Evolving Repertoires & Technology Assessment: Nanotechnology in Dutch Daily Newspapers

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Note:
The working paper is based on and draws heavily from a paper submitted to 'Science as Culture'. The following text has been expanded with additional background and information on the discussion of nanotechnology within the Netherlands.

Introduction

Newspaper coverage of new and emerging science and technology, in this case nanoscience and nanotechnologies, is interesting in a number of ways.[1] Especially when most people have little experience with a new technology, newspaper coverage can provide heuristics for understanding and assessment (Scheufele and Lewenstein 2005). Proponents of the development of new technologies are often concerned about the ways in which new science and technology are represented in the media and possible effects of negative perceptions. This concern is typically overstated, suggesting that print and audio-visual media have the power to form, rather than reflect, public perceptions. For example Nisbet and Huge (2006) suggest that in debates around the regulation of plant biotechnology for many newspapers other national news tended to dominate at the expense of coverage of debates within science and technology.[2] On the other hand, newspaper coverage does frame issues and contributes to agenda building (Nisbet, et al. 2003).

In this paper, we focus on an intermediate level: the repertoires that emerge over time in and through newspaper coverage, which can be drawn upon, and which various actors in turn respond to, exactly because it might be drawn upon. There is no one-to-one relation with effects, because these depend on responses of different actors and their strategies, and on contingent circumstances. Still, such 'newspaper repertoires' are important, because they are publicly available, because they feed into cultural repertoires, and because they enable attentive readers to become cognizant of the new scientific and technological developments, and to some extent connoisseurs (Healey 2004). This enables informal technology assessment, sometimes linked to controversies (Rip 1986), but also ongoing, through the articulation of views.

A number of studies refer to media coverage, and dedicated nanotechnology studies are available for the USA (Faber 2006; Stephens 2005) and the UK (Anderson, et al. 2005). However, they do not address the evolving repertoires. Our study of Dutch newspapers' coverage of nanotechnology over the past fifteen years will trace these repertoires, contextualize them, and discuss various actor strategies.

Repertoires

Repertoire is a key concept in current sociology, especially in cultural sociology (DiMaggio 1997; Lamont 2002). In cultural sociology, Swidler (1986) is the key reference [for later work see Swidler (2001; 2002)]. Lamont and Thévenot (2000) elaborate this concept to illustrate different national cultures and argue that the availability of cultural tools, 'repertoires of evaluation', differ between countries, e.g. the US and France, resulting in different lines of action. Within science and technology studies, the idea of repertoire has also been developed [see for instance Mulkay (1996) and Rip and Talma (1998)].

Swidler (1986) introduced the idea of repertoires (as a 'tool kit') as an alternative to existing conceptions of culture. She argued that culture does not shape

actors' actions by providing them with 'ultimate ends or values'. Instead, culture provides actors with a repertoire of 'symbols, stories, rituals, and world-views' from which they can select different elements to shape their action and solve their problems. She argued that the ways through which culture shapes action differs between more or less established modes of live and 'unsettled periods'. During settled periods culture shapes action by limiting the available range of strategies of action. In unsettled times, cultural meanings are more articulated and shape action more directly because they provide lines of action people are not familiar with, cf. Scheufele and Lewenstein (2005, p. 660).

While plausible, this view needs to address further questions. If a repertoire is seen as constraining actor's actions, how can it evolve? And if it evolves, which seems plausible, how can it then be constraining? If actors can pick selectively from this repertoire, why do they choose specific elements in this repertoire and not others? This suggests that the characteristics and dynamics of the repertoire itself are important in addition to the general question of how repertoires shape actors' actions in everyday life.

In a recent assessment of the repertoire literature, Silber (2003) suggests that there is a common, even if not always articulated, thread: the importance of an 'internal structure', 'hierarchy' or 'logic' in a repertoire. Thus, it is worthwhile to articulate such a thread.

Individuals are not completely free in their choice of action, but are instead constrained by a 'limited pool of regimes of criticism and justification' (Silber's reference to Boltanski and Thévenot). Whereas Swidler's concept of repertoire has no internal organization or order, the conceptualization of regimes of justification has an internal logic (Silber 2003, p. 432).

This brief discussion of the concept of repertoire is sufficient to support our approach. The newspaper coverage of nanotechnology is conceptualized as contributing to, as well as solidifying, an evolving repertoire about science, technology and society. As a repertoire it is especially interesting to study because due to its public nature, it is in principle accessible to everybody to draw from and shape lines of action. The newspaper repertoire is of course part of a much broader repertoire. This is particular apparent not only in the sense that there are other media that discuss nanotechnology, but also in more general and broadly disseminated discourse on the relationship between technology and society. In Western culture, patterns exist that influence the construction of repertoires around particular technologies. Patterns that are often of an antagonistic nature. Examples are perspectives like 'proponents-opponents' or 'insiders-outsiders'. Other patterns are recurring statements on 'promises' and 'risks', or more general about promotion and control of science and technology (Rip and Talma 1998).

It is possible to conceive of newspaper coverage, here of nanotechnology, as a repertoire because after a first period of isolated items there is a sense of talking about the same topic, even if there are no formal references to earlier newspaper items. The repertoire reflects broader repertoires, but also introduces further framing. The journalists writing the articles (or sometimes just selecting from press releases) are the carriers of the evolving repertoire, and sometimes consciously so, when they seek out actors and give them voice selectively in the texts.

In this paper, the internal structure of the newspaper repertoire on nanotechnology is analyzed. Does the newspaper repertoire become more articulated over the years? How do the different topics and themes relate to each other? To what extent becomes the repertoire more or less stable?[3]

While the empirical analysis of the internal structure of newspaper repertoires is the main concern of this paper, the question whether and how such repertoires have effects cannot be completely backgrounded. Media may have direct influence on scientists (Lewenstein 1995), and can function as test sites for new technologies (Oudshoorn 1999). Effects will be different for different media, e.g. television and print media, and for different audiences (Nisbet, et al. 2002; Scheufele and Lewenstein 2005). There is no simple link between the media and the so-called public (Ten Eyck (2005). During the analysis of newspaper articles some impacts of the coverage will be highlighted. We will discuss the possible effects of newspaper repertoires more broadly in the discussion section.

Overall newspaper coverage of nanotechnology

To study how newspapers discuss nanotechnology, all 'nanotechnology' related documents in the main (quality) Dutch daily newspapers were retrieved from the LexisNexis Academic database. For this purpose the terms 'nanotechnologie' (nanotechnology), 'nano-technologie', and combinations of 'nano' and 'technologie' or 'nano' and 'wetenschap' (science) were used as keywords. The time period was 1992, when the first article appeared, till the end of 2005. The sample contained 237 articles from the Dutch newspapers: *NRC Handelsblad*, *de Volkskrant*, *Trouw*, *Het Parool* and *Algemeen Dagblad*. These newspapers are distributed nationally, except for *Het Parool*, which is distributed in Amsterdam, which as the capital city of the Netherlands is where many opinion leaders live.

In addition also all items referring to nanotechnology in *Het Financieele Dagblad* were retrieved. This newspaper caters to financial and business audiences. As it turned out, press releases and the calendar of upcoming events dominated in this newspaper, so the items are not informative for our purpose. But there are interesting opinion pieces, and we will discuss these when relevant.[4]

Figure 1 gives an overview. Nanotechnology received much more attention from 1999 onwards. What is striking is the large increase in articles that mention nanotechnology in passing, or as an item in the discussion of another topic (for example innovation) compared with articles that focus solely on nanotechnology. The latter does not show a sustained upward trend after the main shift that occurred from 1997 to 1999. What does happen is that articles about nanotechnology start appearing in other places, for example in the *Staatscourant*, the official government magazine announcing new laws, regulations and measures, which regularly also features a background article on its second page (Van Kasteren 2004).

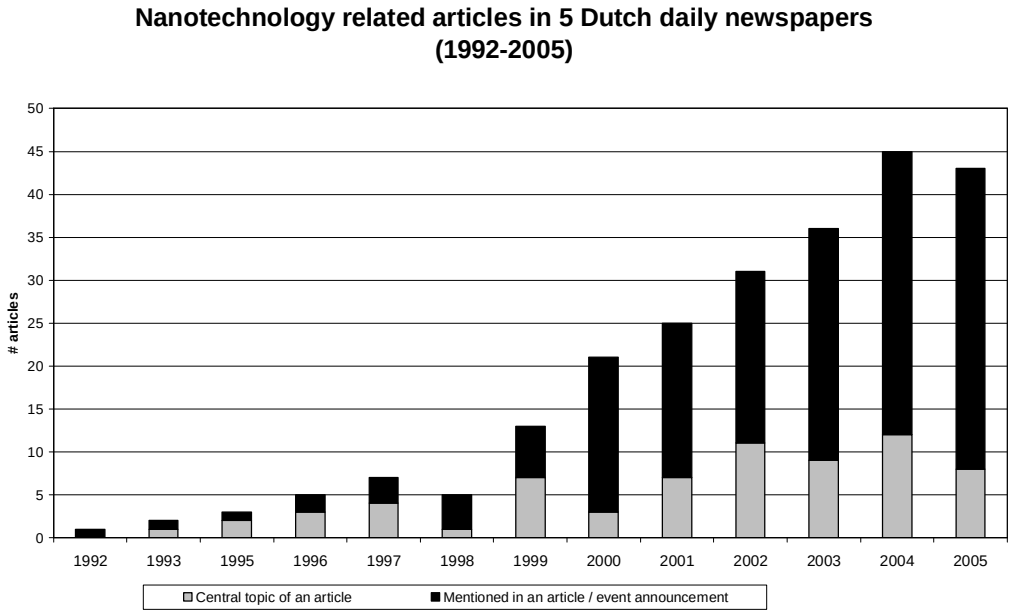

Figure 1: 'Nanotechnology' articles in 5 general Dutch daily newspapers 1992-2005

The increasing number of articles that mention nanotechnology is partly a consequence of the fact that there are an increasing number of events to report. It also derives from 'nanotechnology' becoming more recognized (so scientific and technological findings tend to be picked up more often, and referred to as nanotechnology) and in a sense, a regular part of discourse. This is visible in how the term 'nanotechnology' has been taken up in other contexts. Early examples are how a composer, Paap, in an interview in 2000, refers to nanotechnology when discussing his dreams of a digital future, speculating about lettuce transported through fiber cables and the possibility of connecting his brains to a computer network in order to 'think' music (Carvalho 2000). An article in 2001 quotes a business professor, Guntherodt, who warns against the newest trend in investment circles, nanotechnology: the mountains of gold of nanotechnology are not in sight yet (Frijlink 2001). Another article in 2001 discusses new developments in radiation therapy and notes that medicals call their invention fashionably: 'nano generators' (Becker 2001).

To analyze the evolution of the repertoire, a simple classification of subjects of the articles was created, focusing on the context in which 'nanotechnology' appears. Figure 2 shows that, in addition to an increase in numbers, there is also an increase in different contexts in which 'nanotechnology' appears.[5] From 1999 onward there are articles discussing visions of Eric Drexler, often referring to the dystopian depicture of possible nanotechnology future scenarios, including Bill Joy's well known article 'Why the Future Doesn't Need Us' (Joy 2000b). From 2002/2003 a focus of the role of nanotechnology in innovation is strongly represented. This shows that the newspaper repertoire evolves and that more contexts or segments are included. We consider this as one aspect of articulation. The other aspect is the articulation of the segments themselves.

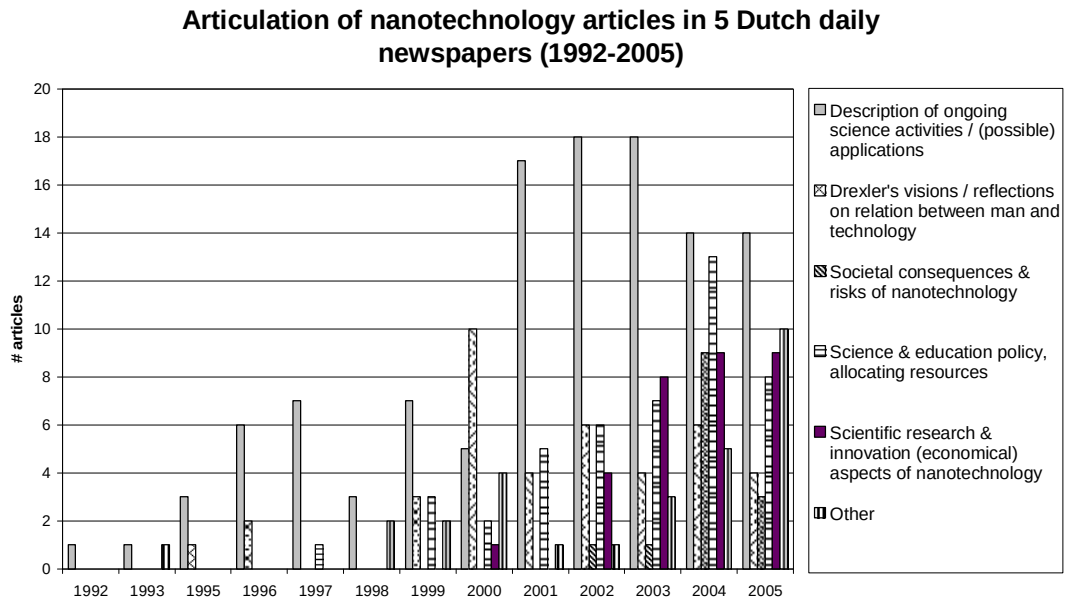

Figure 2: Articulation of 'nanotechnology' in daily newspapers 1992-2005

In the following sections an overview of the evolving nanotechnology repertoire in newspapers will be provided, divided in periods where new segments of the repertoire emerge.

First Period: the rising 'star' of nanotechnology (1992-1999)

In 1992, the 'nanotechnology wave' drifted ashore, at least according to the newspapers concerned. In contrast to the US, it was not surrounded with only high expectations, but instead both favourable and skeptical versions appear throughout the period. Already at this stage an apparently unproblematic dual repertoire of contradictory associations is visible in newspaper coverage. A repertoire that is advantageous for scientists in terms of fund raising, but also for preventing disappointments. Moreover, nanotechnology is chiefly covered from the viewpoint of ongoing scientific research and relatively less significant coverage of broader articulations, see figure 3. [6]

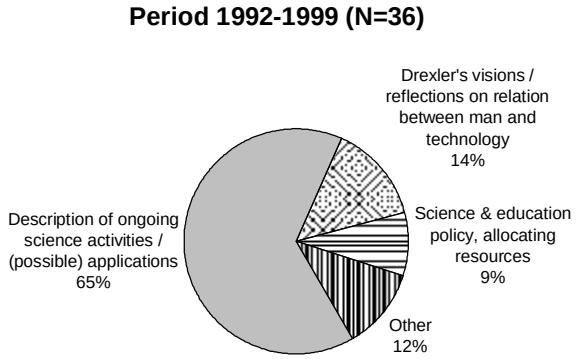

Figure 3: repertoire segments in the period 1992-1999

The first newspaper article that mentions nanotechnology discusses micro mechanical motors made of silicon. Nanotechnology is represented as a development of discoveries on the micro scale, scientists will dive into the nanoscale to construct motors on a molecular scale (Den Hond 1992). In 1993 an article signalled that nanotechnology is gaining a lot of attention and that engineers are aiming for the fabrication of mechanical structures on an increasingly smaller scale (Van den Berg 1993).

While *Engines of Creation* was published in 1986, until 1995 the ideas of Eric Drexler were not discussed in the daily newspapers in the Netherlands. The first article that discusses Drexler's visions speculates that 'sober-minded Europe' will not warm to his ideas (Van den Berg 1995). Like in the newspaper article two year earlier, another article in that year quotes a scientist who states that nanotechnology is 'very popular' (Kruijt 1995).

In 1996 an article signals that 'the star of nanotechnology is rising' and that it is 'good' to include the term in project proposals to funding agencies (Engels 1996). It also remarks that several studies appear from the Ministry of Education, Culture & Science and the European Parliament that suggest that 'we' (The Netherlands, European Union) are falling behind the United States and Japan. At the same time the article concludes that nanotechnology research is not so different from research a decade before. New technologies (like Scanning Tunneling Microscopy) may have enabled new research methods, but the focus of research is still the same: making increasingly smaller structures. In addition, the article quotes scientists who foresee many problems in the development of Drexler's molecular machines. At the same time nanotechnology is becoming increasingly popular and another article in 1996 concludes that one should use 'at least' the prefix 'nano' nowadays (Van den Berg 1996). Apparently, while scientists in the Netherlands may not warm to Drexler's visions, they do warm to the emerging science of nanotechnology.

The relativizing remarks from scientists with regard to Drexler's molecular machines gradually develop into warnings against extravagant promises about nanotechnology. Newspapers quote scientists who claim that the possibilities of nanotechnology are overestimated (Akinci 1999; Anonymous 1999; Van Calmthout 1999) and some disassociate themselves explicitly from Drexler because it negatively impacts the credibility of nanotechnology research (Akinci 1999).

While the rising popularity of nanotechnology is noted in newspapers, this discourse positions itself as skeptical of the high expectations associated with nanotechnology. On the other hand, nanotechnology seems to become strategic science, in which nations compete on the field of science and do not want 'to lag behind' (Engels 1996). This introduces another element in the repertoire, a rhetorical force that may not be linked directly to promises and expectations of existing scientific research but that comes from dynamics between countries. Although relativization with respect to nanotechnology's promises may be opportune, mentioning 'nanotechnology' is apparently important for acquiring funding. At this stage, newspaper coverage can be characterized as containing a dual repertoire.

The skeptical attitude towards expectations appears to be different from the US. A study of popular media in the US noted that (Faber 2006, p.158):

> "The emergence of nanoscale science and technology in public media occurred as a social–rhetorical process. Early articles were not exclusively technical, but their rhetoric engaged societal issues and concerns and authors were able to connect what was a relatively obscure technology to

> important social issues of the day. The articles successfully represented nanoscale science as a field that offered solutions to key social issues."

While there will always be a mixture of strategies, from bold claims to modest proposals, the political culture and ways of mobilizing resources in the US are different from Europe. This influences the ways in which these issues are reported in European newspapers. Swierstra, analyzing Dutch newspaper articles on genomics for the same period, found key genomics scientists (who were into making public statements and appearances in general) warning against the overly optimistic messages coming from the US. The need to avoid later disappointment was one of their arguments (Swierstra 2004, p. 109).

While disassociation to Drexler emerges everywhere in the 1990s (and becomes dominant when big special funding for nanotechnology research arrived on the scene after 1999), there is a difference between the US, with continuing broad promises, and the Netherlands and other European countries where the claims are more modest.[7] This phenomenon has been described elsewhere in literature. A comparative study of newspapers during the period 1988-2004 (with emphasis on 2003-2004) concluded that although the overall sentiment towards nanotechnology was positive in both U.S. and non-U.S. newspapers, the latter are more likely to argue that risks and benefits need to be considered than the former (Stephens 2005, p. 191). A study of public attitudes on nanotechnology concluded that the public in the U.S. is more optimistic towards nanotechnology than in Europe (Gaskell, et al. 2005).[8] Apparently different 'repertoires of evaluation' exist between Europe and the US.

Second Period: the consolidation of nanotechnology research (2000-2002)

During this period newspaper coverage continues to contain a dual repertoire in the new millennium, but by 2002 it has become more articulated. Although the coverage of ongoing scientific research is still dominant, more segments appear and existing segments become more articulated. A salient feature of the latter are articles concerning the relation between man and technology, epitomized in the translated article of Bill Joy. Moreover, many more articles on nanotechnology have appeared, see figure 4. This is also a period in which Dutch actors start to mobilize resources for nanotechnology research. This period can be characterized as a further consolidation and articulation of the nanotechnology repertoire.

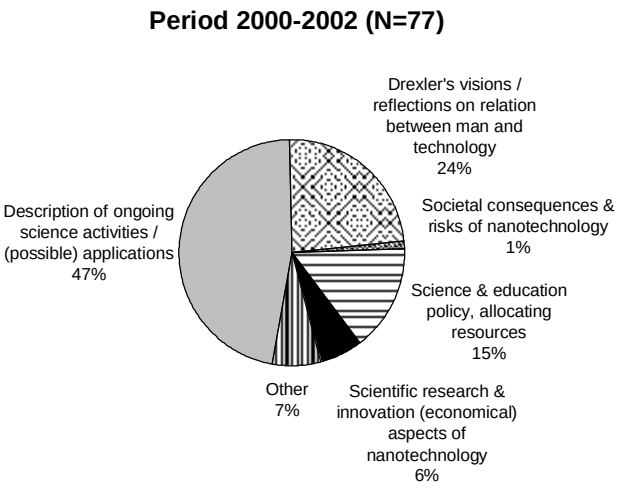

Figure 4: repertoire segments in the period 2000-2002

In 2000 several articles appeared (Ormel 2000; Starink 2000; Stein 2000; Van Delft 2000) that discuss these themes and refer to the article of Joy (2000b) which was also translated and published in a Dutch newspaper (Joy 2000a). Another article quotes a broadcasting station that made a documentary called Technocalyps about human enhancement and the role that nanotechnology could play in this development (Oosterbaan 2000). It argues that in this documentary more attention should be paid to the borderline between science and fiction. In the same year, a newspaper article observes the impact of science in the arts sector and quotes artists who describe robotics, genetics and nanotechnology as becoming dominating factors in life that require new perspectives on mankind (Van der Jagt 2000).

Descriptions of ongoing nanoscience remain a dominant feature in newspaper coverage. Articles discuss for instance the coupling between electronics and nerve cells (Van Delft 2000) and lab-on-a-chip developments (Voormolen 2000). Significant attention is paid to the Dutch physicist Dekker who conducts research on nanotubes (Anonymous 2002b; Van Calmthout 2001; Van den Berg 2001). Also the scientific fraud of Schön, who was considered to be one of the 'wonderboys' of nanotechnology, receives much attention (Anonymous 2002a; Anonymous 2002c; Lagendijk 2002a; Lagendijk 2002b; Van Calmthout 2002b).

Scientists quoted in newspapers continue to be skeptical about the great promises and expectations of nanotechnology. They discard them as extravagant. For instance professor Kouwenhoven at the University of Delft argues that the promise of the manipulation of individual atoms is more complex to fulfill than envisaged.[9] Similarly according to Professor Knol at the University of Bielefeld the 'grey goo' scenario is improbable: malicious robots have to act quickly to rebel successfully against humanity, their batteries are usually flat within half an hour (Van Delft 2000).

During this period central actors in Dutch nanoscience and nanotechnologies began to coordinate their actions in order to mobilize funding for nanoscience and technology at a larger scale [see Mangematin et al. (2005)]. In general these activities are not reported in the media, with the exception of the funding of a new nanotechnology research institute in Groningen (Joustra 1999). It would take some time before nanotechnology research was taken up on the national level. In 2001, the Dutch Research Council NWO selected nanotechnology as one of the themes eligible for extra funding (Van Delft 2001).[10] The logic behind this mobilization of resources

was not questioned in the newspaper articles. For instance articles quote a staff member of NWO who argues that it is necessary to have large multi-annual investments for genetics, nanotechnology and bioinformatics to keep pace with international developments (Anonymous 2001) or refer to the Minister of Economic Affairs who argues that nanotechnology, genomics and informatics are important for the economy and that the Netherlands are in danger of lagging behind in research on this fields (Anonymous 2000).

Newspapers have a dual nanotechnology repertoire consisting of, sometimes implicit, references to great promises as well as relativization of these promises at the same time. Scientists probably profit from the nanotechnology hype, as indicated by newspaper articles about the importance of the label nanotechnology for funding, and their success in getting these funds reinforces the hype. At the same time they present themselves as realistic. By such public distantiation they act strategically, anticipating possible disappointments at a later stage.

Third Period: the confrontation of nanotechnology and society (2003-2005)

From 2002 onwards the dual repertoire makes way for a more antagonistic repertoire. Contradictory views on nanotechnology are increasingly contrasted. Coverage simply of nanoscience becomes less dominant and societal and economical issues increasingly enter the agenda. Optimistic views with respect to profitable societal and economical returns become increasingly questioned. The repertoire not only becomes more articulated, its internal structure also becomes more balanced, see figure 5.

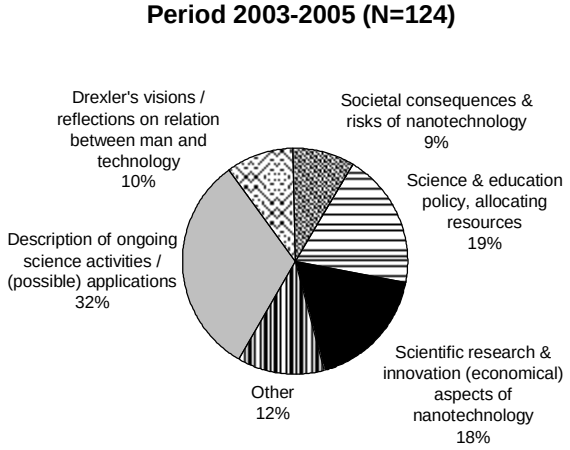

Figure 5: repertoire segments in the period 2003-2005

The increasing sociotechnical critique springs from the broad, more or less philosophical discussions covered in the second period. An article in 2002 signals that Dutch nanotechnology scientists start to worry about fears of nanotechnology with the public (Van Calmthout 2002a).[11] The article quotes physicist professor Mooij at the Technical University of Delft who considers the effects of a possible movie based on Crichton's novel 'Prey!' on public opinion about nanotechnology. Although the story of murderous robots which escape from a laboratory is pure science fiction, Professor

Mooij argues that scientists cannot neglect the possible images of fear associated with nanotechnology. Professor Mooij intends to discuss this with his colleagues in the NanoNed research program, then under construction, and explore how to prevent public distrust against nanotechnology. The newspaper article also points out that outside of the Netherlands studies appeared that pay attention to risks and benefits of nanotechnology. It refers to studies from the environmental group ETC, Greenpeace UK and a study financed by the Economic and Social Research Council in the UK. The article quotes scientists in the Netherlands who conclude that it had been comparatively 'quiet' in the Netherlands with respect to risks and benefits of nanotechnology.

From 2002 onwards two major changes occurred. Innovation and risks became important issues in the nanotechnology repertoire. In 2003 articles discuss the decreasing innovation strength of the Netherlands and question the emphasis on nanotechnology as an engine for innovation. According to economics professors Van den Bosch and Volberda at the Erasmus University Rotterdam it is not necessary for the Netherlands to orient itself at all cost on nanotechnology and biotechnology. Priority should be given to things that the Netherlands already master particularly, for example, the exploitation of knowledge on tulips, and more attention is necessary for organizational innovation (De Vre 2003; Jorritsma 2003).

In December 2003 the government of the Netherlands made the final allocation of the knowledge infrastructure budget of €800 Million. €95 Million was reserved for the research programme NanoNed (Anonymous 2003). With own contributions of universities, TNO and Philips, the total budget (including earlier funding of 60 M euro) totalled 250 M euro in 2004 (Aan de Brugh 2004).

In February 2004 members of parliament questioned the government priorities for research: genomics, ICT and nanotechnology. It is suggested, by government and opposition parties, that the government is promoting the exact sciences disproportionately and emphasizing economic benefits too strongly (Anonymous 2004). A report from the Innovation Platform in October 2004, an initiative of the Dutch Government to strengthen the innovation power of the Netherlands, broadened the approach of the government suggesting that the Netherlands should concentrate on flowers and food, advanced technology, shipbuilding and hydraulic engineering, and the creative industries. In this context nanotechnology is positioned in the 'advanced technology' category (Persson 2004). Another article in 2004 compared the results of the 'bottom up' approach of the Innovation Platform with the more 'top down' approach of foresight studies. It concluded that nanotechnology, biotechnology and ICT are 'fashionable' and appear on the list of not only the Ministry of Economic Affairs in the Netherlands but also in other countries. The attention for these fashionable technologies eclipses less futuristic technologies that are important for firms (Schoonen 2004).

Not only is the national science priority setting discussed during this period, the specific motivations of ongoing nanotechnology research are also questioned. For instance according to Van Houten of Philips Research, Nanoned is too scientific. He suggests that an explicit focus on applications – as in the United States and Japan – is preferable. He refers to the knowledge paradox of Europe. Scientifically, Europe can measure up to the United States, but Europe is lagging behind in business (Aan de Brugh 2004). Companies also warn against negative effects of extravagant expectations of nanotechnology. Professor Put of chemicals company DSM discards the idea of nanomachines that supposedly could enter the body and make an end to diseases as "nonsense". According to him it is important for scientists to take care that

nanotechnology doesn't end up in the wastebasket due to irrational fears of nanotechnology (Aan de Brugh 2004).

Not only the relation between innovation, economic growth on the one hand and scientific research on the other became a key issue during this period. Risks of nanotechnology, especially health related aspects of nanoparticles, became a key issue as well.

An interesting event in 2004 was the appearance in *Het Financieele Dagblad* of an opinion piece by Reijnders, environmental science professor at the University of Amsterdam and the Open University and linked to the Foundation Nature & Environment. In this article the author warns of the risks of nanoparticles and argues for a ban on non-degradable particles that may be released in the environment. According to Reijnders there exists little or no interest in assessment of risk during the development of nanotechnology in the Netherlands (Reijnders 2004b). This opinion piece was also discussed by some participants in a workshop on 17th Feburary 2004 about health risks of nanoparticles organized by the Rathenau Institute.[12] During the meeting, a number of actors felt they had to respond. Two articles in *Het Financieele Dagblad* (Borm 2004; Speller 2004) and two articles in *de Volkskrant* (Lagendijk 2004; Van Calmthout 2004) referred to this opinion piece.

Toxicology professor Borm at the University of Düsseldorf (Germany) and lecturer at the Centre of Expertise in Life Sciences in Heerlen partially agrees with Reijnders' diagnosis of limited interest in risk assessment of nanotechnology in the Netherlands. According to him, though debates on these issues have been initiated in other countries, discussion is more recent in the Netherlands, beginning with a workshop organized by the Rathenau Institute in February 2004. He notes existing Technology Assessment reports published in Germany and France and that the Netherlands are not pioneering in this respect. Instead of introducing a moratorium on nanoparticle research he pleads for participation in an already ongoing international process in which nanotechnologists, toxicologists and biologists discuss possible undesirable effects of nanotechnology applications (Borm 2004).

Similarly in an opinion piece in *Het Financieele Dagblad*, nanoscience professor Speller of the Radboud University Nijmegen pleads for an open dialogue between scientists and the public that should be started as soon as possible (Speller 2004). In an article in *de Volkskrant* she explains why she does not agree with a moratorium on nanoparticles. Professor Speller argues that many possible hazardous consequences of nanoparticles do not differ from those of traditional chemicals that are already in our environment. According to her the advantages outweigh the disadvantages. She compares the debate around nanotechnology with that of biotechnology (Van Calmthout 2004):

> "Especially in biotechnology things have been destroyed through exaggerated distrust and too much caution. In any case, this resulted in the disappearance of lots of research from the public domain and our sphere of influence. [..] The greatest danger is the disappearance of nanotech from the public sphere [translation HTK & AR]."

The reference to biotechnology, especially GM food now crops up in newspaper articles. Physicist professor Lagendijk of the Institute for Atomic and Molecular Physics discussed the emerging debate about health risks in his column in *de Volkskrant* (Lagendijk 2004):

> "Scientific researchers regularly face negative publicity about their profession. Environmental activists seize every opportunity to put scientific and technological developments in a bad light. They have been very successful with their actions against genetically manipulated food in Europe. The new target of environmental activists is nanotechnology. Many health risks are expected to be linked with this technology. No physicist or chemist is able to define exactly what nanotechnology means, but the green can already devise doom scenarios if this technology would be introduced. [..] In order to avoid making the same mistake as with genetically manipulated food, scientists will take the grievances of the environmental movement very seriously. Or at least they will pretend to do so. They are scared to death for demonstrators near the entrance of their laboratory [translation HTK & AR]."

The debate on the possible risks of nanoparticles does not remain confined to debates between scientists.[13] The repertoire becomes more articulated through the involvement of other actors linked with other nanotechnology issues. Newspaper articles quote for example a report by Swiss Re, a reinsurance company, drawing parallels between nanoparticles and asbestos (Van Nieuwstadt 2004b) and pleading for an open debate on risks of nanotechnology (Aan de Brugh 2004). Newspapers also refer to reports of the Rathenau Institute, the Royal Netherlands Academy of Arts and Sciences (Becker 2005; Van Calmthout 2004; Van Nieuwstadt 2004b) and the RIVM (National Institute for Public Health and the Environment) (Aan de Brugh 2004) that pay attention to the risks of nanotechnologies. Journalists also follow what happens on an international scale. For example they report Eric Drexler's renounciation of his 'grey goo' scenario. This is important news because of the role of Drexler and the 'grey goo scenario' in the repertoire. According to the newspaper article Drexler wants to make space for a realistic exchange of ideas about risks of nanotechnology (Van Nieuwstadt 2004a).[14]

The nanotechnology repertoire in this period showed the emergence of new segments in the repertoire: economic and environmental/health related aspects of nanotechnology. Interestingly especially the latter provoked a lot of responses from the scientific community.[15] This segment of the repertoire provokes them because it may potentially constrain the actions of scientists, threatening continuity of research. From the articles it remains unclear whether these responses also lead to any actions other than pleas for open debates, for example in the form of decision making or other actions.

Discussion: evolving repertoires' potential for technology assessment

The analysis of newspaper articles shows that cultural repertoires concerning nanotechnology have evolved and became more articulated. The identified segments of the repertoire and their contents have stabilized not only in the selected newspapers, but also in other media (Van Kasteren 2004), and in Dutch academic literature.[16] An interesting question is the relation between evolving newspaper repertoires and reports that analyze, and comment on, nanotechnology research and its relations with society. There will be differences and similarities in topics, while the treatment in the reports will often be more systematic.

For the purpose of this paper we limited ourselves to two reports in the Netherlands that appeared in 2004. In both cases, the second author was involved in the preparation, as a co-author and as a member of the working party, respectively. An overview report on societal aspects of nanotechnology by the Rathenau Institute (Van Est, et al. 2004), a government-funded, independent organization for technology assessment and societal debate on issues of science, technology and society. And a report by the Royal Netherlands Academy of Arts and Sciences (Koninklijke Nederlandse Academie van Wetenschappen 2004), requested by the Minister of Education, Culture and Sciences who referred to the increasing interest in nanotechnology, and wanted to know about opportunities as well as risks and eventual regulation, issues also treated by the Commission of the Royal Society and the Royal Academy of Engineering in the UK which was finalizing its report at that time (The Royal Society & The Royal Academy of Engineering 2004).

The Academy Report was prepared by a working party consisting of five nanoscientists, a sociologist of science and technology (Arie Rip), and a toxicologist who also chaired the working party. Much time was devoted to discussion of possible public reactions to nanotechnology, and the need to inform the public about the realities of nanotechnology so that trust would be generated (as the scientists formulated it). There was reference to the media and their role, and selective use of the evolving newspaper repertoire. Parts of earlier versions of the report addressed possible reactions and tried to preempt them by spreading a message that there was no cause for concern. After criticisms from two outside readers, the final report did a better job. It focused on the importance of stimulating nanoscience and technology research, relativized the possibility of the 'grey goo' scenario, suggested further research on environmental and health aspects of nanoparticles and argued for an open debate on benefits and risks of nanoscience and nanotechnology. In the end, there was a large degree of similarity in topics and treatment between the newspaper repertoire and the report of the Academy. The Academy Report goes in more scientific detail, about nanoscience and about risks of nanoparticles, but does not discuss the role of nanotechnology and science policy in the context of innovation and knowledge economy, which is a segment of the newspaper repertoire. While the Academy Report was received well in the scientific community, and was referred to by government agencies, it was only occasionally quoted in newspapers (Becker 2005).

The Rathenau Report is more systematic, as befits an institute devoted to Technology Assessment. The authors wanted to offer an overview of issues, with some analysis, so that ongoing and future discussions and assessments could be articulated better. It also attempted to take into account that nanotechnology is an enabling technology improving performance and sometimes creating new functionalities in a variety of sectors. Social and ethical issues in these sectors were then taken as the entrance point for the discussion of nanotechnology. Like the Academy Report, it pays less attention to economic issues. The report pleads for an open debate, rather than the all too common struggle between proponents and opponents. While the Rathenau Report wants to engage with the evolving newspaper repertoire, adding to it and providing more depth, its authors have less need to ascertain a future for nanotechnology, a need which colored the discussions of the working party preparing the Academy Report. The Rathenau Report was widely read, and influenced further reporting. There was occasional reference to it in the newspaper articles (Becker 2005; Van Calmthout 2004; Van Nieuwstadt 2004b).[17]

There are two points with which we want to conclude this discussion of reports. First, based on this discussion we conclude that the newspaper repertoire,

although not systematically, covered some important themes that also appeared in the systematic reports. Second, consider the timing of the reports versus the newspaper articles. The latter were already discussing (with the exception of the risk issues that appeared in 2004) many themes before the appearance of the reports.

The timing of these reports is especially interesting. It shows the lag of assessment of nanotechnology which is also visible in newspaper repertoire. See particularly the evolution of the Figures 3-5. Even if in 21st century there are attempts to do better by anticipating through for instance ELSI and ELSA activities, assessment still develops at a relatively late stage when developments are already well underway. What kind of an explanation, although speculative, could be given for this phenomenon, other the difficulty of assessing possible impacts of technology in an early stage of its development?

In the first period (1992-1999) nanotechnology is presented as a rising star, and at the same time, as embedded in ongoing science. It has a dual repertoire where nanotechnology receives a label that is positively associated with something that is worth funding, but at the same time it is emphasized by scientists that one should not expect too much, too soon. This dual repertoire continues, more articulated, in the second period (2000-2002) when the mobilization of funding is well underway and nanoscience receives more attention in newspapers. Broad social and ethical considerations appear, but are apparently not associated negatively with the mobilization of resources for nanotechnology research. It is only in the third period that conflicting views on nanotechnology appear to be confronted with each other: its risks and advantages (innovation) and its priority in science policy.

It appears that at the moment when the balance of the dual repertoire of advantages and disadvantages shifts, or threatens to shift, to the 'wrong direction' the need for assessment type of activities becomes more urgent. The 'wrong direction' would mean potentially constraining elements that threaten continuity, success or acceptation of activities. In fact, what is striking is that scientists play a prominent role in discussing risks and benefits of nanotechnology. It is in the debate around nanoparticles that one can recognize for the first time an emerging antagonistic pattern of promotion and control that is considered to be a characteristic feature of science, technology and society discourse (Rip and Talma 1998).[18] Scientists anticipate on this antagonistic pattern by referring back to biotechnology (Lagendijk 2004; Van Calmthout 2004). The media coverage seems to be balanced and not cast in terms of those who are in favor and those who are against nanotechnology. The debate on risks of nanoparticles may perhaps function as a trigger for a more proponent-opponent pattern in the nanotechnology repertoire.

The articulation of this evolving repertoire shares similarities with sociotechnical criticism, equivalent with literary criticism, and social learning which are considered, next to anticipation and feedback, to be key components of technology assessment (Rip, et al. 1995; Schot and Rip 1997). In this paper only one element of technology assessment (TA) is discussed, namely the increasing articulation of the repertoire. It is at the intermediate level of the newspaper repertoire, the addition and elaboration of new and existing segments and the observed shift within the internal structure from dual to more antagonistic patterns, that we suggest that the repertoire itself could be viewed as some form of TA. We call this type of assessment informal because it is not done according to a specific technology assessment methodology like for instance the one developed and practiced by OTA (Van Eijndhoven 1997). Moreover, informal has the connotation with informal, casual dress which is an

appropriate metaphor emphasizing the idea of accessibility. Rip (1986) discusses scientific controversies as examples of informal TA.[19]

Whether informal technology assessment is also conducted via the newspaper repertoire, as a source for actors shaping lines of action, is a more complex question and not the central research topic in this paper. Literature suggests an interesting link between newspaper coverage and technology assessment (TA) activities. Ironically, although TA has the underlying notion of bridging the gap between science, technology and society, actors who perform TA activities have to do some bridging themselves.[20] In order to improve the uptake of their findings they have to make it 'user friendly' (Fisher 2005, p. 326):

> "The challenge for nano-ethicists, then, becomes encoding their research and conclusions in terms that can be readily translated into design and development constraints and requirements, such as criteria, specifications, and guidelines that can be incorporated into technological decisions and artifacts. In short, social scientists will need to make their research 'user friendly' for nanotechnologists and 'policy relevant' for decision makers."

Whether TA activities catch ground may not depend on their scientific quality, but on their confrontation with already existing views as Mohr remarks (1999, p. 24):

> "Recently in connection with a public forum on gene technology a politician of the Green Party [political party in Germany, HTK & AR] stated frankly: "I cannot afford to learn things from you, which I can under no circumstances communicate to my clients." This means: Whether or not the results of a TA study will be perceived at all will not primarily depend on its scientific quality but on the pattern of preprogrammed opinions which the study meets in political circles, in the media, and in the public."

Therefore, the observed articulation of the newspaper repertoire and especially the shift from dual to antagonistic patterns may clear the ground for technology assessment activities. It may assist in making recipients of newspaper repertoire more susceptible for this type of arguments and support the timing of the appearance of the mentioned academic reports on social issues of nanotechnology in the Netherlands, cf. Hill (1988) who talks of the cultural fit of technology. In this perspective newspaper coverage forms the background with which other information is contrasted with and functions indirectly as an agenda and frame building instrument. A recent study that analyzed the effects of how nanotechnology is presented on public opinion remarked (Cobb 2005, p. 222):

> "Framing an issue differently often, though not always, affects opinions [..] Why study the framing of nanotechnology if mass preferences are not thought to dictate scientific policy choices? One reason is that policy makers are thought to be responsive to the general policy direction favored by mass opinion (Page and Shaprio 1992). Elites might not implement specific policy because of public opinion, but they are more likely to fund some scientific projects, and not others, when public preferences support the policy decision."

A part of the dynamics of newspaper repertoire is located with the journalists. When one examines the names of the reporters of the articles it becomes clear that a small number of journalists is responsible for the articles in the newspapers. The journalists are often science journalists and incidentally more economically oriented. These actors are the carriers of informal Technology Assessment. They develop their own knowledge and opinions on nanotechnology and select topics and interlocutors. The journalists sketch a picture of ongoing developments in science and technology and add some, at this stage still balanced, sociotechnical critique: what are advantages and disadvantages of these developments? To develop further knowledge on how the repertoire develops and evolves it would be interesting to research how the journalists construct their articles.

Conclusions

Media are often projected as driving hypes or dramatizing events. What was articulated in daily newspapers in the Netherlands was not the hype but the necessity of a balanced sociotechnical critique of nanotechnology. For the purposes of this paper the newspaper coverage was conceptualized as contributing to, as well as solidifying, a particular repertoire about science, technology and society. The changing internal structure of the repertoire was the central theme of this paper. The analysis of newspaper articles showed the evolution and increasing articulation of this repertoire. A repertoire, which in contrast to US newspaper coverage, seems to be skeptical of nanotechnology. Newspapers conclude that nanotechnology research is not very different from research a decade before and quote Dutch scientists who are modest in their expectations and disassociate themselves from extravagant expectations of nanotechnology. At the same time newspapers signal that nanotechnology is apparently good for funding. This ambiguous and somewhat contradictory dual repertoire becomes more articulated during the period between 1992–2002. In this period the repertoire mainly focuses on ongoing scientific activities. In the period between 2000-2002 it becomes extended with more attention to broad sociotechnical issues associated with nanotechnology and witnesses attempts of resource mobilization. In the period between 2003-2005 the repertoire evolves further by discussing more intensively risks and benefits of nanotechnology. Instead of a dual repertoire, different and sometimes contradictory opinions are contrasted and in general more antagonistic patterns emerge in the repertoire. Interestingly, predominantly scientists are starting the discussion and engage in a public exchange of opinions, especially with respect to nanoparticles. We suggest that the dynamics at the intermediate level of the repertoire, both its articulation and shift in pattern, could be viewed as informal technology assessment. Whether people actually draw from this repertoire to shape lines of action and actually perform acts of anticipation and feedback was beyond the scope of this paper. Although the coverage of scientific research remains the dominant context, its' role diminished over time. It is only in the last few years that more assessment of nanotechnology is visible in newspapers. This lag of assessment may be inevitable due to the speculative nature of many nanotechnologies' projections.

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Notes

[1] In this article these are covered by the umbrella term 'nanotechnology'. Some interesting websites on nanotechnology are: http://www.nano.gov; http://www.nano.org.uk; http://www.cordis.lu/nanotechnology.

[2] Nisbet and Huge describe how environmentalist Bohlen intentionally uses newspaper attention in order to shift the attention to what he considered flawed regulatory decisions with respect to plant biotechnology. He suspected and demonstrated via laboratory analysis that a genetically modified corn which was only approved for animal food, had found its way into products for human consumption. These results were offered to a reporter who, after double-checking, published this in the Washington Post. A few days later, the producer of taco shells, in which the GM corn was found, issued a nation wide recall. Other food companies recalled millions of boxes of taco shells. The company who developed the GM corn fired the executives of their crop science division and put it up for sale. The affair generated large press attention to plant biotechnology, but didn't reach the front pages. It was mainly covered from business and regulatory angles and not from a political perspective. News about the tight presidential race and the controversy over the disputed Florida vote count overshadowed the GM affair. Polls indicate that in the end the event had little impact on public concern on plant biotechnology. Moreover only incremental regulatory changes with respect to plant biotechnology were implemented.

[3] With stability of the repertoire is meant whether a certain discussion of the relation between science, technology and society is only mentioned occasionally and disappears from the discourse or it remains part of the discourse. Articulation occurs when substantial links are formed where there were none or only weak ones. When a new relation towards nanotechnology is discussed and remains a stable element in the repertoire, e.g. the context of innovation, the newspaper repertoire has an additional segment. This repertoire becomes increasingly robust when the number, type (context) and strength of linkages towards nanotechnology increases. This increasing robustness is a measure of social learning (Rip, 1986).

[4] A brief study of the articles in Het Financieele Dagblad (FD) resulted in the following observations. 140 nanotechnology related articles were published from 1997 when the first article on nanotechnology appeared in FD announcing a symposium at the TU Delft on nano-electronics . Until 2001 there appeared each annum no more than 6 articles. In 2001 the number of articles increased strongly (quadrupled) with a peak of 38 articles in 2003. After 2003 the number of articles dropped till 23 in 2005. Approximately 75% of the articles are concerned with issues of science policy, resource allocation, which is not surprising because FD is a financial, business oriented newspaper. With the exception of the articles that appeared in 1998 en 2004, nanotechnology is seldom a central topic of an article. In 1998 several articles reported about attempts to mobilize resources for nanotechnology research. In 2004 attention was paid to innovation and risks of nanotechnology with opinion pieces that received also attention in the general daily newspapers.

[5] Totals do not match with figure 1 because articles can belong to more than one category.

[6] In figures 3-5 'N' refers to the number of articles in that period.

[7] For a discussion of some of Drexler's ideas and the 'radical' nature of these ideas, see for instance Bueno (2004).

[8] Eurobarometer survey, 15,000 respondents in Europa. US survey, 850 respondents.

[9] Kouwenhoven has observed the effort with which Don Eigler of IBM manipulated individual atoms. In 1989 Eigler used his Scanning Tunneling Microscope to position individual atoms to spell out 'IBM'. By now this IBM logo is famous and considered to be a landmark in the development of nanotechnology.

[10] Relatively late compared to the US. In 2001 the Clinton administration submitted the budget for the National Nanotechnology Initiative (Anonymous, 2006).

[11] The year 2002 could be viewed, like the year 1999, as a period of transition between the distinguished phases. The borders that are drawn are used to emphasize the observed evolution in the repertoire.

[12] Personal communication Arie Rip, February 2006

[13] Newspapers not only discuss potential consequences of nanotechnology research. They also bring nanotechnology closer to everyday life. For instance by describing available nanotechnology products (Abcouwer 2005; Becker 2005; Anonymous 2005) or by describing public discussions on risks & benefits of nanotechnology based products (Van Nieuwstadt, 2005).

[14] For a recent discussion of risks and media, see Pidgeon et al. (2003).

[15] Other examples of direct responses are pieces by scientists who corrected 'errors' or mis-representations of science that appeared in newspapers, cf. Kluytmans (2001), Kooijmans (2004) and Reijnders (2004).

[16] Rather than cycles of attention in newspapers there are now also ongoing activities of institutionalized actors such as the Rathenau Institute and the RIVM (National Institute for Public Health and Environment).

[17] It would be interesting to analyze the relation between the popular press and specialized scientific press more in depth. For instance by analyzing different repertoires and their relations with help of the Bucchi diagram (Bucchi, 1998).

[18] The presentation of risks of nanotechnology looks strikingly similar to those of other technologies. In the case of nuclear technology there was the risk of the 'runaway reactor', biotechnology had the risk of the 'runaway organism', molecular manufacturing has the 'runaway nanobot', and nanoparticles runaway in the sense that they may chemically react with other materials they are not intended to react with.

[19] The idea of media as some form of technology assessment has also been addressed elsewhere in literature, cf. Oudshoorn (1999) and Sassower (1990).

[20] Since its conception in the late 1960's, technology assessment has steadily evolved in a variety of practices and approaches. While the classic approach emphasized the analysis of secondary impacts of technology on society and the availability of 'objective information' for decision makers, later approaches emphasized the mutual shaping of technology and society (Van Eijndhoven, 1997). Today, we observe an emerging institutionalization of technology assessment practices. Examples are the establishment of the ELSI activities in the US with respect to genomics and nanotechnologies and ELSA activities in the European Framework programmes. TA is not only about mapping and assessing possible consequences of technology, it is also about changing the way how new technologies are introduced into society. One could describe this normative component as an attempt to have 'better' technology in a 'better' society (Schot & Rip, 1997, p. 256).

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