** GS in Advanced Optical Technologies. **Uni Frankfurt/M** (2) – Int. GS for Translational Biomedicine; Otto Stern PhD-School in Natural Sciences. **Uni Freiburg** (2) – Molekulare Zellforschung; Polymer Sciences and Microsystems. **Uni Gießen,** Study of Culture. **Uni Göttingen,** GS für Geisteswissenschaften und Theologie. **Med. Hochschule Hannover,** Biomedical Research School. **Uni Hannover,** Multiscale Modelling. **Uni Heidelberg,** GS of Fundamental Physics. **Uni Hohenheim,** Food Systems, Life Sciences. **TH Karlsruhe,** Optics & Photonics. **Uni Köln,** GS Biowissenschaften. **Uni Mainz,** Material Science. **Uni Mannheim,** Mannheim GS. **Uni München** (2) – GS of Science; GS of Systemic Neurosciences. **TU München** (2) – GS of Science and Engineering; Munich Mathematical Science Center. **Uni Stuttgart,** GS for Advanced Manufacturing Engineering. **Uni Tübingen,** Textuality & Dynamics of Cultures. **Uni Ulm,** Molecular Medicine. **Uni Würzburg,** GS for Life Science

Förderlinie Exzellenzcluster:
RWTH Aachen (2) – Technology for High-Wage Countries; High-Speed Mobile Information. **FU Berlin,** Governance in a Globalized World. **HU Berlin** (2) – Materials in New Light; Cell Differenciation. **TU Berlin** (2) – Communcation Cluster; Concepts of Catalysis. **Uni Bonn,** Mathematics. **Uni Bremen,** Ocean Margins. **Uni Darmstadt** (2) – AmbientWeb: Intelligent Objects; Multiscale Engineering Advanced Devices. **Uni Dresden,** From Cells to Tissues to Therapies. **Uni Erlangen-Nürnberg,** Advanced Materials. **Uni Frankfurt/M,** Macromolecular Complexes. **Uni Freiburg,** Microsystems and Functional Materials. **Uni Gießen,** Cardio-Pulmonary Systems. **Uni Göttingen** (2) – Molecular Physiology of the Brain; Haeckel Centre for Biodiversity Research. **Uni Hamburg** (2) – Light and Matter; Atomically Tailored Materials. **Med. HS Hannover** (2) – Reconstructive Therapy. **Uni Heidelberg,** Cellular Networks. **TH Karlsruhe, Nanostructures**. **Uni Kiel** (2) – Future Ocean; Inflammation at Interfaces. **Uni Köln,** Media. **Uni Konstanz,** Grundlagen von Integration. **Uni Leipzig,** Tissue Regeneration. **Uni Marburg,** Converging Sciences. **Uni München** (4) – Innovation; Protein Science; Photonics; **Nanosystems**. **TU München** (3) – Technical Systems; Green Revolution II; Origin of the Universe. **Uni Oldenburg,** Hearing Disorders. **Uni Stuttgart,** Simulation. **Uni Tübingen,** Neurosciences. **Uni Würzburg,** Immune Surveillance

Elite-Unis:
RWTH Aachen, FU Berlin, Uni Bremen, Uni Freiburg, Uni Heidelberg, TH Karlsruhe, Uni München, TU München, Uni Tübingen, Uni Würzburg

25.01.06 taz Bildung 110 Zeilen TAZ-Bericht S.18

Example IV: "Nano" as a reference to the size range The 45-minute film rarely reaches the nanolevel of thoughts and values which Schätzing constantly seeks." (Süddeutsche Zeitung, 19.05.2007)

stimmend ist.

1036 jk

Unschlagbar selbstsicher

Ein Filmporträt des Schriftstellers Frank Schätzing

Der Kölner Frank Schätzing, weltweit gekaufter Schriftsteller von Öko- und Köln-Krimis, so etwas wie Kölns Nationalheiliger nach Adenauer und vor Podolski, dieser Frank Schätzing also sagt im Arte-Porträt über seine Heimat: „Erstaunlich, dass so viele hässliche Häuser etwas Schönes ergeben." Und der Dom, der bestehe doch nur „aus Stein und Taubenscheiße".

Wie zum Trotz lässt die Kölnerin Andrea Klüting den Autor zur attraktiven Touristentour in der Rheinstadt ausschwärmen. Dom, Philharmonie, Hohenzollernbrücke. Viel schöner Stein und Taubenscheiße. Schätzing, und nur er, erzählt dazu aus seinem Leben. Harmonisches Elternhaus, Schulniete in Naturwissenschaften, die Anfänge als Werbetexter, der Durchbruch als Autor mit dem maritimen Thriller *Der Schwarm*. Das Intimste, was man im Film zu sehen bekommt, ist die türkisfarbene E-Gitarre, auf der Schätzing seine Musikerambitionen auslebt. Auf die „Nano-Ebene" der Gedanken und Werte zu stoßen, die Schätzing stets sucht, gelingt dem 45-minütigen Film selten.

Besonders ausführlich erzählt Schätzing, was genau ihn zum *Schwarm*-Stoff motivierte und sich durch den Erfolg geändert hat. Der Bestseller soll nun verfilmt werden – die Rechte liegen bei der Schauspielerin Uma Thurman und dem Produzenten Michael Souvignier, der auch dieses Arte-Porträt produzierte –, und Schätzing traut sich durchaus die Regie zu. Er ist unschlagbar selbstsicher. Das ist dokumentiert. In einer *Monitor*-Ausgabe tauchte Schätzing zu Jahresbeginn als Gewährsmann dafür auf, dass die Gletscher schmelzen. Klimaschutz ist populär, Schätzing fast populärer.

Einmal zeigt er sich bei genüsslicher Speise in einem guten Restaurant. Sollen die Leute denken, er sei ein „dekadentes Arschloch". Plagen einen wie ihn Zweifel oder Ängste? Tatsächlich doch? Dass er die Welt durch seine Liebe zur Wissenschaft so sehr seziere, dass er sie nicht mehr zu etwas Schönem zusammensetzen könne, das fürchte er. Andererseits habe er erkannt (und meint das bestimmt nicht monetär): „Man kann einen Teil der Naivität, die man braucht, um genießen zu können, wieder zurückholen." Mit der Sicht auf Köln klappt's da schon prima. Schätzing sagt: „Köln ist vom Herzen schön." Klar. SENTA KRASSER

Mein Leben – Frank Schätzing, Arte, Samstag, 17.30 Uhr.

Example V: Use of the partial word “nano” to create a new product name iPod Nano (FAZ. 25.03.2006, p. 18)

Kurze Meldungen

British Airways saniert Fonds

British Airways (BA) saniert den betriebsinternen Pensionsfonds. Um die aktuelle Deckungslücke zu beseitigen, stellt Europas drittgrößte Fluglinie als einmalige Zahlung 500 Millionen Pfund (720 Millionen Euro) bereit. Gleichzeitig soll das Rentenalter für die BA-Belegschaft durchschnittlich um jeweils fünf Jahre erhöht werden, teilte Konzernchef Willie Walsh in London mit. Fondsmanager nahmen die Vorschläge mit Erleichterung auf, in der Belegschaft ist der Sanierungsplan jedoch höchst umstritten. Führende Banken hatten zuvor gewarnt, daß das Pensionsdefizit bedrohliche Ausmaße erreicht hätte. Die Deckungslücke im Pensionsfonds beträgt 1,4 Milliarden Pfund. *(ufe.)*

Lufthansa erhöht bei Fraport

Die Deutsche Lufthansa hat ihren Anteil am Flughafenbetreiber Fraport in den vergangenen Wochen auf 9,1 Prozent aufgestockt. „Wir bewegen uns weiter in Richtung zehn Prozent“, sagte eine Lufthansa-Sprecherin am Freitag. Konzernchef Wolfgang Mayrhuber hatte am Vortag in einer Analystenkonferenz die Erhöhung des Fraport-Anteils angesprochen. Die Fluggesellschaft war im vorigen Oktober beim Betreiber ihres wichtigsten Flughafens eingestiegen und hatte im November die Fünf-Prozent-Schwelle überschritten. Lufthansa strebt auch einen Sitz im Aufsichtsrat von Fraport an. *(Reuters)*

Toshiba gewinnt Patentklage

Der japanische Computerkonzern Toshiba hat am Freitag eine Patentklage gegen den südkoreanischen Chiphersteller Hynix gewonnen. Nach der Entscheidung eines Tokioter Gerichts muß Hynix den Verkauf von NAND-Speicherchips in Japan einstellen, teilte Toshiba mit. Hynix kündigte an, gegen das Urteil Berufung einzulegen. Ein Hynix-Sprecher sagte, das Urteil betreffe nur einen Teil seiner NAND-Chipprodukte. Das japanische Unternehmen hatte im Jahr 2004 Patentklage gegen Hynix eingereicht. Toshiba zufolge verstößt Hynix bei NAND-Speicherchips gegen Patente des japanischen Unternehmens. Hynix ist der weltweit zweitgrößte Produzent von NAND-Speicherchips nach Samsung Electronics. Diesen Halbleitern wird großes Wachstumspotential vorausgesagt. Sie kommen vorwiegend in Digitalkameras und digitalen Musikabspielgeräten wie dem iPod Nano vom amerikanischen Computerkonzern Apple zum Einsatz. *(Reuters)*

Deutsche Wohnen trennt sich

Die Deutsche Wohnen AG hat die verbliebene Verbindung mit der Deutsche-Bank-Tochtergesellschaft DB Real Estate gelöst. Wie das Immobilienunternehmen mitteilte, stimmte die außerordentliche Hauptversammlung der Deutsche Wohnen der Aufhebung des Beherrschungsvertrags mit der DB Real Estate Management GmbH zu. Die tatsächliche Entflechtung bedarf noch der Zustimmung der DB Real Estate Management GmbH. Die Deutsche Bank beziehungsweise ihre Tochtergesellschaft ist zwar nicht an der Deutsche Wohnen beteiligt, aber durch den Beherrschungsvertrag bilanziell mit dem Unternehmen verflochten. Der Beherrschungsvertrag war der DB Real Estate zugestanden worden, nachdem dort den Aktionären der Deutsche Wohnen ein Andienungsrecht für ihre Aktien eingeräumt worden war. *(Dow Jones)*

Südleasing wächst

Mit einem Zuwachs im Neugeschäft von fast 18 Prozent auf 2,75 Milliarden Euro hat die Südleasing GmbH das Jahr 2005 abgeschlossen. Besonders kräftig um 55 Prozent wuchs das Immobilienleasing mit einem Neugeschäft von 410 Millionen Euro. Mit dem Kraftfahrzeugleasing erzielte das Unternehmen 305 Millionen Euro Neugeschäft (plus 15 Prozent), mit Mobilienleasing 2,03 Milliarden Euro (plus 13 Prozent). Besonders wachstumsstark war bei der Tochtergesellschaft der LBBW das internationale Geschäft mit einem Plus von 46 Prozent. Stärkster Markt ist Nordamerika, gefolgt von Österreich und Spanien. Vor Steuern stieg das Ergebnis um 20 Prozent von 67 Millionen Euro. *(sup.)*

Beru zahlt Dividende

Für das Rumpfgeschäftsjahr 2005 (April bis Dezember) will der Autozulieferer Beru AG aus Ludwigsburg eine Dividende von 83 Cent je Stückaktie zahlen. Das entspricht einer Ausschüttungsquote von knapp 43 Prozent des Gewinns von 19,5 Millionen Euro. Im Jahr zuvor hatte Beru einen Gewinn von 23,6 Millionen Euro erzielt und eine Dividende von 1,10 Euro bezahlt. *(sup.)*

B 2: Examples of articles on the opportunity-risk debate about nanotechnology

B 2.1: Highlighting the opportunities

Nie wieder putzen

Saubere Fenster dank Lotuseffekt: Auch die Baustoffindustrie profitiert mittlerweile von den Erkenntnissen der Nanotechnologie

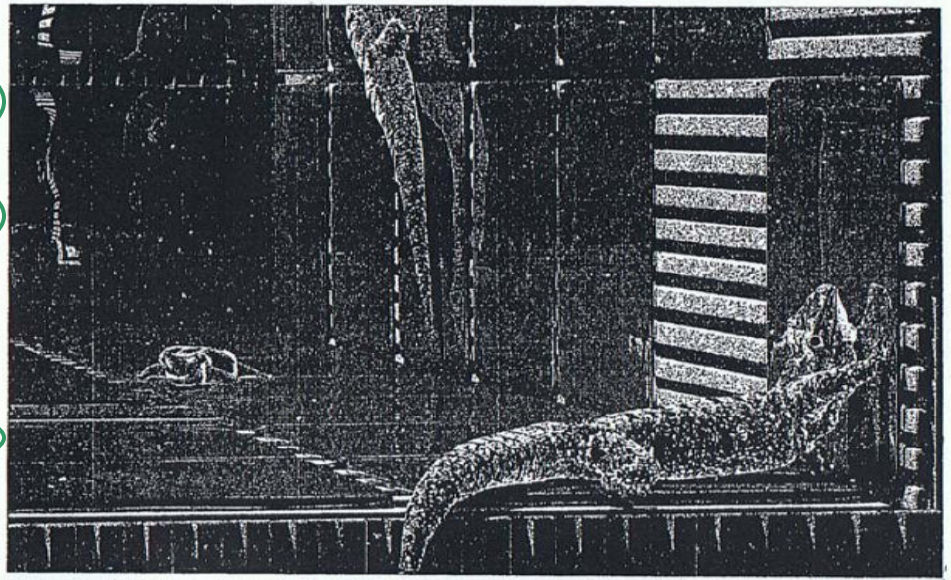
Von Tilman von Rohden

Dächer, Fenster und Fliesen, die sich selber reinigen. Fassaden, die Strom produzieren. Wandfarben, die Bakterien und schlechte Raumluft bekämpfen. Es klingt wie aus dem Märchenland, was die Nanotechnologie leistet oder zumindest in Aussicht stellt. Diese junge Wissenschaft steht noch ganz am Anfang. Dennoch können Mieter und Bauherren schon heute einige dieser neuartigen Produkte und Materialien nutzen. Die veränderten Eigenschaften sorgen für Langlebigkeit, Bequemlichkeit oder vielfältigere und verbesserte Anwendungen.

Nanotechnologen interessieren sich für Strukturen von einem bis 100 Nanometer. Ein Nanometer ist ein Milliardstel Meter. Zum Vergleich: Ein menschliches Haar ist 50 000 mal dicker. Auf dieser Mikroebene verhalten sich Materialien anders als üblich. Wie diese Prozesse physikalisch zu erklären sind, ist noch nicht endgültig erforscht. Aber das Verständnis reicht, um Nanotechnologie gezielt einzusetzen. Beispielsweise bei neuem Fensterglas, bei dem nur mit Hilfe von Sonnenlicht und Regenwasser die Scheiben sauber gehalten werden.

Die Natur stand Pate für diese Methode, denn die Selbstreinigung der Lotuspflanze zeigt, wie es geht. Das technische Trick beruht auf nanometergroßen Titandioxidpartikeln, die auf der Außenseite des Glases unsichtbar aufgetragen sind. Das Nanomineral zersetzt mit Hilfe von Licht organische Stoffe wie Staub, Fett oder Dreck. Zudem zerfließen Wassertropfen am Titandioxid zu einem hauchdünnen Film, der den zersetzten Dreck mit sich fortreißt. Der Lotuseffekt kann natürlich auch für Fensterprofile genutzt werden – oder für Wintergärten, Balkonbrüstungen, Dachziegel, Lampenschirme oder Fliesen im Bad. Ein Ende der Anwendungsmöglichkeiten ist derzeit nicht abzusehen.

Fliesen profitieren noch in anderer Hinsicht von der Nanotechnologie. Beim Verlegen der Kacheln versprechen Nano-Kleber deutliche Vorteile. Diese Produkte stellen nur geringe Anforderungen an den Untergrund und haften im Vergleich zu konventionellen Klebern besonders stark. Zudem können die verlegten Fliesen selbst nach 30 Minuten noch neu positioniert werden. Andererseits ist ein solcher Fliesenboden schon nach fünf Stunden begehbar. Ob der Begriff „Nano" hier gerechtfertigt ist, ist Ansichtssache, denn solche Kleber enthalten keine Nanopartikel. Doch bildet das in Wasser aufgelöste Pulver während der Aushärtung eine feine Kristallisation in der Größe von zehn bis 100 Nanometer aus.



Nanostrukturen sollen eine besonders gute Haftung zwischen Fliesen und Untergrund bewirken, verspricht etwa die Degussa AG, die einen speziellen Fliesenkleber entwickelt hat. Abgeschaut wurde das Prinzip von den Geckos. Foto: Degussa

Auch bei Farben und Lacken kommt Nanotechnologie zum Einsatz. So vernichten spezielle Innenfarben Gerüche oder Schadstoffe in der Raumluft. Organische Verbindungen wie das gefährliche Pentachlorphenol (PCP), das früher in Holzschutzmitteln vorkam, oder Formaldehyd werden chemisch zersetzt. „In einem Wohncontainer wurde die Farbe getestet. Nach einer einzigen Nacht mit der Farbe unterschritt die Menge an Formaldehyd den gesetzlichen Grenzwert", sagt Professor Horst Kisch, Chemiker an der Universität Erlangen-Nürnberg. Andere Innenfarben bekämpfen Pilze, Bakterien und Algen. Selbst Antibiotika-resistente Krankenhauskeime werden vernichtet.

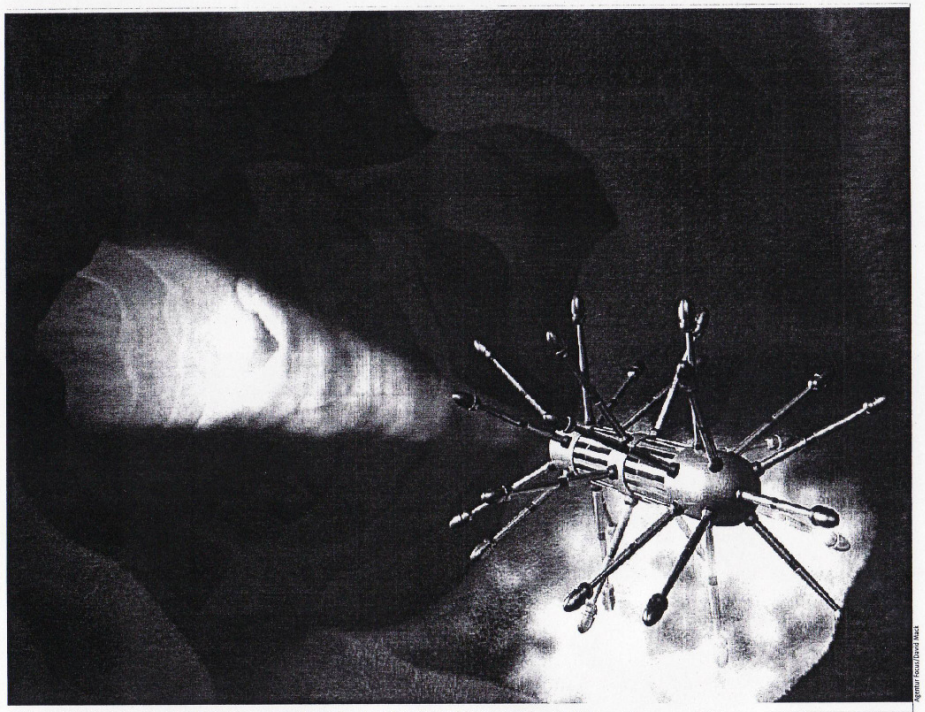
Der Schmutz perlt ab

Außenfarben setzen dagegen auf den Lotuseffekt. „Schmutzpartikel können nicht anhaften und werden von den abperlenden Regentropfen einfach mitgerissen. Die Fassade bleibt trocken. Algen und Pilzen wird auf natürliche Weise eine wichtige Lebensgrundlage entzogen", wirbt ein deutscher Farbenhersteller.

Der vielleicht spektakulärste Fortschritt wären nanobasierte Farben und Lacke, die Energie liefern, ähnlich den Sonnenkollektoren. Wobei Lacke den Vorteil bieten, dass sie wesentlich größere Flächen am Haus Strom produzieren könnten. Im übrigen finden Sonnenkollektoren derzeit viel Aufmerksamkeit. Es gibt erste Versuche, den Wirkungsgrad der Kollektoren mit Nanotechnologie drastisch zu erhöhen, von zehn auf etwa 50 Prozent. „Der Weg von der Theorie zur Praxis dürfte etwa genau so schwierig sein wie bei der Kernfusion", meint Paul Alivisatos, Chemiker an der University of California. Wenn es klappt, hätten die Industriegesellschaften ihre Energieprobleme möglicherweise gelöst.

(Süddeutsche Zeitung, 16.08.2006)

B 2.2: Example of an article on the opportunity-risk debate (Part I) (Financial Times Deutschland, 21.02.2006, p. 33)



Auf Patrouille: Kleinste **Nanomaschinen** könnten eines Tages durch die Blutgefäße gleiten und sie von schädlichen Ablagerungen befreien

Winzige Arzthelferchen

Mit Elan arbeiten Wissenschaftler daran, Nanoteilchen für die Medizin zu nutzen. Ihre neuesten Ergebnisse präsentierten Forscher jetzt auf der Nanomed 2006 in Berlin.

VON **ANNETTE BOLZ**

Ist auf dem Raumschiff Voyager jemand krank, injiziert der Doktor kurzerhand Nanopartikel. Und schwupps! ist das Crewmitglied wieder gesund und kann weiterhin unbekannte Welten entdecken. Was in der Science-Fiction-Serie Startrek prima funktioniert, ist in der Realität noch nicht möglich. Doch Wissenschaftler forschen zurzeit mit großem Elan daran, Nanoteilchen für medizinische Zwecke einzusetzen. Die künstlichen Teilchen, nur einige millionstel Millimeter groß, sollen eines Tages Krebs heilen, verlorengegangene Körpersubstanz ersetzen oder mangelhafte Gene reparieren können.

Allerdings geht der Fortschritt nur langsam voran, wie der Nanomedizinkongress vergangene Woche in Berlin zeigte. Erst wenige Nano-Produkte sind bislang auf dem Markt, wie zum Beispiel das Kalziumphospat-Präparat Nanitactive vom Düsseldorfer Unternehmen Henkel, das sensible Zahnhälse schützen soll oder AdNano, eine Zinkoxid-Emulsion von Degussa, die unter anderem Sonnencremes zugesetzt wird. Die meisten medizinischen Entwicklungen im Nanobereich werden zurzeit noch im Labor getestet: entweder an Zellkulturen oder an Ratten.

Zu den wenigen Nanopartikeln, die bereits am Menschen erprobt werden, gehören Eisenoxid-Moleküle. Andreas Jordan, Leiter der Arbeitsgruppe biomedizinische Nanotechnologie der Berliner Charité keine Nebenwirkungen. Deshalb kann man die Prozedur so oft wiederholen, wie es nötig ist", sagt Jordan. Ob die von ihm so getaufte „MagForce Nanocancer Therapy" tatsächlich die hohen Erwartungen

bis sie auf einen Rezeptor treffen. Ein pulsierendes Magnetfeld lässt die Kügelchen anschließend auf und nieder hopsen: „SOON klopft regelrecht an die Tür der Zelle an", sagt Hol-

Creme, die aus kleinsten Apatitkristallen besteht. Die Partikel ähneln dem menschlichen Zahnschmelz und können Karieslöcher im frühen Stadium auffüllen. An solchen Nanofüllmaterialien arbeitet auch Matthias Hannig von der saarländi-

Toxikologe an der University of Edinburgh.

Spätestens seit der Feinstaubdebatte ist bekannt, was kleinste Teilchen im menschlichen Organismus anrichten können: Gelangen Nanoteilchen in die Lunge, können sie zu

Mit dem Alter wird das Sexualleben besser

Männer über 50 haben ein erfüllteres Sexualleben als 30- oder 40-jährige. Das geht aus einer Studie hervor, die nun im britischen Urologen-Fachjournal „BJU-International" erschienen ist. Forscher aus Norwegen und den USA hatten für die Untersuchung 1185 Männer zwischen 20 und 79 Jahren zu ihrem Sexualleben befragt. Obwohl mit dem Alter die Sexualfunktion der Männer abnimmt, nimmt die sexuelle Zufriedenheit zu, fasst Co-Autorin Sophie Fossa vom Rikshospitalet-Radiumhospitalet Trust in Oslo die Ergebnisse zusammen. DPA

Flugzeuge mit Noppen fliegen besser

An herkömmlichen, glatten Flugzeugflügeln strömt die Luft mit rund 300 Metern pro Sekunde vorbei. Kleine zylindrische Noppen an der Flugzeughaut können die Bildung von Turbulenzen spürbar beeinflussen. Das entdeckte Jens Fransson vom Königlichen Institut für Technologie in Stockholm und sein Team nun in Windkanalversuchen: Die Strukturen verbessern das Strömungsverhalten der Luft deutlich. Wegen des geringeren Widerstands könnte so Treibstoff gespart werden. Ihre Tests beschreiben die Forscher im Fachblatt „Physical Review Letters". WSA

Zu viel Morphium im Mohnbrötchen

Zurzeit könnte der Verzehr von Speisen mit Mohn zu überraschenden Nebenwirkungen führen. Davor warnt das Bundesinstitut für Risikobewertung (BfR). Die schwarzen Mohnsamen sind normalerweise unbedenklich, obwohl sie vom Schlafmohn stammen, jener Pflanze, aus deren Milch und Kapseln Opium gewonnen

B 2.2: Example of an article on the opportunity-risk debate (Part I) (Financial Times Deutschland, 21.02.2006, p. 33)

... Zinkoxid-Emulsion von Degussa, die unter anderem Sonnencremes zugesetzt wird. Die meisten medizinischen Entwicklungen im Nanobereich werden zurzeit noch im Labor getestet: entweder an Zellkulturen oder an Ratten.

Winzige Arzthelferchen

Zu den wenigen Nanopartikeln, die bereits am Menschen erprobt werden, gehören Eisenoxid-Moleküle. Andreas Jordan, Leiter der Arbeitsgruppe biomedizinische Nanotechnologie der Berliner Charité und Geschäftsführer der Magforce Nanotechnologies AG, will mit diesen magnetisierbaren Partikeln die Krebstherapie revolutionieren. Dazu injiziert er die winzigen Eisenoxid-Kügelchen direkt in den Tumor, anschließend setzt er den Patienten einem starken Magnetfeld aus. Dadurch beginnen die Metallkörnchen zu zappeln, das wiederum erzeugt Wärme: Die Temperatur in den Krebszellen steigt auf bis zu 46 Grad Celsius. Die Hitze schädigt die bösartigen Zellen so enorm, dass sie durch eine anschließende Chemotherapie oder eine konventionelle Bestrahlung sehr leicht zerstört werden können.

Zurzeit testet Jordan das Verfahren bei Eierstockkrebs und Karzinomen am Gebärmutterhals sowie bei Sarkomen und bei Tumoren der Prostata. Geplant ist eine Studie mit Brustkrebspatientinnen. „Es gibt keine Nebenwirkungen. Deshalb kann man die Prozedur so oft wiederholen, wie es nötig ist", sagt Jordan. Ob die von ihm so getaufte „MagForce Nanocancer Therapy" tatsächlich die hohen Erwartungen erfüllt, muss abgewartet werden.

Ebenso spekulativ ist die Heilkraft von Nanopartikeln bei der Gentherapie. Anstatt Viren zu benutzen, um heilendes Erbgut in eine Zelle einzuschleusen, versuchen Forscher, Eisenoxid-Teilchen als Genfähre einzusetzen. Heinrich Hofmann von der Ecole Polytechnique in Lausanne testet gerade 70 Nanometer große Partikel, die er SPION (Superparamagnetic Iron Oxide Nanoparticles) taufte.

Mithilfe eines statischen Magnetfelds können die winzigen Moleküle auf der Zelloberfläche nach links und rechts geschubst werden, bis sie auf einen Rezeptor treffen. Ein pulsierendes Magnetfeld lässt die Kügelchen anschließend auf und nieder hopsen: „SPION klopft regelrecht an die Tür der Zelle an", sagt Hofmann. So gelangt die Fähre samt ihrer angehängten Last in den Körper, nach 24 Stunden hat sie die Gene abgeliefert. Der Vorteil: Die Eisenpartikel lassen sich nicht nur zielgenau leiten, sie sind auch berechenbarer als Viren. Das Verfahren hat die Forschungsgruppe bereits am Kniegelenkspalt getestet. Am lebenden Objekt zeigten sich die Nachteile: Manche der Nanopartikel transportieren nicht sonderlich effizient, ein anderer Subtyp schädigt das Gewebe und löst Entzündungen aus.

Mini-Medizin

Anwendung Nanopartikel könnten die Heilkunde revolutionieren. Denn sie sind vielseitiger als herkömmliche Arzneien.

Risiko Wie gefährlich die Partikel sind, ist noch nicht hinreichend erforscht. Das betrifft sowohl die akuten als auch die langfristigen Nebenwirkungen.

Die Zahnmedizin ist nanotechnisch gesehen bereits weiter. So entwickelten japanische Forscher vor einem Jahr eine Anti-Karies-Creme, die aus kleinsten Apatitkristallen besteht. Die Partikel ähneln dem menschlichen Zahnschmelz und können Kariеslöcher im frühen Stadium auffüllen. An solchen Nanofüllmaterialien arbeitet auch Matthias Hannig von der saarländischen Universitätsklinik in Homburg. Seine Nano-Kristalle bestehen aus Fluor-Apatit und geben das schmelzschützende Fluor dauerhaft ab. „Jetzt checken wir die mechanischen Fähigkeiten des Materials", sagt Hannig.

Die meisten medizinischen Entwicklungen im Nanobereich werden noch im Labor getestet

So verlockend die Verheißungen der Nanomedizin klingen, so wenig ist über die Risiken der Partikel bekannt. Was passiert, wenn der Körper die Nanoteilchen abbaut? Entstehen dann giftige Fragmente? Derzeit ist noch nicht einmal erforscht, was die Molekülbällchen im Körper überhaupt anstellen: „Nanopartikel können sogar ins Gehirn gelangen und so das zentrale Nervensystem überschwemmen", sagt Ken Donaldson, Nanotoxikologe an der University of Edinburgh.

Spätestens seit der Feinstaubdebatte ist bekannt, was kleinste Teilchen im menschlichen Organismus anrichten können: Gelangen Nanoteilchen in die Lunge, können sie zu Asthma, Krebs und Herz-Kreislauf-Erkrankungen führen.

Zurzeit unterliegen Nanomaterialien für den medizinischen Gebrauch den gleichen Sicherheitsbestimmungen wie andere Medizinprodukte auch. David Rickerby von der Forschungsstelle der Europäischen Kommission in Ispra, Italien, findet, die Sicherheitsvorkehrungen reichten nach heutigem Wissensstand aus. Schließlich müsse eine Balance bestehen zwischen Sicherheitsanforderungen und Entwicklungsfreiheit.

Ob diese Regularien wirklich ausreichen, muss weitere Forschung zeigen. Bis dahin bleiben mögliche Gefahren in den unendlichen Weiten des Nanokosmos verborgen.

... im Mohnbrötchen

Zurzeit könnte der Verzehr von Speisen mit Mohn zu überraschenden Nebenwirkungen führen. Davor warnt das Bundesinstitut für Risikobewertung (BfR). Die schwarzen Mohnsamen sind normalerweise unbedenklich, obwohl sie vom Schlafmohn stammen, jener Pflanze, aus deren Milch und Kapseln Opium gewonnen wird. Aktuelle Analysen zeigen jedoch, dass der Morphingehalt im Speisemohn in der Vergangenheit stark angestiegen ist. Die Ursache, glaubt das BfR, seien Schlampereien bei der Gewinnung des Samens: Kapseln oder Milchsaft würden zuvor nicht sauber vom Samen getrennt. Zudem hänge der Morphingehalt auch davon ab, wann und wo die Pflanze geerntet worden sei. Wer zu viel des morphinhaltigen Mohns isst, könnte schlimmstenfalls unter beeinträchtigtem Bewusstsein, unter flachem Atem und Kreislaufproblemen leiden, so BfR-Präsident Andreas Hensel. Möglicherweise wird man aber auch nur schön ruhig und zufrieden. FTD

KONTAKT: wissenschaft@ftd.de

INVESTMENTFONDS

Tägliche Veröffentlichung der Anteilspreise – mitgeteilt von vwd group

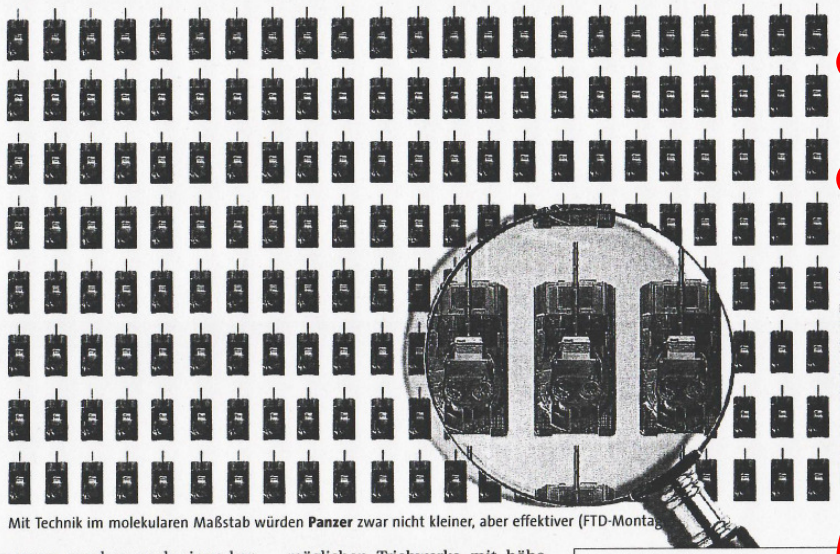
[illegible]

B 2.3: Example of an article highlighting the risks

Militärtechnik im Kleinstformat

Neue Konventionen für nanotechnologische Waffen fordert Rüstungsexperte Jürgen Altmann im FTD-Interview. Heute präsentiert er in Berlin seine Bestandsaufnahme.

VON **NIELS BOEING**



FTD-Montage: Broken Arts/Davide Guglielmo; FTD/Thomas Lehne

Mit Technik im molekularen Maßstab würden **Panzer** zwar nicht kleiner, aber effektiver (FTD-Monta

Nicht nur Autohersteller und Mediziner sind begeistert von den Möglichkeiten der Nanotechnologie. Auch das Militär schielt längst nach der Technik im molekularen Maßstab. „Der Hype um einen Nano-Krieg hat weltweit schon angefangen", warnt Jürgen Altmann, Physiker und Rüstungskontrollexperte an der Universität Dortmund. Heute legt der 57-Jährige die erste Bestandsaufnahme zum Thema vor. Der Titel seines Buches: „Military Nanotechnology: Potential Applications and Preventive Arms Control", finanziert von der Deutschen Stiftung Friedensforschung.

Vor allem in den USA werde bereits geprüft, ob Nanotechnologien in zukünftigen Waffensystemen eingesetzt werden könnten, sagt Altmann. „Zu den mehr als 20 Anwendungsfeldern zählen neue Werkstoffe für zerstörerische Geschosse, leichtere Kampfjets, Manipulationen an den Körpern von Soldaten oder neuartige Biowaffen."

In den 80er Jahren begann Altmann, nach Sensoren zu suchen, die vertragswidrige Bewegungen von Panzern und Flugzeugen nachweisen können – als erster ziviler Forscher überhaupt. „Ich wollte nicht nur vor schlimmen Waffen warnen, sondern auch einen konstruktiven Beitrag leisten."

Als er vor sechs Jahren eine Studie zu militärischen Anwendungen der Mikrosystemtechnik begann, stieß er auf die nächste Stufe der technischen Miniaturisierung: die Nanotechnik. Sie nutzt Strukturen, die kleiner als 100 millionstel Millimeter sind.

Ein Beispiel für die Verbesserung konventioneller Waffensysteme durch Nanotechnik sieht Altmann in unbemannten, autonomen Kampfjets. Ohne Pilotensysteme und dank leichterer und härterer Nanowerkstoffe könnten sie viel kleiner gebaut werden. Temperaturbeständige Nanomaterialien ermöglichen Triebwerke mit höherem Wirkungsgrad, die die Minijets schneller und wendiger machen. Nanoelektronik in Geschossen und Flugkörpern könnte dazu führen, dass sie trotz geringer Größe dieselbe Zerstörungswirkung entfalten wie ihre konventionellen Gegenstücke heute.

Vor allem in der Manipulation der molekularen Maschinerie von Zellen sieht Physiker Altmann große Gefahren. So sei es längst nicht mehr Science-Fiction, Verfahren der Nanomedizin als Blaupause für genetisch maßgeschneiderte Erreger zu nehmen. Bereits jetzt halten es Biologen für denkbar, dass künstliche Bakterien so programmiert werden, dass sie im Körper eines Opfers Zellvorgänge wie die Proteinfaltung verändern – mit tödlichen Folgen.

„Die Nanotechnik wird die Entwicklung neuer B-Waffen beschleunigen. Irgendwann haben wir womöglich mit Viren zu tun, die Bio-Hacker in einem Kellerlabor hergestellt haben", sagt Altmann. Denn Genmaterial könne sich jeder Bastler mittlerweile bei entsprechenden Herstellern kaufen. Dass militärische Forschungseinrichtungen bereits gezielt an solchen Nano-B-Waffen arbeiten, kann er zwar nicht nachweisen. Aber angesichts der Tatsache, dass gut zehn Prozent der Ausgaben der DARPA, der Forschungsagentur des US-Verteidigungsministeriums, als geheim eingestuft sind, „könnte man vermuten, dass auch an derartigen Waffen geforscht wird, mindestens, um zu wissen, was ein Gegner machen könnte".

Unter den acht Empfehlungen, die er in seinem Buch ausspricht, ist deshalb auch die Forderung, die Konventionen über B- und C-Waffen der neuen Entwicklung anzupassen. „Mikroskopische Systeme, die in den Körper eindringen können und teilweise oder ganz künstlich hergestellt sind, sollen in die B-Waffen-Konvention einbezogen werden", schreibt Altmann.

Die nächste Überprüfungskonferenz der B-Waffen-Konvention wird im Dezember 2006 in Genf stattfinden. Altmann hofft, dass sich dort einige Delegationen für seine Vorschläge stark machen. „Es ist wichtig, dass die internationale Gemeinschaft jetzt über die Gefahren redet. Dann bleibt noch Zeit, etwas dagegen tun zu können", sagt Altmann. Schon in fünf Jahren könnte es zu spät sein.

Friedensforscher

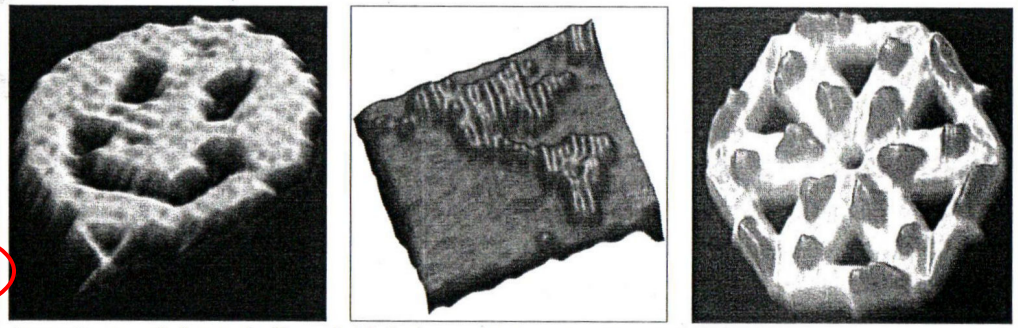
Jürgen Altmann beschäftigt sich seit 20 Jahren mit militärischer Nanotechnologie. Der 57-Jährige leitet das Projekt „Neue nichttödliche Waffen" an der Uni Dortmund und ist Mitherausgeber der Zeitschrift „Science and Global Security".

Financial Times Deutschland, 20.02.2006, S. 28

B 3: Example of an article on language analysis

Nano-Origami

Falttechnik mit Erbmolekülen



Jüngste Errungenschaften aus der Nanowelt: Ein Smiley, eine Karte von Amerika und ein Sechseck. Fotos Nature

An Petit-Point-Stickerei oder filigrane Häkelarbeiten erinnern diese drei Objekte, die aus einem Labor des California Institute of Technology in Pasadena stammen. Das „Garn", aus dem der Smiley, die Umrisse des amerikanischen Kontinents sowie das durchbrochene Sechseck erzeugt wurden, mißt allerdings nur ein Tausendstel der Dicke des menschlichen Haares und besteht aus der Erbsubstanz, der Desoxyribonukleinsäure. Aus diesem Grund sind die drei abgebildeten Objekte winzig klein. So hat der Smiley einen Durchmesser von weniger als hundert Nanometern. Der Maßstab der Karte Amerikas beträgt etwa 1 : 200 Billionen. Dank eines Verfahrens, das Paul Rothemund entwickelt hat, lassen sich die fadenförmigen Moleküle der Erbsubstanz zu zweidimensionalen Gebilden von beliebiger Gestalt verarbeiten. Dazu füllt der Forscher zunächst einen Rahmen mit langen, in Einzelstränge aufgetrennten DNS-Molekülen, die er darin mäanderförmig verlegt. In einem zweiten Schritt fügt er viele kurze Oligonukleotide hinzu, die wie Heftklammern wirken. Sie verbinden sich an bestimmten Stellen mit den Abschnitten der langen DNS-Stränge und verweben auf diese Weise das Erbgut zu einem stabilen Objekt („Nature", Bd. 440, S. 297). Für das abgebildete Hexagon hat Rothemund eine weitere Stufe der Selbstorganisation genutzt. Zunächst erzeugte er Dreiecke, die sich anschließend von selbst mit Hilfe passender Kontaktpunkte zu Sechsecken zusammenlagerten.

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UTA BILOW

(FAZ, 22.03.2006, S. N1)

Wie Zwerge die Welt verändern

Nanotechnologie ist ein unscharfer Begriff, der Verschiedenes subsumiert und zudem oft in einem populärwissenschaftlichen Sinne gebraucht wird. In jedem Falle geht es um sehr kleine Teilchen und Einheiten. Das Wort „nánnos" kommt aus dem Griechischen und bedeutet Zwerg. Die Zwerge aus den bekannten Märchen wirken allerdings wie Riesen, vergleicht man sie mit den hier in Rede stehenden Nanoteilchen. Sie reichen vom einzelnen Atom bis zu einer Größe von 100 Nanometern. Ein Nanometer ist ein Millionstel Millimeter – das entspricht dem Größenverhältnis eines Fußballs zur Erdkugel.

Interessant sind Nanopartikel für die Forschung und Anwendung, weil diese Super-Mini-Teilchen veränderte Verhältnisse aufweisen. Denn die mechanischen, optischen, magnetischen, elektrischen und chemischen Eigenschaften dieser kleinsten Strukturen hängen insbesondere von ihrer Größe und Gestalt ab.

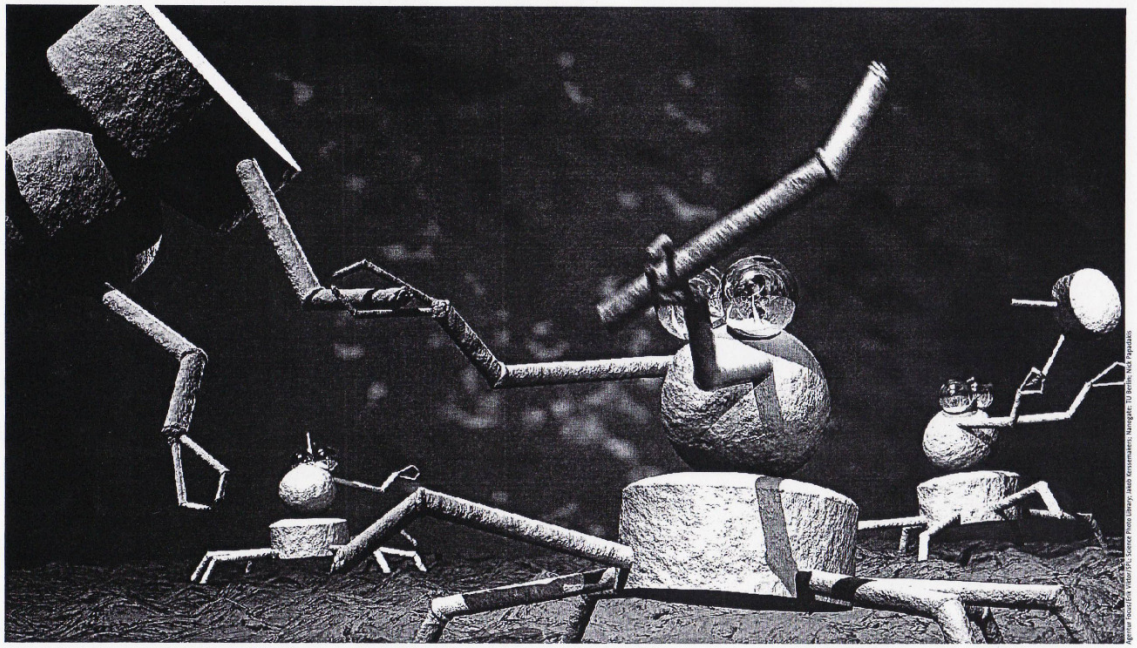
Für die Nanotechnologie interessieren sich die Physik, Chemie und Biologie. Anwendungen entstehen derzeit in der Energietechnik (Brennstoff- und Solarzellen), in der Umwelttechnik (Materialkreisläufe und Entsorgung) oder in der Informationstechnik (neue Speicher und Prozessoren).

Irreführender Name

Nach Schätzungen des Berliner Bundesministerium für Bildung und Forschung besitzen die USA und Europa etwa gleich viele Unternehmen mit Bezug zur Nanotechnologie. Ungefähr die Hälfte der in Europa ansässigen Firmen stammen nach diesen Angaben aus Deutschland. Im Frühjahr 2006 gerieten zwei Nano-Haushaltsputzmittel in die Schlagzeilen, weil sie gravierende gesundheitliche Probleme verursachten. Untersuchungen ergaben jedoch, dass dafür letztlich nicht die Nanoteilchen verantwortlich waren. Überhaupt war die Bezeichnung „Nano-Putzmittel" irreführend, weil die Produkte gar keine Nanopartikel enthielten. Mit „Nano" wollte der Hersteller darauf hinweisen, dass die Putzmittel einen nanodünnen Film nach dem Versprühen auf der Oberfläche von Keramik oder Glas bilden. *tvr*

(Süddeutsche Zeitung, 16.08.2006, S. 49

B 4: Example of an article on image analysis I



Pure Fantasie: Winzige **Nanoroboter** bauen nach Zufuhr von Material und Energie selbstständig Kopien von sich selbst. Stand der Forschung sind Moleküle, die nach Art von Lego-Bausteinen ineinander einrasten

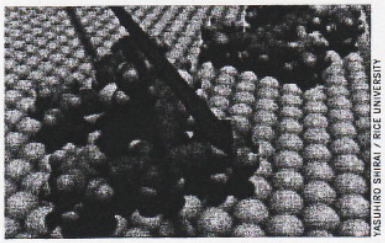
Baukolonnen im Schnapsglas

(Financial Times Deutschland, 30.11.2006, S. 29)

NANOTECHNIK

Kleinster Motorwagen

Exakt 169 Atome genügen, um ein Auto mit Motor herzustellen – allerdings ist es nicht für menschliche Passagiere geeignet. James Tour und sein Team von der Rice-Universität in Houston, Texas, konstruierten das vier millionstel Millimeter kleine Gefährt aus fünf aneinandergereihten Ringstrukturen, an deren erstem und letztem Ring die Achsen in Form frei drehbarer



YASUHIRO SHIRAI / RICE UNIVERSITY

Motorisiertes Nanoauto (Modell)

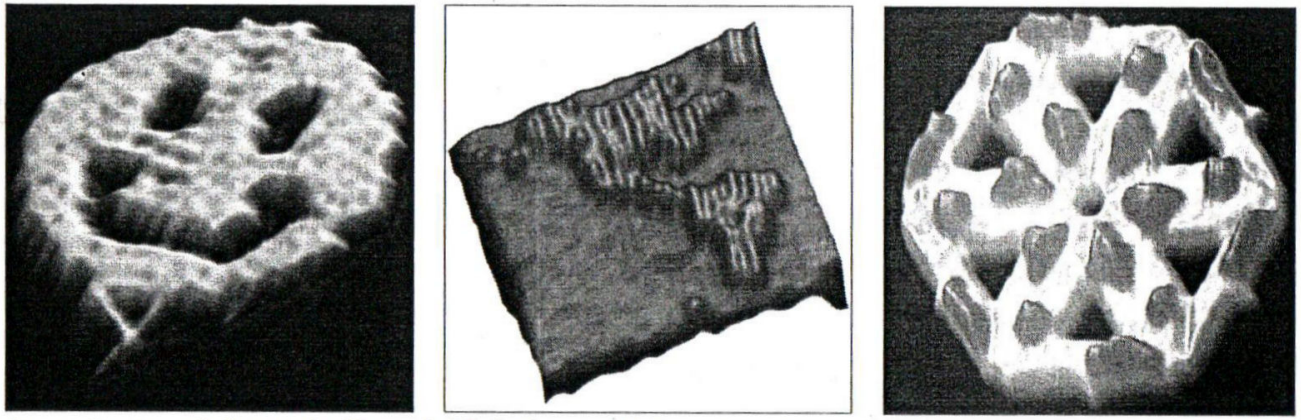
Kohlenstoffverbindungen angebracht sind. Seit kurzem ist das Nanoauto auch mit einem Motor ausgestattet: einem molekularen Schaufelrad, das sich dreht, sobald es durch einen ultravioletten Lichtimpuls angeregt wird.

(Spiegel 17/2006, S.137)

B 4: Example of an article on image analysis II

Nano-Origami

Falttechnik mit Erbmolekülen



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UTA BILOW

(FAZ, 22.03.2006, S. N1)

B 5: Example of an article - framing

B 5.1: Frame ‘Research and development”

Kein Nano im Spray

Löste Treibgas die Vergiftungen aus?

Nanopartikeln waren definitiv nicht die Ursache für die schweren Gesundheitsschäden, die kürzlich mehr als hundert Personen in der Schweiz und in Deutschland nach der Benutzung von Versiegelungs-Sprays der Marke „Magic Nano“ erlitten hatten. Das ist das Ergebnis von chemischen Analysen, die das Bundesamt für Risikobewertung (BfR) in Berlin in Auftrag gegeben hat. Danach haben die beiden mit Treibgas arbeitenden Sprays offenkundig gar keine Partikeln enthalten, die kleiner als hundert Nanometer waren, was mittlerweile auch der Hersteller von „Magic Nano“ zugegeben hat. Inwieweit andere Bestandteile die Symptome – von Atemnot bis hin zu Lungenödemen – ausgelöst haben, ist laut BfR noch nicht vollständig geklärt (siehe F.A.Z. vom 24. Mai). Fest stünde, daß die in „Magic Nano“ enthaltene Flüssigkeit mehrere Jahre bereits als Pumpspray vertrieben wurde, ohne daß es zu gesundheitlichen Beeinträchtigungen gekommen war. Somit erhärte sich der Verdacht, daß die Vergiftungen durch das Einatmen der mikrometergroßen Aerosole des Treibgases hervorgerufen wurden. F.A.Z.

(Frankfurter Allgemeine Zeitung, 01.06.2006, S.38)

B 5.2: Frame ‚Fortschritt im Bereich IuK'

7711, MK

Die Nano-Klapperschlange

Wissenschaftler konstruieren Maschinen aus einzelnen Molekülen / Von Markus Breidenich

MÜNCHEN, im August. Aufgewachsen ist Hermann Gaub im Schwäbischen. Dort, in der Nähe von Biberach, hatten seine Eltern eine Reparaturwerkstatt für Landmaschinen. Und dort hat ihn wohl schon früh jene Faszination ergriffen, die bis heute seinen Alltag bestimmt: „Jedenfalls haben mich die Traktoren, Motoren und Werkzeuge begeistert, die in der Werkstatt herumstanden", sagt Gaub. Heute, mit 48 Jahren, ist er Inhaber des Lehrstuhls für Angewandte Physik der Ludwig-Maximilians-Universität in München – und kann sich in seiner Forschung ganz und gar seinen Maschinen widmen.

Allerdings sind die Werkzeuge und Apparate, mit denen er sich nun beschäftigt, um einiges kleiner als die Traktoren aus der elterlichen Werkstatt. Die Maschinen, an denen Gaub arbeitet, bestehen oft nur aus einem einzigen Molekül. Im Keller des Physikgebäudes arbeiten die Wissenschaftler seines Instituts mit Werkzeugen, deren Größe nur ein Millionstel eines Millimeters beträgt: einen sogenannten Nanometer. Dieser Längenbezeichnung verdankt das Forschungsfeld des Instituts seinen Namen: Nanotechnologie. Der Begriff allein beflügelt die Phantasie. Von winzig kleinen U-Booten war die Rede, die in den Körper von Patienten eingespritzt werden könnten, um dort an Ort und Stelle Krankheitsherde zu reparieren. Von derartigen Auswüchsen der Phantasie will Gaub allerdings nichts wissen: „Das ist doch eher Science-fiction als Science", wiegelt er ab und bezeichnet allzu große Versprechungen für die Zukunft als unseriös. Allerdings müsse man sehr wohl zwischen Science-fiction und Visionen unterscheiden. Denn letztere habe er schließlich doch. „Unsere Gesellschaft wird von Maschinen bestimmt. Und immer kleinere Apparate werden das Zusammenleben verändern", sagt er. „Wir Wissenschaftler machen darauf aufmerksam, was eines Tages sein wird." Die Gesellschaft fordert er auf, sich bereits jetzt darüber Gedanken zu machen.

Die Ideen für den Aufbau der winzigen Apparate schaut Gaub oft von der Natur ab: „Welche Maschinen benutzt sie?" Wenn er diese Frage beantwortet hat, dann will er diese kleinen Instrumente nicht nur nutzen, sondern sie auch nachbauen. Sein Ziel ist es, eines Tages sogenannte Hybride herzustellen, Werkzeuge also, die einerseits aus natürlichen, biologischen Teilen bestehen, zum anderen aber auch technische Komponenten enthalten, zum Beispiel Halbleiter.

Ein besonders eindrucksvolles biologisches Werkzeug ist für Gaub das Gift der Klapperschlange. Was in der Natur für jedes Opfer des Reptils zu einem tödlichen Mechanismus wird, kann für den Wissenschaftler zu einem hilfreichen Instrument werden. Die einzelnen Moleküle des Gifts bohren Löcher in die Außenhülle von biologischen Zellen, die sogenannte Membran, und zerstören sie dadurch. Wissenschaftler versuchen nun, das Klapperschlangengift als Schere zu benutzen. Die Moleküle könnten dann Kreise und Linien aus der Membran herausschneiden. Dadurch entstehe eine Art Schablone, die beispielsweise zum Herstellen winzig kleiner Schaltkreise auf einem Mikrochip verwendet werden könne.

Aber nicht nur Scheren hat die Werkzeugkiste der Nanotechnologen zu bieten. Auch winzig kleine Sicherheitsgurte aus Protein-Molekülen und Reißverschlüsse aus DNA gehören zur Ausstattung. So jedenfalls veranschaulicht Matthias Rief die Objekte seiner Forschung. Der 35 Jahre alte Professor untersucht an Gaubs Institut die Zugfestigkeit nanometergroßer Proteine, die im Muskel unter anderem für dessen Stabilität sorgen. „Das Molekül funktioniert wie ein kleiner Sicherheitsgurt, der die Bestandteile des Muskels beim Strecken zusammenhält", erklärt Rief. Mit der Spitze eines sogenannten Kraftmikroskops zieht der Forscher an einem Ende des Moleküls, bis es unter dem Einfluß des Gewichts seine Form ändert. Rief untersucht diese Formvariationen, um mehr über die Funktionsweise des Proteins in der Biologie zu erfahren. Das Gewicht, mit dem gezogen wird, ist dabei winzig klein. Es verhält sich zu dem einer Mücke in etwa so wie das Gewicht der Mücke zu dem eines Elefanten.

Mit der gleichen Methode untersucht Rief auch die Erbsubstanz DNA. Er belastet das Molekül, das wie eine Wendeltreppe geformt ist, bis die Stufen aufbrechen und zwei getrennte Stränge übrigbleiben. „Wenn die Kraft wieder weggenommen wird, kann man die Geschwindigkeit messen, mit der sich die DNA wie ein Reißverschluß wieder zusammensetzt", erklärt er. Die Erbsubstanz läßt sich dabei nur wenig Zeit – eine Eigenschaft, die für den Organismus lebenswichtig ist. In der Sekunde schafft es das Molekül, rund 10 000 seiner Stufen zu reparieren.

Daß die Physiker auch mit biologischen Materialien arbeiten, ist für Gaub selbstverständlich. Die Trennung zwischen den traditionellen Disziplinen Physik, Chemie und Biologie sei im Studium notwendig, um gewisse Standards zu definieren. „Später sollte das Interdisziplinäre im Vordergrund stehen", sagt Gaub. Vor allem gehe es darum, die Kommunikationsschwierigkeiten der einzelnen Disziplinen untereinander zu überwinden, sagt der Forscher, während er sich an den Tisch im sogenannten Cens-Raum des Instituts setzt. Cens, das ist die Abkürzung für „Center for Nanoscience", eine Organisation, in der sich 1998 sechs Forschergruppen der Ludwig-Maximilians-Universität zusammengeschlossen haben, um gemeinsam Nanotechnologie zu betreiben. Inzwischen arbeiten 300 Wissenschaftler in der Organisation. „Cens hat allerdings kein eigenes Gebäude", betont Gaub. Es ist vielmehr ein lockerer Zusammenschluß von Instituten verschiedener Fachrichtungen mit dem Ziel, Forschung zu erleichtern und Wissenschaftsverwaltung zu straffen. Wissenschaftler aus der ganzen Welt beteiligen sich an den Veranstaltungen des Zentrums. Die Diagramme und Formeln an der Tafel des Sitzungsraums vermitteln einen kleinen Eindruck von den Diskussionen, die in solchen Seminaren stattfinden. Und gelegentlich führen die Forschungsarbeiten auch zu einer Firmengründung. In den Unternehmen versuchen die Wissenschaftler, die Methode der Einzelmolekülexperimente und der Proteinforschung in der Wirtschaft zu vermarkten. Ein Jahr lang stellt die Universität den Gründern einen Raum zur Verfügung, so daß sie auf den ersten Schritten die Ausstattung der Universität nutzen können. Aber der Unternehmergeist steht für Gaub und seine Mitarbeiter nicht im Vordergrund. „Neues entdecken, das ist die Pflicht des Physikers", sagt er, und: „Grundlagenforschung hält uns jung."

„Grundlagenforschung", sagt Hermann Gaub, „hält uns jung." Foto Jan Roeder

(Frankfurter Allgemeine Zeitung, 28.11.2007)

Metallische Nanoröhrchen werden zu Halbleitern

Mit einem starken Magnetfeld lassen sich metallische Nanoröhrchen aus Kohlenstoff in halbleitende Röhrchen und umgekehrt verwandeln. Das haben zwei amerikanische Forschergruppen herausgefunden („Science", Bd. 304, S. 1129, S. 1132). Richard Smalley von der Rice University in Texas und seine Kollegen setzten einwandige halbleitende Kohlenstoffzylinder – also Röhrchen, die nur aus einer Graphitlage bestanden – einem homogenen Magnetfeld von maximal 45 Tesla aus. Die Feldlinien waren dabei parallel zur Längsachse der Zylinder gerichtet. Als die Forscher die Feldstärke erhöhten, wurde die für Halbleiter typische Bandlücke zwischen Leitungsband und Valenzband kleiner. Dadurch zeigten die Nanoröhrchen zunehmend metallisches Verhalten. Die Forscher um Alexey Bezryadin von der University of Illinois in Urbana-Campaign konzentrierten sich dagegen auf metallische mehrwandige Nanoröhrchen. Mit zunehmendem Magnetfeld begann sich eine Bandlücke auszubilden, und die Metalle verwandelten sich in Halbleiter. Von einem Schwellenwert an verschwand die Lücke wieder, und die Nanoröhrchen wurden wieder metallisch. Die Ergebnisse könnten die Anwendungen der Gebilde beflügeln. Bei der Herstellung der filigranen zylindrischen Gebilde finden sich nämlich stets beide Sorten von Nanoröhrchen im Produktgemisch. F.A.Z.

(Frankfurter Allgemeine Zeitung, 26.05.2004)

Wärmende Winzlinge mit Kraft

Vielfältige Einsatzmöglichkeiten für Carbon Nano Tubes

An kalten Wintertagen ist Autofahrers Leben hart, besonders dann, wenn das Fahrzeug unter der Laterne parken muss: Rundum sind die Scheiben zugefroren, die Außenspiegel erscheinen matt, und wenn der Fahrer sich, des Eiskratzens müde, in seinem Gefährt niederlässt, beschlagen die Scheiben auch noch von innen. Der Grund: Trifft die warme Atemluft auf kalte Oberflächen, dann kondensiert dort die Feuchtigkeit, so wie die Luft eines schwülen Sommerabends an einem frischgefüllten Weißweinglas. An kalten Tagen bleibt die Wahl zwischen zwei Übeln: entweder die Fenster öffnen oder den Innenraum des Automobils langsam erwärmen.

Die Fraunhofer-Technologie-Entwicklungsgruppe (TEG) in Stuttgart bringt nun eine dritte Variante ins Spiel. Die neuartige Technik der Wissenschaftler wärmt direkt die Windschutzscheibe an – allerdings nicht mit Heizdrähten aus teurem Kupfer, sondern mit einem transparenten Kunststofflack aus einem ganz besonderen Kohlenstoff, sogenannten Carbon Nano Tubes (CNT). Mit seinem Team feilt Ivica Kolaric derzeit an einem Verbundmaterial, das in ein oder zwei Jahren nicht nur Autoscheiben, sondern auch Badezimmerspiegel oder die Außenspiegel von Kraftfahrzeugen beschlagfrei halten soll. Erste Tests hat der neuartige Verbundwerkstoff erfolgreich bestanden.

Carbon Nano Tubes eignen sich bestens als flächiges Widerstandsheizelement, denn der Kunststofflack setzt elektrische Energie zu über 90 Prozent in Wärme um. Verantwortlich dafür sind die besonderen elektrischen Eigenschaften und die hervorragende Wärmeleitfähigkeit der CNT. Zudem ist der CNT-Lack eine echte Flächenheizung. Verbindet man eine Stromquelle mit der transparenten Schicht, so verteilen sich elektrische Energie und Wärme gleichmäßig über die gesamte Fläche. Auch bei kleinen Macken, zum Beispiel durch Steinschlag, bleibt die Heizung, anders als bei Heizdrähten, voll funktionsfähig. Und es genügt eine geringe Spannung: Ein 12-Volt-Bordnetz reicht zur Stromversorgung völlig aus.

Mit bloßem Auge betrachtet, sieht reines CNT aus wie dunkles Mehl. Nimmt man ein leistungsstarkes Mikroskop zu Hilfe, dann entpuppt sich das Pulver rasch als fein verschlungene Knäuel winziger Kohlenstoffröhrchen (Carbon Nano Tubes), deren Durchmesser nur wenige millionstel Meter beträgt, die aber leicht hundertmal länger werden können. Für den leitfähigen Verbundwerkstoff braucht es nur einige zehntel Gewichtsprozente CNT-Mehl, das man mit einem Polymergranulat vermischt und weiterverarbeitet. Die Geometrie eines einzelnen CNT-Röhrchens erinnert an Maschendrahtzaun, der zu einer entsprechend winzigen Röhre aufgewickelt wird, wobei an den Ecken der Maschen die Kohlenstoffatome sitzen. Die Winzlinge sind echte Multitalente, die sich nicht nur als passgenaue Heizung im Automobil, zur Erwärmung von Motorradgriffen oder als Fußbodenheizung eignen. Auch die mechanischen Eigenschaften sind außergewöhnlich. Ihre Zugfestigkeit übertrifft die von Stahl um das Zwanzigfache. Das eröffnet eine Vielzahl von Anwendungen, bei denen Gewichtsersparnis bei gleichzeitig hoher mechanischer Belastung im Vordergrund steht. Eine erste Serie von 30 000 Tennisschlägern wurde bereits statt mit Kohlefaser-Verbundwerkstoffen mit einem kostengünstigen CNT-Komposit verstärkt. Auch die Eigenschaften von Skiern, Golfschlägern oder Fahrrädern lassen sich, davon ist man bei der Fraunhofer-TEG überzeugt, mit CNT-Werkstoffen weiter optimieren. ULLRICH HNIDA

(Frankfurter Allgemeine Zeitung, 26.05.2004)

B 5.3: Frame „Wirtschaftliche Nutzung“

Intel feiert Meilenstein

65-Nanometer-Chip schon 2005

SANTA CLARA · 30. AUGUST · dpa · Intel ist ein wichtiger Schritt in der Chipproduktion der nächsten Generation gelungen. Der Konzern stellte erstmals einen Speicherchip (SRAM) mit mehr als einer halben Milliarde Transistoren in der 65-Nanometer- Fertigung her. Dabei wurden weitere technische Details verbessert, mit denen Chips künftigen Ansprüchen an Leistung und Stromverbrauch genügen sollen. Der SRAM-Chip sei voll funktionstüchtig und habe eine Leistung von 70 Megabit, teilte Intel mit.

Da PC, mobile Computer und andere Geräte immer kleiner werden, muss die Leistungssteigerung auch auf immer engerem Raum Platz finden. So sollen die Schaltkreise (Gates) der 65-Nanometer-Chips, in denen die Transistoren an und ausgeschaltet werden, so klein sein, dass hundert von ihnen in einem menschlichen Blutkörperchen Platz finden könnten. Derzeit produziert Intel als erstes Unternehmen seine Prozessoren in Massenfertigung mit 90-Nanometer-Technologie. Dabei sind die Strukturen, die auf einem Chip aufgebracht werden, statt wie üblich 130 nur 90 Nanometer breit. Ein Nanometer ist ein Milliardstel Meter. Der Wechsel auf die 65-Nanometer-Fertigung ist bereits für 2005 geplant.

(Frankfurter Rundschau, 31.08.2004)

IBM baut kompletten Schaltkreis auf einem Nanoröhrchen

Washington – Einen kompletten elektronischen Schaltkreis haben IBM-Forscher auf einem einzelnen Nanoröhrchen aus Kohlenstoff untergebracht. Das Bauteil messe ein Fünftel des Durchmessers eines menschlichen Haares, schreiben sie in der jüngsten Ausgabe von „Science“. Der nur unter einem Elektronenmikroskop sichtbare Schaltkreis ist eine weitere Entwicklungsstufe hin zu immer kleineren und schnelleren Bausteinen künftiger Computer.

Zusammen mit Kollegen der Universität Florida in Gainesville und der Columbia-Universität in New York hatten die IBM-Experten um Zhihong Chen winzige Drähte so an einer Nanoröhre angebracht, daß sie wie die Zähne eines Kamms abstanden. An diese wurden die Elemente des Schaltkreises geklemmt. Der so konstruierte sogenannte Ring-Oszillator eigne sich für Tests neuer Technologien zur Herstellung von Chips, so die Forscher. Das neue Bauteil ließ sich mit maximal 50 Megahertz takten. Das sei zwar weniger als bei heutigen Silizium-Chips, aber fast einemillionmal schneller als bei bisherigen Versuchen mit Nanoröhren.

In der Chipbranche gilt seit vier Jahrzehnten die von Intel-Mitbegründer Gordon Moore gemachte Vorhersage („Moore's Law“), daß sich die Zahl der Transistoren auf einem Chip etwa alle 18 Monate verdoppelt – und damit auch die Leistungsfähigkeit. Moore selbst schätzt, daß sein Gesetz bis 2017 gültig sein wird. Bereits jetzt stößt die konventionelle Chiptechnik an Grenzen, unter anderem weil die immer kompaktere Bauweise Probleme mit zu großer Hitze bereitet. Die Chiphersteller suchen daher intensiv nach Alternativen zur Silizium-Technologie. *dpa*

(Die Welt, 03.04.2006)

und Robotik die Innovationskraft der „Old Economy" betonen

FOTO: DPA/JENSEN

MG Technologies will Umsatz mit Nanotechnik verdoppeln

Konzerntochter Sachtleben Chemie wird Kompetenz-Zentrum – Mikrotechnik Schwerpunktthema in Hannover

VON DANIEL WETZEL

Duisburg – Die Fähigkeit, Teilchen von der Größe eines Millionstel Millimeter herzustellen, soll der Sachtleben Chemie in den kommenden Jahren zweistellige Zuwachsraten bescheren. „Wir wollen den Umsatz mit Nanotechnik bis 2005 verdoppeln", sagte der Vorsitzende der Geschäftsleitung, Wolf-Dieter Griebler, vor der Hannover Messe im Gespräch mit dieser Zeitung: „Nanotechnik war bis vor kurzem noch in der Inkubationsphase – jetzt sind wir soweit, dass wir abheben können."

Der Duisburger Konzern, der mit seiner Muttergesellschaft Dynamit Nobel für das Chemiegeschäft der MG Technologies AG steht, stellt aus titanhaltigen Schlacken Titandioxid her: Ein Pulver, das als weißfärbendes Partikel vor allem in Kunststoffen, Farben, Lacken und branche ebenfalls signifikant über fließen.

men, die Partikel auf eine Größe von drei bis fünf Nanometer herunter zu brechen. Ein Nanometer entspricht einem Milliardstel Meter. „Aus der Sicht eines Nanoteilchens ist ein Golfball so groß wie die Erde", beschreibt Griebler die Dimension. „Nanoteilchen haben Fähigkeiten, die eine ganze Generation neuer Produktideen ermöglichen." Die Nachfrage der verarbeitenden Industrie steige „rapide."

Werden Mikro-Partikel immer weiter zerteilt, entstehen mit der größer werdenden Oberflächenenergie in der Tat geradezu wundersame Eigenschaften: So können Feinst-Partikel in Nano-Größe den fünfprozentigen Anteil UV-Strahlung aus dem Sonnenlicht filtern. „Verkehrsschilder verblassen, Kunststoffe werden spröde – die ultraviolette Strahlung ist eine volkswirtschaftliche Katastrophe", sagt Griebler: „Farben und Kunststoffe, färbt nicht nach." Sonnenschutz-Creme mit einem Lichtschutzfaktor größer als 25 ist erst durch Zugabe von nanofeinen Teilchen aus dem Hause Sachtleben möglich geworden. Autolacke bekommen durch den Hightech-Aufstrich einen neuen „Flipflop-Effekt" genannten Metallic-Look, der Kundenherzen höher schlagen lässt. „Wir finden fast täglich neue Anwendungsgebiete", freut sich Sachtleben-Chef Griebler.

Zudem sorgt die Tatsache, dass Nanopartikel nach UV-Bestrahlung so genannte „Freie Radikale" produzieren, für einen höchst „fotoaktiven Effekt": Nanoteilchen töten Bakterien. Das geschmacksneutrale weiße Pulver kann also Wasser keimfrei machen. Schon denken Produktstrategen an eine mit Nanofarbe bestrichene „Keimkiller-Tapete", die allergie- und pilzgeplagten Haushalten Erleichterung schaffen soll. Pharmakonzerne erforschen, ob sich Nanoteilchen gar in der Krebstherapie einsetzen lassen.

Mit Hochdruck arbeitet Sachtleben mit der verarbeitenden Industrie an den neuen Anwendungen. Ein französischer Autobauer hat dabei entdeckt, dass sich in der Herstellung von Auto-Katalysatoren teure Inhaltsstoffe wie Platin vergleichsweise günstig durch Nanopartikel aus Duisburg ersetzen lassen: Die Kostenersparnis, schätzt Griebler, liegt im zweistelligen Prozentbereich.

„Wir entwickeln uns vom Grundstoff-Lieferanten zum weltweiten Technologie-Partner", beschreibt der Sachtleben-Chef die Auswirkung auf sein Unternehmen. „Das stabilisiert auch unser herkömmliches Geschäft." Im Konzern wird die Nano-Kompetenz der Duisburger hoch geschätzt: Zusammen mit den ebenfalls nanokundigen Töchtern Chemetall und Ceramtec gründet MG Technologies ein „Kompetenzzen-

B 5.4: Frame „Medizinischer Nutzen“

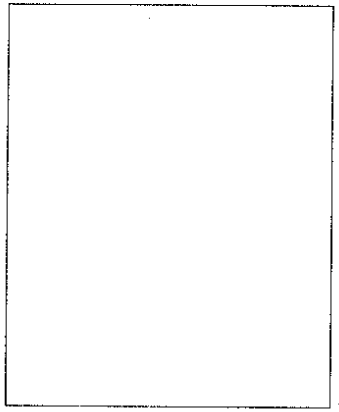
Biowaffen auf der Spur

Forscher wollen die Nanotechnologie nutzen, um gefährliche Erreger nachzuweisen

Von **Simone Tiedtke**

Ein Detektor schlägt sofort Alarm, wenn Anthrax oder andere gefährliche Erreger durch die Luft schwirren. Das wäre ein beruhigendes Gefühl. Aber leider gibt es bisher kein derartiges Gerät. Tatsächlich können nur wenige Speziallabors bedrohliche Biowaffen bestimmen. Die Verfahren sind aufwändig und teuer. Das könnte sich aber ändern: Wissenschaftler haben ein Messverfahren entwickelt, das erstmals parallel und damit schneller als bislang mehrere Moleküle identifizieren kann.

Die neue Methode nutzt die Nanotechnologie und birgt die Möglichkeit, in einer Stunde mehrere Hundert Erreger zu identifizieren. „Die Marktreife wollen wir in zwei bis drei Jahren erreichen“, sagt Gunnar Brink, Geschäftsführer des Unternehmens Nanotype, das die Technik entwickelt. Auch Biowaffen könnten damit besser identifiziert werden. „Vom Konzept her möglich“, kommentiert Harald Fuchs, wissenschaftlicher Leiter des Centrums für



Milzbrand lässt sich schon erkennen – andere Erreger hingegen noch nicht

spricht dem Gewicht eines kleinen Apfels. Bisher ließ sich die Kraft nur an einzelnen Molekülen messen. Bei dem neuen Verfahren reißen Balkenwaagen im Miniatur-Maßstab, untergebracht auf einem Chip, gleichzeitig an je zwei Molekülen – bis sie sich

Vielfältige Anwendungen stehen damit offen – grundsätzlich eignet sich jede biologisch oder medizinisch relevante Molekül-Verbindung. Medikamente könnten schneller entwickelt und individuell auf das genetische Profil eines Patienten abgestimmt werden. Derzeit arbeiten die Forscher an einem Produkt, das Erreger schnell erkennt, um Infektionen in Krankenhäusern vorzubeugen.

Gängige biochemische Analyseverfahren dauern mehrere Stunden bis zu Tagen. So auch in Deutschland, wo Milzbrand-Erreger mikroskopisch oder mit molekularbiologischen Verfahren wie der Polymerasekettenreaktion bestimmt werden. Dabei erkennt ein „Marker“ den Erreger anhand seiner Erbgutabschnitte.

In den USA ist seit neuestem ein Anthrax-Schnelltest auf dem Markt, der in weniger als einer Stunde Ergebnisse liefert. Aber nicht nur Zeit- und Kostendruck verlangen nach neuen Analysemethoden. Manche Erreger lassen sich mit bekannten Verfahren noch nicht bestimmen.

(Financial Times Deutschland, 08.11.2001)

Scharfer Blick ins Hirn

Mit verblüffender Präzision können Forscher am Paul Scherrer Institut in der Schweiz die Blutgefäße des Gehirns röntgen. Die dreidimensionalen Bilder zeigen rot das Adergeflecht eines Maushirns.
Der mit einem Pfeil markierte Bereich wurde vergrößert (grün, blau).
Erreichbar ist derzeit eine Auflösung im Mikrometerbereich, bald sollen noch schärfere Aufnahmen die Nanowelt abbilden.
Biomediziner der Zürcher Hochschulen sowie des Pharmakonzerns Novartis wollen mit solchen Röntgenbildern klären, ob etwa Durchblutungsstörungen die Alzheimer-Krankheit fördern. Mangelnde Blutzufuhr könnte die fatalen Ablagerungen im Hirn auslösen. Auch die Entstehung der Osteoporose will man mit solchen Bildern besser verstehen.
Die PSI-Forscher können nicht nur winzige Details sichtbar machen, sondern besonders kontrastreiche Bilder erzeugen. Brustkrebsfotos sind meist schwammig, weil Tumor und gesundes Gewebe Röntgenlicht gleich stark absorbieren. Durch beide Gewebe läuft Röntgenlicht jedoch verschieden schnell. Das lässt sich auswerten (Phasenkontrast) und ermöglicht schärfere Bilder. Die Kombination von hoher Auflösung und scharfem Kontrast wollen die Forscher für künftige Superröntgenbilder nutzen. An Geräten für die medizinische Praxis wird schon gearbeitet.
Länder: Schweiz C4EXSI

(Die Zeit, 26/2006)

Winzige Partikel schützen vor Zahnschmerz

Innovation von Henkel und BASF – Nano-Partikeln schließen Löcher im Schmelz – Markteinführung geplant

VON ANNA SALAS

Dresden – Schmerzempfindliche Zähne sind weit verbreitet. Etwa 45 Prozent der Europäer leiden unter teils heftigen Schmerzattacken, sobald Kaltes, Heißes oder Süßes die Zähne berührt. Bei ihnen ist der Zahnhals durch zurückweichendes Zahnfleisch unzureichend geschützt. Winzige Dentinkanälchen liegen frei und leiten den schmerzverursachenden Reiz direkt an die Zahnnerven. Einzige Hilfe bisher: Durch spezielle Salze, meist Kaliumnitrat, werden die Nervenreizleitungen unterbrochen, die Symptome gelindert.

Den Ursachen des Schmerzes geht jetzt ein Material aus der Nanotechnologie an die Wurzel, eine Kombination aus Nano-Calciumphosphat (Apatit) und Protein. Sie verschließt die Dentinkanälchen mit zahnidentischem Material. Professor Rüdiger Kniep vom Max-Planck-Institut für Chemische Physik fester Stoffe in Dresden hatte untersucht, wie Zähne wachsen und wie sich dieser Prozeß im Reagenzglas nachvollziehen läßt. Das Ergebnis: Die Komponenten von Apatit – Calcium-, Phosphat- und Fluorid-Ionen – diffundieren in wäßriger Lösung in einen Gelatinepfropf. Ionen und Gelatine verwachsen dabei zu einem vernetzten, unlöslichen Composit aus 98 Prozent Apatit und zwei Prozent Protein (Gelatine). Dieses gleicht dem Material, aus dem Zähne bestehen.

Ähnlich sind auch Forscher von BASF in Ludwigshafen vorgegangen und haben die Ausgangsstoffe in eine Zahnpasta eingebracht. Sie verwenden jedoch ausschließlich nanoskalige Apatitkristalle. Diese bilden einen zusammenhängenden dünnen Film auf dem Zahn, der die Fehlstellen des Zahnschmelzes teilweise überdeckt. Diese Filmbildung kommt durch das selbsttätige und kontrollierte Aneinanderlagern (Selbstorganisation) von Nanopartikeln zustande. Noch jedoch befindet sich diese Reparaturmöglichkeit im Entwicklungsstadium.

Hier sind die Composit-Forscher um Professor Kniep einige Schritte weiter: Um die Erkenntnisse aus der Grundlagenforschung in die Anwendung zu übertragen, arbeiteten die Unternehmen Henkel in Düsseldorf und Sustech in Darmstadt zusammen – letztere ist ein Joint Venture der TU Darmstadt, von Professoren verschiedener Universitäten und Henkel.

Das Ergebnis ist das Material „Nanitactive", das einen als „Neomineralisierung" bezeichneten Prozeß anstößt. Hierbei reagieren die Nanitactive-Teilchen mit den im Speichel enthaltenen Calcium- und Phosphatbausteinen und bilden auf der Zahnoberfläche eine Schicht, die der in der Natur entspricht. Die neomineralisierte Materialschicht verhält sich im Mund wie körpereigenes Zahnmaterial und unterliegt dem natürlichen Auf- und Abbau von Material an der Zahnoberfläche. Das zeigen auch Untersuchungen der Dentinkanälchen mit dem Elektronenmikroskop. Nach 20 Behandlungen mit Nanitactive sind alle Dentinkanälchen geschlossen. Es entsteht eine ein bis zwei Mikrometer dicke Schicht aus zahnähnlichem Material, die eng mit den Zähnen verbunden ist und die Dentinkanälchen abdeckt.

In klinischen Tests hat sich eine neue Zahncreme mit Nanitactive bereits bei der Behandlung sensitiver Zähne bewährt. In nächster Zeit wird sie auf den deutschen Markt kommen.

(Die Welt, 28.10.2005)

B 5.5: Frame “Risk debate”

Mehr Vorsorge bei Nanotechnologie

Die Vereinten Nationen haben sich für eine stärkere Kontrolle der Nanotechnologie ausgesprochen, die in immer mehr Bereichen von der Entwicklung neuer Medikamente bis zu Lebensmitteln eingesetzt wird. Die Politik müsse schnell handeln, um Vorteile und Risiken der neuen Technik besser einschätzen zu können, hieß es in dem UN-Umweltbericht. Die Nanotechnologie könne auch Elektronik, Medizin und die Energieindustrie grundlegend verändern, erklärte der Generaldirektor des UN-Umweltprogramms, der Brasilianer Achim Steiner. "Das ist eine phänomenal wachsende Technik, aber wir müssen wissen, was wir da in die Atmosphäre entlassen", sagte Steiner. Er forderte weitere Forschungen, um mögliche Gefahren abzuwehren. **AP**

taz Nr. 8197 vom 9.2.2007, Seite 18, 26 Agentur

(taz, 09.02.2007)

Biotechnik – eine Branche mit Zukunft

Deutschland entwickelt sich zu einem international anerkannten Wissenschaftsstandort

Die Entwicklung der Biotechnikbranche in Deutschland ist eine Erfolgsstory. Über die Gentechnik, die tragende Säule der Biotechnik, ist wegen des dunklen Kapitels in der deutschen Geschichte des 20. Jahrhunderts zwar kaum gesprochen worden. Doch in den letzten Jahren hat sich Deutschland in einem bemerkenswerten Aufholprozeß zu einem international anerkannten Wissenschaftsstandort in der modernen Biotechnologie entwickelt.

Aus einer Studie der Wirtschaftsprüfungsgesellschaft Ernst & Young geht hervor, daß sich die Zahl der Biotech-Unternehmen in Deutschland von 1997 bis 1999 von 173 auf 279 und der Umsatz um 30 Prozent auf 517 Millionen Euro erhöht hat. Analysten sagen ein starkes Wachstum der Biotechnikbranche auch für die nächsten Jahre voraus.

Bei den Unternehmen dieser Branche handelt es sich zumeist um Dienstleister für Arzneimittelhersteller. Nur wenige Unternehmen entwickeln selbst Medikamente. Ernst & Young bemängelt: „Viele der neugeschaffenen Unternehmen verfolgen die Kommerzialisierung nur eines Produkts oder einer singulären Technologie. Damit können sie weder Produktionsfehlschläge kompensieren, noch sind sie attraktiv für die großen potentiellen Partner, die Life-Science-Konzerne." Wegen des internationalen Konkurrenzdrucks wird es nach Meinung der Wirtschaftsprüfer künftig vermehrt Fusionen und Akquisitionen geben.

Die Biotechnologie ist keine Wissenschaft, in der eine entscheidende Rolle spielt. Besonders in der Pharma- und der landwirtschaftlichen Forschung hat die moderne Biotechnologie seit ihrer Begründung in den siebziger Jahren zu einem starken Innovationsschub geführt.

Für die Weiterentwicklung in der modernen Biotechnik wiederum ist vor allem die Genomforschung verantwortlich. Mit der Entschlüsselung des menschlichen Genoms haben sich für die Biotechnik neue Horizonte geöffnet. In der medizinischen Forschung kann die Entschlüsselung des Genoms, sobald die biologische Funktion der einzelnen Gene und ihre Funktion in der Zelle sowie die biologischen Folgen ihrer Beeinflussung durch Arzneimittel verstanden ist, neue Ansatzpunkte für die Entdekkung und Entwicklung neuer Medikamente und Diagnosemethoden liefern. Vor allem verspricht man sich von der Entschlüsselung der menschlichen Genomsequenz neue Therapiemöglichkeiten bei Erb- und Volkskrankheiten. Forscher sprechen von maßgeschneiderten Medikamenten, die keine Nebenwirkungen aufweisen werden. Ihre Entwicklung wird jedoch noch Jahre in Anspruch nehmen.

Der Einsatz der Gentechnik nimmt auch in den anderen biotechnisch relevanten Bereichen wie Ernährung, Landwirtschaft und Umweltschutz immer weiter zu. In der Landwirtschaft und Ernährung verspricht man sich zum Beispiel durch die Entschlüsselung von Totalsequenzen und Nutzpflanzen eine Beschleunigung der Züchtung. In von Medikamenten in der Bevölkerung inzwischen weitgehend akzeptiert wird, ist die Akzeptanz für transgene Pflanzen oder gentechnisch veränderte Lebensmittel fast nicht gegeben. Angesichts dieser Vorbehalte planen die Bundesregierung und die Wirtschaft nun ein Programm, in dem in einem Forschungszeitraum von drei Jahren die Wechselwirkungen von gentechnisch veränderten Pflanzen auf die Umwelt genau erforscht werden. Gleichzeitig soll ein breiter Dialog mit der Öffentlichkeit angeregt werden.

Auch Bedenken um die Sicherheit der neuen Techniken werden geäußert. Viele halten die drei Zukunftstechnologien Gentechnik, Nanotechnologie und Robotik vor Mißbrauch nicht sicher, da diese Technologien von einzelnen Menschen oder kleinen Gruppen mißbraucht werden könnten. Sie erfordern keine großen Produktionsanlagen oder seltene Rohmaterialien. Wissen allein genügt, um sie zu nutzen. Vor allem aber die Biotechnik ist mehr als jede andere Technik auf die Akzeptanz der Bevölkerung angewiesen. Deshalb ist für die Etablierung der Biotech-Industrie in Deutschland nicht zuletzt ein höheres Maß an Öffentlichkeitsarbeit notwendig, um mehr Transparenz für die Bevölkerung zu schaffen. Die Forschungsministerin Edelgard Bulmahn hat zu diesem Zweck das Jahr 2001 zum „Jahr der Lebenswissenschaften" erklärt. Im Rahmen der Initiative „Wissenschaft im Dialog", die die Bundesregierung gemeinsam mit den Wissenschaftsorganisa-

(Frankfurter Allgemeine Zeitung, 29.08.2007)

„Mit Nanopartikeln veredelt“

Die Technologie des Allerkleinsten drängt immer stärker in den Alltag / Von Christian Schwägerl

Die Nanotechnologie hatte bislang den Ruf, ein Spezialthema von Science-fiction-Fans und Grundlagenforschern zu sein. Wer mit offenen Augen durch eine Fußgängerzone geht, kann inzwischen einen anderen Eindruck bekommen. Im Drogeriemarkt ist auf einem Fensterreiniger zu lesen: „Die Nano-Protect-Formel sorgt für streifenfreien Glanz.“ Nanopartikel schützten die Scheibe „wie ein unsichtbarer Schutzschild“. Im Regal nebenan wird für Sonnencreme mit spezieller „Nanoformel“ geworben.

Im Bekleidungshaus verteilt ein renommierter Anzughersteller Stoffproben, die der Kunde versuchsweise beschmutzen soll. Der Stoff sei „mit Nanopartikeln veredelt“ und schütze so gegen Flecken, da diese sich mit Wasser abwaschen ließen. Bügeln reiche, „um den Nanoschutz wieder vollständig zu aktivieren“. Eine Straße weiter bietet eine große Schuhkette ein Spray als „Nano-Nässe-Blocker“ an.

Das Kürzel „Nano“ avanciert offenbar zum Werbeträger. Zwar handelt es sich ursprünglich nur um ein Längenmaß, das für den millionsten Teil eines Millimeters steht. Zugleich symbolisiert „Nano“ aber die rasch wachsenden Fähigkeiten von Wissenschaftlern und Ingenieuren, Kleinststrukturen Atom für Atom aufzubauen und ihre besonders hohe Leitfähigkeit zu nutzen. Der Anwendungsbereich der neuen Technologie ist riesig, er reicht von der Fertigung leistungsstärkerer Computerchips über neue Instrumente der Krebsdiagnostik bis zu schmutzresistenten oder energieerzeugenden Oberflächen.

Gänzlich neu ist nun, daß große Unternehmen die avantgardistischen Verfahren bereits offensiv vermarkten. Vom Kürzel „Nano“ auf den Verpackungen erhoffen sich diese Firmen eine gesteigerte Neugierde der Kunden und einen Sympathiebonus für Innovationskraft. Wie die Verbraucher auf das Zauberwort reagieren, wird aufmerksam beobachtet. Die Technologie ist nämlich nicht unumstritten, zumal auch Umweltorganisationen wie Greenpeace ständig neue Märkte suchen. Nachdem Verbrauchern mit Erfolg Angst vor der Gentechnik eingejagt wurde, kommt nun das Warnen vor Gesundheitsschäden durch umherfliegende Nanopartikeln in Schwung. Die Industrie betont, daß Nanopartikeln, sobald sie einmal im Produkt verarbeitet seien, sich nicht von anderen Materialien unterschieden und daß Herstellungsprozesse, bei denen kleinste Schwebstoffe entstünden, eben isoliert von der Außenwelt zu geschehen hätten. Doch die Kombination aus neuer Technologie und vagem, unsichtbarem Risiko könnte die Nanotechnologie dennoch in Verruf bringen. Soll, wie es Szenarien des Bundesforschungsministeriums besagen, die Nanotechnologie in Zukunft in fast allen Produktionsverfahren zum Einsatz kommen, ist der Ruf der Technologie für die Wirtschaft äußerst wichtig. Das Feld ist unbestellt: Noch wissen Umfragen zufolge nur fünfzig Prozent der Deutschen überhaupt etwas mit dem Kürzel „Nano“ anzufangen, nur fünfzehn Prozent wissen, was genau sich dahinter verbirgt.Die Protagonisten der Nanotechnologie zeigen sich sensibel für gesellschaftliche Sorgen. Zum einen schreiben die Firmen Sicherheit groß und lassen die neuen Produkte ausgiebig testen. Das Bundesforschungsministerium bereitet derzeit ein eigenes Forschungsprogramm zur gesundheitlichen Wirkung von Nanopartikeln vor. Zum anderen wird der mögliche Nutzen neuer Verfahren für die Umwelt hervorgehoben: Nanobehandelte Fensterscheiben und Nanotech-Anzüge müßten seltener gereinigt werden, was Wasser spare. Nanotechnologie werde helfen, den Energieverbrauch von Computern und sogar von Automobilen drastisch zu reduzieren, sagen Firmenvertreter.

Doch die gesellschaftliche Diskussion über die Gentechnik zeigt, daß selbst umweltfreundliche Problemlösungen, wie die Sanierung verseuchter Flächen durch gentechnisch veränderte Bäume, in Verruf kommen, nur weil sie unter die Rubrik „Gen“ fallen. Das Kürzel „Nano“ habe eine Eigendynamik, sagt Axel Lenzer von der Firma Philips Semiconductors, es müsse verhindert werden, daß die Bedeutung in Richtung Gentechnik umschlage. Peter Kücher, Leiter des neuen Fraunhofer-Zentrums für nanoelektronische Technologien in Dresden, rät zu offensivem Argumentieren: Es sei doch besser, den atomaren Bereich zu beherrschen und auszunutzen, als ihm wie bisher ausgeliefert zu sein.

In Großbritannien wird bereits hitzig über die Nanotechnologie debattiert. Dabei wird nun auch mit neuen Formen gesellschaftlicher Technologiebewertung experimentiert. Eine erstaunliche Allianz, die das Verteidigungsministerium und auch Greenpeace umfaßt, hat Mitte Mai eine „Nano-Jury“ aus zwanzig unabhängigen Laien einberufen. Experten sollen dieser Jury Chancen und Risiken vortragen, am Ende wird eine umfassende Bewertung aus Sicht von Normalbürgern stehen. Zumindest die Jurymitglieder dürften nach getaner Arbeit mit den Werbeslogans auf den neuen Fensterreinigern und Schuhsprays etwas anzufangen wissen.

(Frankfurter Allgemeine Zeitung, 06.06.2005)

9 Annex C: Code book and lists

"Risk perception of the subject nanotechnology: analysis of media coverage"

Working definition nanotechnology
"Nano" (Ancient Greek for dwarf): In the scientific context nano describes a unit which corresponds to a billionth part (10^{-9} = 0,000 000 001). Nanotechnology moves in a range of a billionth metre (10^{-9} meter) which designates the area in which more and more quantum physics effects play an important role. Nanotechnology describes and offers methods and/or processes which make possible the manipulation of these tiny components of nature. Hence, nanotechnology cannot be reduced to one area or market; it is far more the case than it is interdisciplinary. Almost all scientific faculties and research institutions as well as a large number of sectors use nanotechnology.

General coding instructions
General comment: unless the coding instruction explicitly requires something else, only *clear article contents are coded*, i.e. only what is explicitly mentioned and not what the coder may have in terms of background knowledge about the situation or individual actors.

The subject matter of the investigation is an analysis of coverage of nanotechnology between January 2000 and December 2007 with regard to agenda setting, media framing (issue- specific and generic) and theoretical discussion aspects. The examination focussed on the national dailies *Frankfurter Allgemeine Zeitung*, *Süddeutsche Zeitung*, *Tageszeitung*, *Frankfurter Rundschau* and *Die Welt*, the news magazine *Financial Times Germany*, *Focus* and *Der Spiegel* as well as *Die Zeit*, the most important German weekly newspaper.

Investigation unit
All newspaper articles in the above journals or newspapers were initially sourced via the relevant online archives of the GBI media database (cut-off date 11 March) using the key words nano* or combinations like "nanotechnology", "nanotechniques", "nanoscience", "nanomaterials", and "nanoparticles" and selected after examination. All the articles for coding are available as texts.

Analytical unit/coding unit
The individual article is the analytical unit.

Coding condition
Within the article nanotechnology must play a key role in order for the content variables like main topic, actors, opportunities or risks to be coded. In this context the deciding factor is not that most of the lines are devoted to nanotechnology. However, there must be a correlation between the number of lines, the importance of and the content presented on this topic. Consequently, all articles with 50% nanotechnology content are to be fully coded. The mere mention of nanotechnology – for instance within the framework of stock exchange reports, as a course of study or future technology – is not sufficient for coding. In this case *only* the identifiers (including the word field analysis) are recorded.

If it is not explicitly mentioned, the subject nanotechnology must be identified through processes, new methods or innovative applications in conjunction with the size range "nanometre". In this case the size range must be explicitly mentioned.

Examples of an implicit link to nanotechnology
"The solid consists of many, alternating thin layers of barium and calcium chloride. The individual layers are just a few millionths of a millimetre (nanometre thick). For the production of these so-called heterostructures the researchers (…)." (FAZ, 10.01.2001, p. N1)

"The cause of this unusual electrical behaviour are so-called surface phenomena which only occur in thin layered surfaces in the nanorange (…)."(FAZ, 10.01.2001, p. N1)

"In the race for faster and faster processors the transistors (…) must become smaller and smaller so they can fit onto a circuit board – in the case of the next generation electricity will only have to cover a distance of 45 nanometres. In order to be able to further reduce the size, engineers must improve the isolation layer in the transistors (…) after more than ten years research they have succeeded in replacing the silicon oxide used so far with a new compound with superior material properties" (SZ, 30.01.2007, p. 16)

"The researchers around Pierre Petroff (…) have produced a tiny circuit board made of the semi-conductive material gallium arsenide. So-called quantum points made of indium arsenide are embedded in it. These are nanosized collections of atoms in which charge carriers can only assume discrete conditions. If the 200 nanometre thick board is irradiated with short laser pulses, free electrons and positively charged holes are created in the gallium arsenide (…)." (FAZ, 10.01.2001, p. N3)

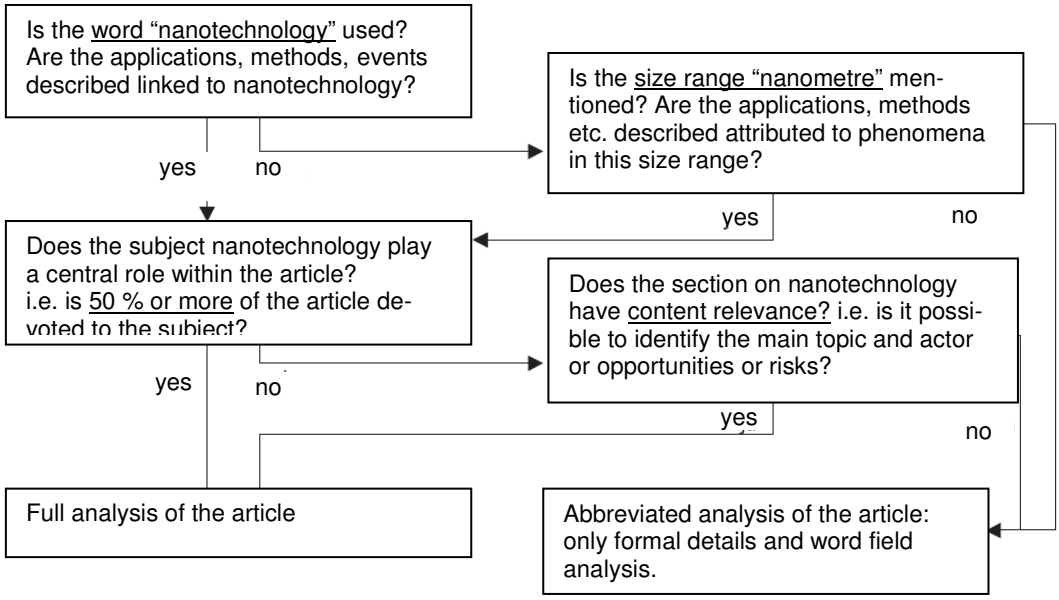
"As once dreamt up by Hollywood and projected on the big screen, cancer medication is soon to be directly transported via the blood stream to the sick cell by means of a submarine measuring only one nanometre (10^{-9} metre) in size (…)." (taz, 23.03.2007)

Rule of thumb: Inclusion of the article when at least 50% is devoted to the subject of nanotechnology and/or content relevance (information on the main topic, actors, opportunities or risks)

Decision tree
Is this an article about nanotechnology and how in depth should my analysis of it be?

Procedure
1 The first step is to read the entire article in order to determine whether the above inclusion criterion "nanotechnology is the main topic" actually applies. Identifiers are coded.
2 Coding of individual variables in the article can begin during the second reading. When coding a few variables it is necessary to read the whole article or parts of it again (please note the coding instructions). It may helpful to make notes whilst reading.
3 In cases of uncertainty the entire article should be read once more.

Fig. 25: Decision tree



Organisational details

All documents, information and updates on the media analysis "Risk perception of nanotechnology" are documented in the joint project file on the BSCW work platform.

- The individual working times and the status of coding are continuously recorded in a joint excel file.
- Uninterrupted coding work should not exceed three hours as otherwise major concentration losses are to be expected.
- Discussion of individual codings or agreements amongst coders is desirable. The decisions taken and the rules derived from them are to be documented in a transparent manner for everyone.
- All rules and innovations agreed in the coding process must be documented on the joint BSCW work platform.
- Additions to the topic, actor and image lists are undertaken continuously on the joint BSCW work platform. Hence the first step when commencing work is to open the updated lists.
- Care should be taken to ensure each coder codes articles from all years and all newspapers/journals to avoid any systematic differences because of the choice of article.
- Coded articles are to be given a "consecutive number" and a coder abbreviation as the identifiers, and are to be stored in the corresponding file for processed articles.

Please note
When coding attention should focus generally on the link to nanotechnology. All variables in this codebook only refer to parts/sections of an article which deal with the subject nanotechnology and only then are they to be coded. The goal of the content analysis is to present the picture of topics, presentation and assessment of nanotechnology in the coverage by the print media. Other subjects are not of interest in terms of content!

A. Formal characteristics			
Var. No./ SPSS Abbreviation	Variable	Code	Form
V1	ID number of the article	1001-x 3001-x 5001-x 7001-x	*(Zahlenbereich Johanna)* *(Zahlenbereich Silvia)* *(Zahlenbereich Andreas)* *(Zahlenbereich Moritz)*
V2	Coder	1 2 3 4	Johanna Kaminski Silvia Leitel Andreas Thieme Moritz Raulfs
V3_1	Publication	1 2 3 4 5 6 7 8 9	Frankfurter Allgemeine Zeitung Süddeutsche Zeitung Tageszeitung Frankfurter Rundschau Die Welt Financial Times Dtld. Die Zeit Der Spiegel Focus
V 3_2	Source/author of the article	1 2 3 4 5	News agency (e.g. dpa, AFP, Reuters, ddp) Editor/correspondent of the newspaper (own contribution) Mixed form (correspondent *or* editor, *and* new agency) Guest author (e.g. politician) No details Not decidable
V4	Day	1 - 31	1-31
V5_1	Month	1-12	January-December
V5_2	Issue	1-x	Issue number
V6	Year	0-7	2000–2007
V7	Impression after reading	1 2 3 0	For Neutral Against No link to nanotechnology
V8	Headline	string	Main title
V9	Headline Evaluation	0 1 2 3	No link to nanotechnology Positive evaluation of nanotechnology Neutral Negative evaluation of nanotechnology
V10_1	Scale of the article	1 2 3 4 5 6 7 8	up to 1/16 page up to 2/16 = 1/8 page up to 4/16 = 1/4 page up to 5/16 = approx. 1/3 page up to 8/16 = 1/2 page up to 10/16= approx. 2/3 page up to 12/16 = approx.3/4 page up to 16/16 = 1 page
V10_2	Scale of the article (relation)	1 2 3 4 5 6 7 8 9 10	¼ text page ½ text page ¾ text page 1 text page up to 1 ½ text pages up to 2 text pages up to 2 1/2 text pages up to 3 text pages up to 4 text pages more than 4 text pages

A: Formal Characteristics			
Var. No./ SPSS Abbreviation	Variable	Code	Form
V10_3	Scale of the article (relation)	1 2 3 4 5 6 7 8	¼ page ½ page 1 page 2 pages 3 pages 4 pages 5 pages More than 5 pages
V11	Section	0 1 2 3 4 5 6 7 8 9 10 11 12 13	Not identifiable Title page Politics/domestic Politics/foreign Economy/finances Feature/arts section Knowledge/science Sport Travel/transport Advice Local section Weekly supplement Opinion page Other/other section
V12	Page	0 1-x	Not identifiable Page
V13	Media form	1 2 3 4 5 6 7 8	News Report Comment/column/editorial Interview Readers' letter Portrait Essay Other
V14_1	Percent	0 1 2 3 4	No reference to nanotechnology up to 25 % of the article up to 50 % of the article up to 75 % of the article up to 100 % of the article
14_2	Filter	-99 0 1 11	Question not relevant No *(→go to V15_1)* Yes *(→ go tot V16_a)* Filter question not asked

Word field analysis of " excluded" articles (an insignificant part of the article is dedicated to nanotechnology) *Pease note:* In the case of articles which meet the inclusion criterion (see p. 4), please ignore variables V15_1 to V15_3 and go to V16!			
Var. No. / SPSS Abbreviation	Variable	Code	Form
V15_1	Link	0 1 2	No link to nanotechnology Direct/identifiable link to nanotechnology Not clear
V15_2	Association	1 2 3 4 5 6 7 8 9 10 11 12 13 14 999	Speed (real) (Unimaginable) speed Weight (real) (Unimaginable) lightness Size/length (real) (Unimaginable) size= tiny Power (real) (Unimaginably low) power Nanotechnology as a course of study/field of research "The nanotechnology" Company name Product name Nanotechnology products Mention of an individual Other
V15_2b	Association II	0 1 2 3 4 5 6 7 8 9 10 11 99	No link to nanotechnology Political association Social association Cultural association Legal association Economical association Ethical-moral association Scientific association Military association Ecological association Sport Other Not decidable
V15_3	Coinage	0 string	No new terms Open recording

B: “Recipient angle”			
Var. No. / SPSS Abbreviation	Variable	Code	Form
V16_a	Recognisability	0	No
		1	Yes
		-99	Not completely coded article
V16	Media style	1	Descriptive/factual
		2	Interpretative/evaluative/opinion oriented
		-99	Not fully coded article
V17_1	Information content	1	Very low
		2	(Rather) low
		3	Average
		4	(Rather) high
		5	Very high
		-99	Not fully coded article
V17_2	Technical terms I	0	None
		1	1
		2	2
		3	3
		4	more than 3
		-99	Not fully coded article
V17_3	Technical terms II	0	Are not used
		1	Yes, are (at least partially) explained
		2	No, are not explained
		-99	Not fully coded article
V17_4	Background information	0	No
		1	Yes
		2	Not decidable
		-99	Not fully coded article
V18_1	Comprehensibility I: Complexity	1	Very low
		2	(Rather) low
		3	Average
		4	(Rather) high
		5	Very high
		-99	Not fully coded article
V18_2	Comprehensibility II: Simplicity	1	Simple
		2	Rather simple
		3	Neither/nor
		4	Rather complicated
		5	Complicated
		-99	Not fully coded article
V18_3	Comprehensibility III: Structure	1	Strictly structured
		2	Structured
		3	Rather unstructured
		4	Not structured
		-99	Not fully coded article
V18_4	Comprehensibility IV: Brevity	1	Too short
		2	Rather short
		3	Neither/nor
		4	Rather expansive
		5	Too expansive
		-99	Not fully coded article
V19	Article focus (time)	1	Past
		2	Present
		3	Near future
		4	“Distant” future
		-99	Not fully coded article
C: Image analysis:			

Only those images are taken into account which deal in some way or another with the subject nanotechnology			
Var. No. / SPSS Abbreviation	Variable	Code	Form
V20	Number	0 1-x -99	0 State number Not fully coded article
V21_1 – V21_3	Subject of image	1-x -777	See *List of topics* (List 1) Image content not depicted in analytical material
V22_1 – V22_3	Visualisation	0 1 2 3 4 5 6 7 8 9 99 -777	Image not depicted in analytical material Microscope image Size comparison Technical devices Everyday articles Food Cars Individuals Animals/nature Cannot be classified Image content not identifiable because of the quality of the analytical material Image content not depicted in analytical material

D: Topic structure			
Var. No. / SPSS Abbreviation	Variable	Code	Expression
V23	Localisation	0	Not identifiable
			Individual countries
		1	Australia
		2	China
		3	Germany
		4	France
		5	Israel
		6	Japan
		7	Netherlands
		8	Switzerland
		9	South Korea
		10	U.K./England
		11	U.S.A.
			Alliances
		12	EU/EC (European Community)
		13	UN/United Nations
			Several countries
		14	Several countries involved (including Germany)
		15	Several countries involved (not including Germany)
		16	*Large regions*
		17	Europe
		18	North America
		19	South America
		20	Asia
		21	Australia
		-99	Africa
		22	Not fully coded article
			Other
V24	Main topic	1 - x	See *List of topics* (List I)
		-99	Not fully coded article
V25	Sub-topic	0	No sub-topic addressed
		1 - x	See *List of topics* (list I)
V26	Topic perspective	0	Not decidable
		1	Political perspective
		2	Social perspective
		3	Cultural perspective
		4	Legal perspective
		5	Economic perspective
		6	Ethic-moral perspective
		7	Scientific perspective
		8	Military perspective
		9	Other
V27	Relevance	0	Not identifiable
		1	Individual relevance
		2	Particular relevance
		3	Overall social relevance
		4	Universal/global relevance

E: Actor level/level of spokesperson's comment

Please note: For the following codes all details which refer to the same situation must be given the same Roman numerals. Up to three (main) actors per article may be coded. *The First main actor to be coded is the most important actor* in an article, not the actor mentioned first! The determining factor is the amount of space or time accorded to the angle of that actor. If two actors are on a par, then the actor mentioned first should be coded first.

The following variables make up a set:

First mention in text: Level 1

- Actor (I), prominence (I), contradiction (I), conclusion (I), link to topic (I), assessment
- Actor (II), prominence (II), contradiction (II), conclusion (II), link to topic (II), assessment
- Actor (III), prominence (III), contradiction (III), conclusion (III), link to topic (III), assessment

Var. No. / SPSS Abbreviation	Variable	Code	Form
V28_I - V28_III	Actor (I-III)	0 1-x -99	No actor See List of actors Not fully coded article
V29_I - V29_III	Prominence (I– III)	1 2 3 -99	Dominant, central Equal weighting On the fringes Not fully coded article
V30_I - V30_III	Contradiction	0 1 2 -99	Attitude not contradicted Attitude contradicted Not identifiable Not fully coded article
V31_I - V31_III	Conclusion	0 1 2 -99	Attitude not presented at the end as conclusion Attitude presented at the end as conclusion Not identifiable Not fully coded article
V32_I - V32_III	Link to the topic (= sub-topic)	1 – x -99	See List of topics Not fully coded article
V33_I - V33_III	Assessment	0 1 2 3 4 5 -99	No assessment Very positive Rather positive So-so Rather negative Very negative Not fully coded article

F: Opportunities/benefits and risk dimension

Please note: For the following codes all details which refer to the same situation must be given the same Roman numerals. *Up to* three risks, opportunities, demands and forecasts and the related variables can be recorded.

The following variables make up a set:
Mentioned first in the text:

- Benefit dimension (I), concrete benefit (I), expectation of occurrence of benefit (I), actor responsible for the benefit (I), author of the attribution of responsibility (I)
- Risk dimension (I), concrete risk (I), expectation of occurrence of risk (I), actor responsible for the risk (I), author of the attribution of responsibility (I)
- Demand (I), instruction (I), author of instruction (I), recipient of instruction (I)
- Forecast (I), author of forecast (I)

Mentioned second in the text: Level II

- Benefit dimension (II), concrete benefit (II)…

If no statement is made in the article on one of the variables in the variable set, then this should be coded 0!

Var. No. / SPSS Abbreviation	Variable	Code	Form
V34	Benefit dimension (I – III)	0	Not mentioned/no benefit
		1	Diffuse benefit (not futher specified)
		2	Medical benefit
		3	Scientific benefit
		4	Economic benefit
		5	Legal benefit
		6	Political benefit
		7	Individual benefit
		8	Ethical-moral benefit
		9	Military benefit
		10	Public/social benefit
		11	Ecological benefit
		99	Other benefit
		-99	Not fully coded article

Continuation F: Opportunities/risks and risk dimension			
Var. No. / SPSS Abbreviation	Variable	Code	Form
V35_I - V35_III	Concrete benefit (I - III)	0	Benefit not concretised
			Economic
		1	Major sales revenue potential
		2	New jobs
			Ecological
		3	Environmental detoxification
		4	Climate protection
		5	Sustainability effects
		6	Improved efficiency in energy conversion
		7	Reducing energy consumption
		8	Solving energy problems
		9	New materials
			Medical
		10	Medical diagnosis
		11	Medical treatment
		12	Cancer treatment (special)
		13	New medicines
			Technical
		14	Higher performance data storage media
		15	Miniaturisation in the computer segment
		16	Improved performance in the computer segment
			Military
		17	Individual safety
		18	Superhuman powers
		19	Protection against environmental impact
		999	*Other*
		-99	Not fully coded article
V36_I - V36_III	Expectation of the occurrence of a benefit (I – III)	0	No assessment
		1	Unlikely
		2	Rather unlikely
		3	Rather likely
		4	Very likely
		5	Benefit already occurred
		-99	Not fully coded article

Continuation F: Opportunities/benefits and risk dimension			
Var. No. / SPSS Abbreviation	Variable	Code	Form
V37_I - V37_III	Person responsible for benefit (I – III)	0	Not named
			Persons
		1	Federal government
		2	Opposition
		3	Other political actors
		4	Political institutions
		5	Ethics council/ethics committee
		6	Central bodies/institutions and associations
		7	Scientific actors/groups/institutions
		9	Economic actors
		10	Public figures
		11	Environmental associations
		12	Social groups
		13	Church
		14	Science journalists
		15	Journalists
		16	Foundations/science support
		17	Other actors
		20	“The nanotechnology“ (object)
		30	External circumstances/situation
		-99	Not fully coded article
V38_I - V38_III	Author of the attribution of responsibility	0	Not named
			Persons
		1	Federal government
		2	Opposition
		3	Other political actors
		4	Political institutions
		5	Ethics council/ethics committee
		6	Central bodies/institutions and associations
		7	Scientific actors/groups/institutions
		9	Economic actors
		10	Public figures
		11	Environmental associations
		12	Social groups
		13	Church
		14	Science journalists
		15	Journalists
		16	Foundations/science support
		17	Other actors
		-99	Not fully coded article

Continuation F: Opportunities/benefits and risk dimension			
Var. No. / SPSS Abbreviation	Variable	Code	Form
V39_I - V39_III	Risk dimension (I - III)	0 1 2 3 4 5 6 7 8 9 10 11 99 -99	Not mentioned/no risk Diffuse risk (not further specified) Health risk Scientific risk Economic risk Legal risk Political risk Individual risk Ethical-moral risk Military risk Public/social risk Ecological risk Other risk Not fully coded article
V40_I - V40_III	Concrete risk (I - III)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 *999* *-99*	Risk not specified *For Man* Health risk, fine dust Absorption of nanoparticles through the skin/lungs Damage to genetic information Occupational diseases Data abuse/unnoticed personal surveillance/discrimination *For the environment* Nanoparticles as a new class of non-biodegradable contaminants Nanoparticles in the water cycle Absorption of nanoparticles by plants Destruction of the biosphere Other environmentally damaging effects *Ethical/moral* Artificial intelligence Transcending man/“posthumanism”/transhumanism “Nano-divide“ *Ficticious* Nanorobots/microrobots (Crichton’s “Prey") Self-assemblers/replicators Grey goo Creation of artificial organisms “Material convertors (Fiction: Marcus Hammerschmitt’s “The Censor“) Technology abuse Knowledge-based mass destruction *Other* Not fully coded article

Continuation F: Opportunities/benefits and risk dimension			
Var. No./ SPSS Abbreviation	Variable	Code	Form
V41_I - V41_III	Occurrence of a risk (I –III)	0	No assessment
		1	Unlikely
		2	Rather unlikely
		3	Rather likely
		4	Very likely
		5	Risk already occurred
		-99	Not fully coded article
V42_I - V42_III	Actor responsible for the risk (I – III)	0	Not named
			Persons
		1	Federal government
		2	Opposition
		3	Other political actors
		4	Political institutions
		5	Ethics council/ethics committee
		6	Central bodies/institutions and associations
		7	Scientific actors/groups/institutions
		9	Economic actors
		10	Public figures
		11	Environmental associations
		12	Social groups
		13	Church
		14	Science journalists
		15	Journalist
		16	Foundations/science support
		17	Other actors
		20	“The nanotechnology“ (object)
		30	External circumstances/situation
		-99	Not fully coded article
V43_I - V43_III	Author of the attribution of responsibility	0	Not named
			Persons
		1	Federal government
		2	Opposition
		3	Other political actors
		4	Political institutions
		5	Ethic council/ethics committee
		6	Central bodies/institutions and associations
		7	Scientific actors/groups/institutions
		9	Economic actors
		10	Public figures
		11	Environmental associations
		12	Social groups
		13	Church
		14	Science journalists
		15	Journalist
		16	Foundations/science support
		17	Other actors
		-99	Not fully coded article

Continuation F: Opportunities/benefits and risk dimension			
Var. No. / SPSS Abbreviation	Variable	Code	Form
V44_I - V44_III	Demand (I-III)	0 1 2 3 4 5 6 9 -99	Not mentioned/no demand Risk regulation Promotion of the benefit Both regulation of risk and promotion of benefit Research/studies Ethical standards Improved information/dialogue Other demands Not fully coded article
V45_I - V45_III	Instruction (I-III)	0 1-x -99	No concretisation See *List of instructions* Not fully coded article
V46_I - V46_III	Author of the demand (I-III)	0 *Persons* 1 2 3 4 5 6 7 9 10 11 12 13 14 15 16 17 -99	Not named *Persons* Federal government Opposition (Other) political actors Political institutions Ethics council/ethics committee Central bodies/institutions and associations Scientific actors/groups/institutions Economic actors Public figures Environmental associations Social groups Church Science journalists Journalists Foundations/science support Other actors Not fully coded article

Continuation F: Opportunities/benefits and risk dimension			
Var. No. / SPSS Abbreviation	Variable	Code	Form
V47_I - V47_III	Recipient of the demand (I–III)	0 1 2 3 4 5 6 7 9 10 11 12 13 14 15 16 17 -99	Not named *Persons* Federal government Opposition (Other) political actors Political institutions Ethics council/ethics committee Central bodies/institutions and associations Scientific actors/groups/institutions Economic actors Public figures Environmental associations Social groups Church Science journalists Journalists Foundations/science support Other actors Not fully coded article
V48_I - V48_III	Forecast (I–III)	0 1 2 3 -99	Not known/no forecast Good forecast Poor forecast Not assessable Not fully coded article
V49_I - V49_III	Author of the forecast (I–III)	0 1 2 3 4 5 6 7 9 10 11 12 13 14 15 16 17 -99	Not named *Persons* Federal government Opposition Other political actors Political institutions Ethics council/ethics committee Central bodies/institutions and associations Scientific actors/groups/institutions Economic actors Public figures Environmental associations Social groups Church Science journalists Journalists Foundations/science support Other actors Not fully coded article

G: Genetic framing

Various characteristics of reporting are examined here. Please read the corresponding instructions like a questionnaire. All questions are to be answered by YES or NO.

Coding: The questions are directed towards the entire content of the article/part of article which deals with nanotechnology, also towards the comments of the spokespersons or indirect quotations. The passages which lead to a yes coding should be clearly identifiable but need not dominate the entire article. It is not important whether statements were made by the journalist themselves or other spokespersons.

Var. No. / SPSS Abbreviation	Variable	Code	Form
V50	Negativity	1 0	yes no
V51	Personalisation 1	1 0	yes no
V52	Personalisation 2	1 0	yes no
V53	Personalisation 3	1 0	yes no
V 54	Collectivity	1 2 3 4 0 -99	yes, the “sciences” yes, the ”industry”/“economy” yes, the “politics” yes, other “collective actors“ no Not fully coded article
V55	Emotionalisation 1	1 0	yes no
V56	Emotionalisation 2	1 0	yes no
V57	Conflict 1	1 0	yes no
V58	Conflict 2	1 0	yes no
V59	Aspects	1 0	yes no
V60	Conflict 3	1 0	yes no
V61	Morals 1	1 0	yes no
V62	Morals 2	1 0	yes no
V63	Morals 3	1 0	yes no
V64	Finances 1	1 0	yes no
V 65	Finances 2	1 0	yes no
V66	Costs	1 0	yes no
V67	Economic consequences	1 0	yes no

H: Language level			
Var. No. / SPSS Abbreviation	Variable	Code	Form
V69_I - V69_III	Comparisons	0 1 2 3 4 5 6 999 -99	No comparisons Genetic engineering Asbestos Thalidomide scandal DDT Nuclear age/nuclear power Internet Other Not fully coded article
V70	Metaphors	0 1-x -99	Are not used See *List of images* Not fully coded article
V 71_I - V71_III	Negative Adjectives	0 1 2 3 4 5 999 -99	Not used *Negative connotation* Dangerous Poisonous/toxic Scary Artificial Risky Other Not fully coded article
V 72_I - V72_III	Positive Adjectives	0 1 2 3 4 5 6 7 7 9 10 11 12 13 999 -99	Not used Cheaper More efficient Intelligent Interactive Scratch-resistant Lighter More robust Faster Self-disinfecting Self-cleansing Environmentally friendly Indestructible Magical Other Not fully coded article
V73	New terms	0 String	No new terms Open recording
V74	Basissatz	String	

List of actors

Brief overview of the list of actors

100	Political actors
200	Political institutions
300	Central bodies/institutions/associations
400	Scientific institutions/research groups/scientists
500	Economic actors
600	Public figures (authors, actors, moderators etc.)
700	Social groups/group designations
800	Journalists
900	Foundations/science support
999	Other actors

Coding instructions for extending lists

If actors crop up in the course of individual coding that are not covered by the actor categories presented in this list, then they are initially to be coded 999 "*Other actors*" and then entered in the corresponding input field of the data mask (string= entry of the new actor).

Please note: the inclusion of new actors, topics, opportunities, risks, instructions and images is to be handled extremely sparingly. The first step should always be to examine whether they are covered by the existing categories!

Simplifying the search

The use of a search command can simplify orientation in this list and help to reach the desired upper category more quickly.

100 Political actors

101	Red/Green Federal Government	2000–09/2005
102	Black/Red Federal Government	09/2005–2007
103	Representatives of the SPD	
104	Representatives of the CDU/CSU	
105	Representatives of B. 90/Greens	
106	Representatives of the FDP	
107	Representatives of the PDS	
108	Representatives of the WASG	
109	Red/Green representatives	When two parties are touched on
110	Red/Red representatives	
111	Red/Black representatives	
112	Black/Yellow representatives	
113	The opposition	Is only coded if there is a general tag of "the opposition"
114	Representatives of other parties	
115	The "politics"/"The "politicians"	

200 Political Institutions

201	Federal Ministry of Education and Research (BMBF)
202	Federal Ministry of Economics and Technology
203	Federal State Ministries of Research/Science etc.
204	National Ethics Council/Ethics committee
205	European Commission
206	United Nations (UN)
219	*Other* political institutions

Note on the classification of political actors: if political actors occur as main actors i.e. they talk about nanotechnology or their attitude is paraphrased by a journalist, then they are also coded in the function in which they occur/express themselves. In the case of political/politically motivated controversies on nanotechnology, the actors are always coded according to their party affiliation, as in these cases they are to be seen as representatives of the political stance of their party.

300 Central bodies/institutions/associations

301	Economic research institutes, economics experts
302	VDI Technologiezentrum GmbH
303	Schweizer Rückversicherer Swiss Re
304	Canadian Environmental Technology Centre
305	USA Environmental Agency EPA
306	Bundesanstalt für Materialforschung und -prüfung
307	Bundesinstitut für Risikobewertung (BfR)
308	Öko-Test
309	US-American “National Nanotechnology Initiative (NNI)“
310	Consumer protection organisations/associations/offices
319	*Other* central bodies/institutions/organisations

400 Scientific institutions/research groups/scientists
Research institutions

401	(Natural) scientist
403	(Social) scientist
405	CeNTech (Centre for Nanotechnology, Munich)
406	CeNS (Centre for NanoScience (LMU, Munich)
407	Institut für Nanotechnologie, Karlsruhe
408	Leibniz-Institut für Neue Materialien (INM)
409	Forschungsnetzwerk „NanoMat“
410	Fraunhofer Verbund Nanotechnologie
411	Max-Planck-Institute
412	Netzwerk NanoBioNet
Research institutions mentioned by name outside Germany	
420	European Scientific Body (SCCNFP)
421	Royal Society
422	British Royal Academy
423	Nano2Life (European Network of Excellence for Nanotechnology)
424	Center for Nanoelectronic Systems in Information Technology (CNI), Jülich
425	Foresight Nanotech Institute, Los Altos (CA)
426	MIT Institute for Soldier Nanotechnology, Cambridge (Massachusetts)

Continuation: 400 Scientific institutions/research groups/scientists
Research institutions in the table

Nanoresearchers and/or their research groups mentioned by name	
440	(Group) Harald Fuchs, Münster
441	(Group) Roland Wiesendanger, Hamburg
442	(Group) Dieter Bimberg, Berlin
443	(Group) Christoph Bräuchle, Munich
444	(Group) Hermann Gaub, Munich
445	(Group) Wolfgang Heckl, Munich (LMU, Chair for Nanobiotechnology)
446	Cees Dekker, Dutch physicist (Delfter Institut, NL)
447	Gerd Binnig/Heinrich Rohrer (inventor of the scanning tunnelling microscope)
448	Günter Oberdörster (nanoexperts/practitioners of environmental medicine)
449	Richard Feynman
450	Stanislaw Lem (scientific philosopher)
451	...
Other nanoexperts	
460	Doctors/physicians
461	Practitioners of environmental medicine/Environmental toxicologists
499	*Other* scientific institutions/research groups/scientists

500 Economic actors

501	Actors on the employees' side	Unspecified: trade unions/trade union members, employees/employee associations, works council
502	Actors on the employers side	Employer/employer's president/association, Verein Deutscher Ingenieure (VDI), Bundesverband der Industrie (BDI), Deutsche Industrie und Handelskammer (DIHK)/Deutscher Industrie- und Handelstag (DIHT)
Representatives of individual business sectors		
510	Representative of the pharmaceutical industry	
511	Representative of the textile industry	
512	Representative of the construction industry	
513	Representative of the chemical industry	
514	Representative of the automotive industry	
515	Representative of the information and communication industry	
516	Representative of the armaments and aerospace industry	
517	Representative of the cosmetics industry	
518	Representative of the food industry (including agriculture)	
519	Representative of other industrial sectors	
Companies/firms frequently mentioned by name which are active in the field of nanotechnology		
530	BASF	
531	Beiersdorf	
532	Henckel	
533	Kleinmann	Brand: "Magic Nano", "Magic Nano bath and WC surface sealing agent", "Magic Nano glass and ceramic surface sealing agent"
534	Nestlé	
535	IBM	
Collective designations		
550	"The industry, "The" economy	
599	Other economic actors	

600 Public figures (authors, actors, moderators etc.)

601	Eric Drexler (publicist)
602	Arthur C. Clarke (author)
603	Michael Crichton (author)
604	Ray Kurzweil (author)
605	Bill Joy (publicist)
606	...

700 Social representatives/social groups/group designations

701	Greenpeace
702	Umweltinstitut Munich e.V.
703	BUND
704	Nanojury (British citizens' forum for the assessment of opportunities/risks of nanotechnology)
705	The consumers
706	Critics
707	Advocates
708	(Nano) experts
709	The population
710	Victims/people affected
711	Church/representatives of the church
712	Environmental protectionists/environmental associations
719	*Other*

800 Journalist

801	Journalist/author of the article (none of the science journalists mentioned below)
802	Niels Boeing
803	Christoph Drösser
804	Gero von Randow
805	Max Rauner
806	Ulrich Schnabel
807	Volker Stollorz

900 Foundations/science support

901	VW-Stiftung
902	Alexander-von-Humboldt-Stiftung
903	DFG Deutsche Forschungsgemeinschaft
904	Stifterverband für die Deutsche Wissenschaft
905	Helmholtz-Gemeinschaft Deutscher Forschungszentren
906	Wissensgemeinschaft Gottfried Wilhelm Leibnitz
907	MPG Max-Planck-Gesellschaft
908	FhG Fraunhofer-Gesellschaft
919	*Other* foundations/science support
999	**Other actors** (*cannot be classified in any of the existing categories*)
→	Open recording in the category system

List of topics

Short overview of the topic categories

100	Fundamental research/nanotechnology in general
200	Application: Health care (medicine, medical engineering, pharmaceutics)
300	Application: Automotive industry
400	Application: Information and communication technologies
500	Application: Surface coating
600	Application: Armaments, aerospace
700	Application: Energy management
800	Application: Textile industry
900	Application: Cosmetic industry
1000	Application: Construction
1100	Application: Chemical industry
1200	Food industry/agriculture
1300	Ethical aspects of nanotechnology in general
1400	Nanobiotechnology
1500	Politics
1600	Economics
1700	Sport
1800	Art/Culture
1900	Intoxication cases/product recalls
2000	Debate about Bill Joy's call for moratorium
2100	Overview of nanotechnology
2200	Consumer protection/product labelling
2300	Health and safety at work

Coding instructions for extending the list

If topics crop up in the course of individual coding that are not covered by the (sub-)topics in this list, then they are initially to be coded in the respective upper category (xx**99**) and then entered in the data mask (string = indication of topic in word form).

Please note: the inclusion of new actors, topics, opportunities, risks, instructions and images is to be handled extremely sparingly. The first step should always be to examine whether they are covered by existing categories!

Simplifying the search

The use of a search command can simplify orientation in this list and help to reach the desired upper category more quickly.

100 Fundamental research/nanotechnology in general

101	Theoretical physics
102	Toxicology
103	Structure formation, nanostructures (measurements and analysis of nanostructures)
104	Risk research
199	Other topics in the field of fundamental research

200 Application: Health care (medicine, medical engineering, pharmaceutics)

201	Heart attack diagnosis
202	Diagnosis/early detection of (other) diseases
203	Medical treatments
204	(Special) tumour/cancer treatment
205	Medicine/drug delivery
206	Tissue structure/artificial tissue
207	Neuroprosthetics/artificial organ functions (if neuroprosthetics is only dealt with in conjunction with nanobiotechnology, it is to be coded as 1405)
208	Gene ferries (for gene therapy)
209	Biochip/Biosensor
210	Medical toothpaste/dental hygiene
299	Other topics in the application of healthcare

300 Application: Automotive industry

301	Nanotechnology-based automotive components/sub-systems and materials
302	Nano-based materials for propulsion and energy supply
303	Coatings/multifunctional coatings
304	Sensors (e.g. immobiliser, lighting, air pressure etc.)
305	Car tyres/wear-resistant super grip tyres
399	Other topics in the application automotive industry

400 Application: Information and communication technologies

401	Electronic components
402	Miniaturisation
403	Display
404	Sensors
405	Multifunctional devices
406	Digitalised home electronics
407	Warning and assistance systems
408	Data carriers with nanostructures
409	Data security
410	Data processing on the molecular level (quantum computing)
499	Other topics in the application information and communication technologies

500 Application: Surface coating

501	Surface functionalisation and finishing
502	Protective coating
503	Lotus effect (special)
599	Other topics in the application surface coating

600 Application: Armaments, aerospace

601	Military platforms and carrier systems
602	Reconnaissance (e.g. small reconnaissance planes)
603	Weapons and ammunition
604	Persons: improving physical performance and resistance
605	Camouflage paint
606	Sensors (e.g. in battle dress)
607	Robot soldier
608	Exoskeletons
609	Utopias: battle dust, battle flies, intelligent dust
699	Other topics in the application armaments, aerospace

700 Application: Energy management

701	Solar cells/photovoltaics
702	Solid fuels
703	Energy stores: batteries/accumulators and super condensors
704	Energy converters (e.g. fuel cells)
705	Energy transport
706	Lighting
707	Energy efficiency
799	Other topics in the application energy management

800 Application: Textile industry

801	Intelligent clothing
802	Water and dirt-repellent clothing
803	Firmness
804	UV protection
899	Other topics in application textile industry

900 Application: Cosmetics industry

901	Sun cream
902	Other cosmetics
903	Nanocontainers (customised liposomes in water)
999	Other topics in the application cosmetics industry

1000 Application: Construction

1001	Building materials
1002	Heat insulation/heat protection
1003	Outside surfaces/facades (e.g. graffiti protection)/bricks (e.g. corrosion protection)
1004	Windows
1005	Indoor area
1099	Other topics in the application construction

1100 Application: Chemical industry

1101	Catalysis/catalysts
1102	Filling materials
1103	Pigments/coatings/lubricants
1104	Micro and nanoreaction technology
1105	Membranes and filters
1106	Paints/printing inks/inks
1107	Pesticides
1108	Cleaning agents
1109	Plastics
1199	Other topics in the application chemical industry

1200 Application: Food industry/agriculture

1201	Molecular cuisine/molecular gastronomy
1202	Functional food (packaging of additives like vitamins etc. in nanocontainers, where the smallness of the containers means that they can be absorbed better and in a more targeted way)
1203	Dyes
1204	Additives
1205	Self assemblers (self-replicating food, key word: land of milk and honey)
1299	Other topics in the application food industry/agriculture

1300 Ethical aspects of nanotechnology in general

1301	Nano-divide/fair distribution/fair participation
1302	Precautionary principle
1303	Risk ethics
1304	Privacy/data protection
1305	Medical-ethical problems
1306	Military use of nanotechnology
1307	Anthropological aspects (i.e. man-machine relationship, status of the “citizen cyborg”)
1308	Moratorium (with no link to Bill Joy)
1399	Other ethical aspects of nanotechnology

1400 Nanobiotechnology

1401	Lotus effect (unless a link is established to industrial applications – otherwise surface coating 503)
1402	Gecko adhesive band/nanoadhesive band
1403	DNA sequencing
1404	Targeted manipulation of cellular structures
1405	Neuroprosthetics (only when neuroprosthetics is mentioned in conjunction with nanobiotechnology – if this is mentioned in conjunction with medicine, medical engineering, pharmaceutics, code as 206)
1406	Cellular machines on a biobasis
1499	Other forms of nanobiotechnology

1500 Political areas

1501	Legal policy/amendments to laws
1502	Research promotion
1503	Education policy
1504	Environmental policy
1505	Economic policy
1599	Other political areas

1600 Economy

1601	Economic situation (macroperspective)
1602	Taxes
1603	Subsidies
1604	Stock exchange reports (e.g. stock exchange data/IPOs)
1605	New companies
1606	Company balance sheets and results
1607	Company activities
1699	Other economic topics

1700 Sport

1701	Doping
1799	Other sports topics

1800 Art/culture

1801	Literature
1802	Film
1803	Media/journalism
1899	Other topics in the field of art/culture

1900 Intoxication cases/product recalls

1901	Kleinmann (“Magic Nano bathroom and WC surface sealing agent”, “Magic Nano glass and ceramics surface sealing agent”)

1999	Other intoxication cases/cases of product recalls

2000 Debate about Bill Joy's call for a moratorium

2099	Topics in conjunction with the debate

2100 Overview of nanotechnology

2199	Other

2200 Consumer protection/product labelling

2299	Other

2300 Health and safety at work

2399	Other

List of instructions

Short overview of instructions

Concrete demands concerning the handling of nanotechnology or the opportunities and risks presented by nanotechnology and its various applications can be understood as instructions.

100 Demands/instructions concerning risks (regulation)
200 Demands/instructions concerning opportunities (promotion)
300 Not clearly classifiable instructions: both regulation of risk and promotion of benefit
400 Demand/instruction to stop doing something

Coding instructions for extending the list

If concrete instructions crop up in the course of individual coding that are not covered by the instructions presented in this list, then they are initially to be coded in the respective upper category (**199, 299, 399 or 499**) as "Other" and then entered in the corresponding input field of the data mask (string = entry of a new instruction). At the end of coding work each day all new instructions (as well as topics, actors, opportunities, risks and images) are to be sent to Anne Friedemann (anne.friedemann@uni-muenster.de) and André Donk (adonk@uni-muenster).

In a short memo, all coders will be informed about the classification of the "new" or questionable forms of an existing category or about the new category. New codes will then be assigned a fixed code which is to be used in further coding work.

***Please note*:** the inclusion of new actors, topics, opportunities, instructions, risks and images is to be handled extremely sparingly. The first step should always be to examine whether they are covered by existing categories!

Simplifying the search

The use of a search command can simplify orientation in this list and help to reach the desired upper category more quickly.

100 Demands/instructions concerning risks (regulation)

101	Health and safety at work
102	Toxicological assessment (test methods, classification, limit values)
103	Safety research
104	Moratorium or renunciation of the development and use of the nanotechnology
105	(International) standardised test methods
106	Mandatory product labelling
107	Consumer protection
108	International codes of conduct
109	Appointment of independent research bodies on risk assessment
110	Setting up of a central information office
111	Creation of a legal framework
112	Demand for "nanoethics"
113	Product recall/possible withdrawal of harmful products from the market
114	Limit values for nanoparticles (for instance how many grams of nanoparticles per kg may be contained in food?
115	"Nanogeopolitics" (with an international early warning system under the aegis of the UN)
116	Publication of all toxic effects of nanoparticles in a database
117	Risk research
118	Data protection/protection of privacy
119	Fair participation
199	Other instructions concerning risks (regulation)

200 Demands/instructions concerning opportunities (promotion)

201	Innovation research
202	Public research support

203	Fundamental research
204	Technical democracy
205	Strong research ministry with clear responsibilities
206	Improving communication skills of scientists
299	Other instructions concerning opportunities (promotion)

300 Not clearly classifiable demands/instructions

301	Accompanying research with a social science thrust (→ increasing acceptance in society)
302	Nano discussion platform
303	Suitable training offers (labour market)
304	Transparency in the testing of new nanomaterials
305	Social debate/setting up of citizens' fora
306	International "codes of conduct"
307	
399	Other not clearly classifiable instructions

400 Demand/instruction to stop doing something

401	Premature generalisation of (study) findings
402	Fear of technology
403	Blind faith in technology
404	
405	
499	Other instructions to stop doing something

List of images

100 Images – size comparisons
200 Formulations/images which refer to materiality and its potential
300 Formulations which illustrate the relationship to nature
400 Images/metaphors: size-related description
500 Images/metaphors which refer to visibility or sensory perceptibility
600 Formulations/designations which refer to revolution, innovation and future viability
700 Negative images/metaphors
800 Designations for nanotechnology as "a whole"
900 Other descriptive designations
1000 Descriptive designations for individual applications

Coding instructions for extending the list

If distinctive, clear images occur in the course of individual coding that deviate markedly from those in this list, then they are initially to be coded 999 "other" and entered in the corresponding field of the data mask (string= entry of new image). At the end of coding work every day all new images (as well as topics, actors, opportunities and risks) are to be sent to Anne Friedemann (anne.friedemann@uni-muenster.de) and André Donk (adonk@uni-muenster).

In a short memo, all coders will be informed about the classification of the "new" or questionable forms of an existing category or about the new category. New codes will then be allocated a fixed code which is to be used in further coding work.

Simplifying the search

The use of a search command can simplify orientation in this list and help to reach the desired upper category more quickly.

100 Images: size comparisons

101	"One thousand times smaller than a human cell"
102	One million times thinner than a human hair (size comparison with the thickness of a hair)/comparison: the diameter of a hair is roughly 50,000 nanometres
103	Size comparison: "if you compare the size of a nanoparticle with a football, this corresponds to the ratio of a ball to earth"
104	True to scale comparison: moving a molecule with the tip of a microscope is like wanting to juggle a *golf ball* with the tip of the *Eiffel* tour
105	"One nanometre is the millionth part of a millimetre. This corresponds to the size ratio between a *hot air balloon* and the *earth*." (taz, 13.05.2006, p. 17)
106	Mathematical size details (nanoparticles – not larger than 100 times 10^{-9} millionth of a millimetre)
107	...

200 Formulations/images which refer to materiality and its potential

201	"The stuff the future is made of"
202	"The power of the millionth"
203	"Third industrial revolution"
204	"Playing with matter"
205	"A living cell is a sack full of nanomachines"
206	Customised atoms
207	Programmable matter
208	Tool boxes
209	...

300 Formulations which illustrate the relationship to nature

301	“Overcoming dependency on nature and its forms”/overcoming nature
302	Learning from nature
303	…

400 Images/metaphors: size – related description

401	"Nanos" = Ancient Greek for “dwarf”
402	“Dwarf science”
403	Kingdom of the dwarves
404	Technology of the dwarves
405	Journey to the centre of the atom
406	The kingdom of atoms (and molecules)
407	Scarcely imaginable small world
408	Smallest of all worlds
409	Liliput
410	Quantum world
411	World of the millionth of a millimetre
412	World of the microcosm
413	…

500 Images/metaphors which refer to visibility or sensory perceptibility

501	Limit of the visible
502	Invisible partners
503	...

600 Formulations/designations which refer to revolution, innovation and future viability

601	Gold rush mood
602	Nano “a future word”
603	Paradigm change
604	Revolutionising/revolution
605	Science fiction
606	Miracle
607	Wonder world of tiny giants
608	“Golden age”
609	...

700 Negative Images/metaphors

701	Pandora's box
702	Horror scenarios
703	Dust
704	Superhumans
705	Nanoists
706	Nanomites
707	...

800 Designations for nanotechnology as “a whole”

801	Enabling technology
802	Fundamental technology of the 21st century
803	Cross-sectional technology
804	Risk technology
805	Key technology
806	Future technology
807	...

900 Other descriptive terms

901	Hype word/hype technology
902	"Bio(-), nano(-), info(-)" [Triad which is used again and again in *Die Zeit*]
903	...

1000 Descriptive terms for individual applications

1001	Molecular cuisine/molecular gastronomy
1002	Functional food
1003	Voodoo cuisine

Please note

999 Other images/metaphors

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