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INCORPORATION WORK

The socialisation of bio- and nanotechnology through newspapers

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In this paper, we analyse how the socialisation of new science and technology (technoscience) is performed through newspapers. Newspapers remain an important source of information about emerging technosciences, such as bio- and nanotechnology, even in the age of new social media. This includes communication about scientific and technological developments but also about sense-making and imaginaries related to expectations about future effects. We analyse articles about bio- and nanotechnology to map who participates in such socialisation work and what kind of sense-making processes that are carried out. In this way, we provide insight into the mechanisms that may facilitate, curb or hinder the incorporation of these emerging technosciences into society. We observed four modes of socialisation work, which co-existed in the articles: (1) Auspicious, (2) anxious, (3) ambiguous, and (4) trivialisation. In the conclusion, we discuss the benefits of applying such a perspective to understand current policy instruments aimed at managing science-society relations and in particular to change their temporal focus to be more concerned with research and innovation that are closer to an application stage where work to incorporate new technoscience into society would be more effective.

Keywords: Socialisation, biotechnology, nanotechnology, incorporation work, modes of socialisation

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Introduction: the shared participation in socialisation work

This paper studies the socialisation of emerging technosciences by analysing newspaper articles about bio- and nanotechnology that are fields where science and technology are interwoven. We focus on the issues the articles engage with, and what actors that are involved in their writing. The making of new technosciences is always a social enterprise (e.g., Sørensen and Williams, 2002), but the social shaping of research and innovation processes does not mean that society is well prepared for the incorporation of new techno-scientific knowledge. Rather, most development of new technoscience take place in liminal spaces where they are offered at least partial protection from external forces (Suboticki an Sørensen, 2021). Socialisation efforts may thus be considered incorporation work needed to bring research and innovation into society. Moreover, science and innovation policy has for a long time been concerned with increasing the social benefits of techno-scientific efforts and reducing public anxiety with respect to possible harmful effects. These challenges entail additional work that may be undertaken by a variety of what we may call socialisation actors (Bijker and d'Andrea, 2009; Sørensen, 2013).

The socialisation of technoscience usually includes sense-making processes, such as suggestions regarding the interpretation of the technoscience object in question, including its future use, but also the communication of risks as well as social and ethical concerns (Sørensen, 2013). In this sense, socialisation work may be expected to contribute to make innovations responsible, also because socialisation and innovation are mirror concepts. Without innovation, there is no new technoscience to socialise. Without socialisation, innovations may find it difficult to become incorporated in society. We argue further that it is fruitful to understand activities related to recent developments in science governance, such as the policy programme of Responsible Research and Innovation (RRI), in terms of socialisation work. This includes those emanating from the public engagement efforts that policies like RRI emphasise, since they aim to promote social dialogues regarding the development of new science and technology, to open up and explore a wide set of issues such as the transparency of and public engagement in research and innovation as well as aspects such as gender equality. RRI, for example, is practiced in diverse ways, but there is a widespread focus on anticipation of future impacts on society, responsiveness to societal challenges, and ethical reflection (Schijff and Dijstra, 2020; Stilgoe et al., 2013). Much attention has been given to early intervention, making scientists the main actors to realise such concerns (Solbu, 2018). However, perspectives like those articulated through RRI are relevant along the whole biography of a given innovation or piece of scientific knowledge. This suggest that a broader set of actors than just scientists should be involved, also because scientists struggle with the enactment of such concerns in the limited context of research (Åm, 2019). This paper investigates if such broader participation already can be observed. Bijker and d'Andrea (2009) advocate improving the socialisation of science and technology to increase benefits and contain risks. In this paper, we aim to shed more light on the multiple facets of such work—the degree of public presence, the actors involved, and the arguments produced. Historical examples of socialisation work include the well-known story of how Edison explained and advertised – anticipated – his electric lighting system on the front page of the New York Times before it was invented (Hughes, 1979). The introduction of the motorcar was accompanied by more comprehensive and distributed socialisation work. At an early stage of its development, automobile companies had to explain the car's potential benefits through advertisements, while government institutions and public associations contributed by developing ideas about the benefits of increased mobility, traffic rules and driver training programmes, not the least to calm public anxieties (Sørensen, 1991). In these cases, the socialisation seems to have been effective, but such impact cannot be assumed. Importantly, this paper studies socialisation work, not effects. The latter would have required a different methodological approach.

The increasingly strong links between news media and techno-science make news media a crucial arena for the study of its socialisation and the enactment of science-society relations outside scientific institutions. Science has been medialised, as Peter Weingart (1998) argues, as a result of the growing efforts of news media in shaping public opinion about science and technology and scientists' increased dependence on public support. Clearly, this makes news media into a potential site of socialisation. Weingart expresses concern that some scientists use the media uncritically to promote their work, while the news media themselves tend to employ scientific knowledge selectively to support their own agendas (Nelkin, 1995; Weingart, 2012). These are important worries, but from a socialisation perspective, the importance of the news media is primarily in their potential to mediate to the public issues of anticipation and reflection about the characteristics and effects of technosciences, such as bio- and nanotechnologies.

It is important to acknowledge that socialisation work in news-paper articles is mediated (see, e.g., Rödder, Franzen and Weingart, 2012). However, we study how socialisation work is articulated in the content of such articles, not the underlying processes and mechanisms that shape the articles or the intentions of the actors involved. Thus, we do not study how or why journalists engage with socialisation of science and technology issues but acknowledge their importance in such public sense-making as is well-documented in media studies (Weigold, 2001). Further, in line with the medialisation concept, we consider the news media as an important source of knowledge about new science and technologies and thus as a crucial resource of their sense-making and anticipations, not only during the early stages of development

but also when the new stuff matures (Nelkin 1995; Nisbet and Lewenstein 2002; Skjølsvold, 2012).

When we study socialisation work, first, we are interested in what kinds of information that newspaper articles present. We expect them to report scientific findings and innovation outcomes in technical terms, which Latour (2004) refers to as 'matters of fact'. However, Latour argues that there should be a greater interest in what he calls matters of concern; how science and technology is situated, contextualised and constructed. Solbu (2018) also draws attention to the importance of establishing a contextualised understanding of technoscience. He proposes the concept of epi-knowledge to describe the outcome of such sense-making, which provides insight into the social context of a given piece of technoscience and its making. This includes wider aspects, such as anticipation and reflection regarding social developments and values. When we consider newspaper articles as a socialisation arena, we expect them to provide epi-knowledge with respect to bio- and nanotechnology (see also Weigold, 2001).

Thus, we ask: what does socialisation work entail in the context of newspapers and who are involved? To what extent do the articles engage with science-society issues, pursuing epi-knowledge related to anticipation and reflection? To explain these questions, we now turn to a more detailed discussion of the socialisation concept and a brief review of previous research with respect to bio- and nanotechnology in the news media.

Socialisation, technological frames and the making of socio-technical assemblages

The socialisation approach has emerged from the Social construction of technology (SCOT) theory. The latter describes the development of particular technologies as co-produced with the emergence and alignment of relevant groups of actors, as in the much-cited study of the history of the bicycle (Pinch and Bijker 1987; Bijker 1995). SCOT describes the development of technology as characterised by controversy with respect to design and the interpretation of designs: which social interests will the technology serve, and how may relevant groups of actors circulate their interpretations of the technologies to make them sufficiently shared and eventually stabilised?

From this perspective, the study of socialisation of science and technologies entails an analysis of the following issues: (1) an identification of the socialisation actors and their contributions, (2) the ways in which their sense-making of technoscientific objects are articulated, including the use of positive and/or critical terms, and (3) the features of different modes of socialisation. When we pursue these questions through an analysis of newspaper articles about bio- and nanotechnology, we are particularly interested in the last issue since previous research finds clear differences in the ways in which news media write about emerging technologies and the anticipation of their future effects, as well as social and ethical reflection about these effects.

From an actor-network perspective, socialisation of technoscience may be considered as an ongoing process of assembling and re-assembling human and non-human elements (Latour, 2005). This involves the development of promissory scenarios (Callon, 1987), based on translations of – in our case – developments within bio- and nanotechnology. However, following the increased attention towards science-society relations in today's science governance, there are also expectations that socialisation work should go beyond such promissory scenarios. In addition to anticipation of benefits, there should also be careful reflections regarding these anticipations; who will benefit, what are the risks involved, and how may ethical concerns be dealt with? Thus, governing institutions expect that translation efforts go beyond the way ANT presents them, as the pursuit of an instrumental goal of persuading potential users. We study if such elements are present in the assemblages of socialisation work in newspaper articles.

Similar concerns may be found in the sociology of expectations (Borup et al., 2006) and research into sociotechnical imaginaries, "collectively held and performed visions of desirable futures" (Jasanoff, 2015: 19). Expectations and visions are important ingredients in socialisation work, but the latter may be more heterogeneous and more concrete. Moreover, when we study socialisation work, we are concerned with the potential multitude of actors involved and the multivocal expressions of anticipations, including risks.

In the studies of how news media deal with bio- and nanotechnology, a main issue is the balance between positive and critical perceptions and the degree of controversy. For example, Weingart, Salzmann and Wörmann (2008) assume that the media actively stage debates between optimistic biomedical scientist and a public who shifts between optimism and fear. They thought that these debates would end in a "normalisation" that aligned the views of scientists and those of the public. However, they found that the controversy persisted, and the expected alignment did not happen. In our terms, the effects of socialisation remained ambiguous. This serves as a warning that socialisation work may not be singularly supportive of a new technoscience but may raise concerns that may create friction with regard to incorporation.

Bauer (2002) and Marks et al. (2007) found that the written press covered different forms of biotechnology differently. Within a medical context, which Bauer refers to as 'red biotechnology', the narratives were primarily positive. By contrast, the news media reported much more critically about 'green biotechnology' where there is widespread concern about genetically modified crops. With respect to yet another field of biotechnology, synthetic biology, Ancilloti et al. (2017) reveal a very positive portrayal in the Nordic press. However, biotechnology, foremost reproduction technologies, has also been shown to be heatedly debated in Norwegian newspapers (Levold, 2014).

With respect to news media coverage of nanotechnology, studies from Germany (Donk et al., 2012), Denmark (Kjærgaard, 2010), Canada (Tyshenko, 2014) and Norway (Kjølberg 2009) find that optimistic narratives dominate. Strekalova (2015) makes a similar observation with respect to nanomedicine in American newspapers. However, Weaver et al. (2009) argue that the coverage of nanotechnology in U.S.-based newspapers changed from the mid-2000s to focus more on risk and regulation issues. Boholm (2013) found a considerable number of Swedish newspaper articles that linked nanotechnology and risk, while Macnaughten (2010) predicts increased controversy related to nanotechnology.

Most of the above-mentioned papers use the concept of framing as their theoretical point of departure, which is quite common in studies of news media. According to Entman (1993: 52), "Framing essentially involves *selection* and *salience* (…). Typically, frames diagnose, evaluate and prescribe". However, we primarily take inspiration from a related concept from science and technology studies – technological frames – that implies a focus on technology. According to Bijker (1995: 123), the concept "comprises all elements that influence the interactions within relevant social groups and lead to the attribution of meaning to technical artefacts – and thus to constituting technology". Furthermore, "Technological frames provide the goals, the ideas, and the tools needed for action. They guide thinking and interaction" (Bijker, 1995: 191).

When this paper analyses socialisation work related to bio- and nanotechnology in the written press, it identifies technological or, more accurately, technoscientific frames and study how they are articulated. Both bio- and nanotechnology involves scientific as well as engineering challenges. We expect socialisation work to be co-produced with technoscientific frames in a dynamic way, since Bijker claims that technoscientific frames are co-produced with relevant social groups that may favour or oppose the technoscience in question. Thus, in our analysis, we consider socialisation as processes where relevant social groups may be constructed and where many activities, distributed across many arenas of society and involving many kinds of actors, may be involved.

To try to socialise technoscience in Bijker and d'Andrea's (2009) understanding of the concept, means to try to bridge the gap between research, development and the relevant social worlds of appropriation. In this sense their understanding has a normative underpinning, perceiving socialisation as goal-oriented processes where actors are expected to strive towards a successful embedding of new technoscience into society. However, we propose to use the socialisation concept in a more symmetrical manner without the normative backdrop of science and innovation policy that scientists and engineers are obliged to engage in socialisation of their results. Thus, socialisation work may not necessarily be undertaken, and it may fail to produce acceptance or to make new scientific knowledge and technologies become appropriated and embedded in society. Critical efforts like public protests may limit or prevent the use of a particular technology. Still, the technology acquires meaning through such processes, be they controversial or not. Thus, we do not assume that socialisation work will end disagreements, in line with the findings of Weingart et al. (2008). Striking examples of long-lasting controversies include nuclear power, cars and computer games. These technologies are embedded in society, but they remain controversial and will probably continue to be so in the future. Our approach opens up for understanding socialisation as a non-linear and continuous process of network formation, where actors engage with and form relations with new science and technology and the social environment at different stages of their development. Moreover, such an approach offers a more nuanced perspective on what successful socialisation would entail that goes beyond mere public acceptance. As an example, socialisation work can generate important contextual knowledge about the technologies that enable public deliberation and can inform decision-making processes, regardless of whether these decisions are in favour of or critical towards the technologies in question.

When we ask about modes of socialisation work in relation of bio- and nanotechnology in this paper, we inquire into work that produce closure or resolution of controversies, but also into compromises where socialisation actors conduct work that help embed these technologies while allowing for controversies to continue. In principle, this requires anticipation as well as reflection regarding how to deal with conflicting perceptions and assessments. Do the newspaper articles contribute insights into strategies for living with technoscientific controversies?

Bijker and d'Andrea (2009) largely base their understanding of socialisation on studies of science communication, which conclude that many scientists and engineers refrain from communicating and engaging with the public (e.g., Davies, 2008; Heidenreich, 2018). Today's science governance, with RRI policies as the most recent example, is meant to amend this situation by putting pressure on scientists and research institutions to initiate social dialogues about their research and innovation efforts. Åm (2019) shows that mainly, scientists accommodate rather than enact demands emanating from RRI policies. However, the findings that many scientists are reluctant to engage in social dialogues may

paint a too pessimistic picture of ongoing socialisation work and public deliberations regarding new technoscience. Therefore, we have chosen to analyse newspaper articles, which provides a more comprehensive and probably a more realistic impression of the publically available social dialogues than interviews with scientists do. We expected to observe a broader engagement by studying the socialisation of emerging technoscience in newspapers because we should encounter a wider group of actors, since newspapers tend to invite people with different positions and views. However, we did not include new social media because that would require much additional work to collect and analyse data. Moreover, in Norway, news media have retained a large readership (Allern, 2017).

Thus, this paper contributes by inquiring into what actors contribute to the public dialogues about new technosciences such as bio- and nanotechnologies that takes place in newspapers, and how we may characterise such socialisation work by analysing the technoscientific framing that shapes the sense-making of these technosciences in the articles. This may give raise to distinct modes of socialisation, which we aim to identify. As a part of the inquiry, we also study the relative importance of providing information about technoscientific facts and findings compared to the provision of epi-knowledge (Solbu, 2018), and how this influence the content of socialisation work.

Method

To answer the research questions, we chose a qualitative approach with an emphasis on diversity and article content. This required a varied, yet limited number of newspaper articles for analysis. It should be noted that newspapers occupy a prominent position in public life in Norway, with widespread readership,[1] even if new social media also is very important. Moreover, we consider newspapers to be multi-actor arenas, even if the content is selected, often edited, and written mainly by journalists. Thus, we chose to use articles regardless of authorship.

To identify relevant articles, we used the digitally searchable media database Retriever that contains all articles published by every Norwegian newspaper for the period we study, 2010–2014. We restricted the search to Norway's eleven national newspapers to provide a manageable but varied sample of articles presenting a diversity of arguments and viewpoints. We see regional issues as less pertinent to the two technological fields. The selected newspapers belong to roughly three segments (circulation in 2014, in 1000): 1) popular papers: *Verdens Gang* (138) and *Dagbladet* (74), 2) large quality papers: *Aftenposten* (188), and 3) medium-sized to small papers with outspoken political and value-oriented agendas: *Dag og Tid* (11, weekly), *Dagens Næringsliv* (70), *Dagsavisen* (22), *Klassekampen* (19), *Morgenbladet* (29, weekly), *Nationen* (12), and *Vårt Land* (23).[2] Thus, we cover Norway's largest newspapers while providing diversity with respect to political and value-based focus.

With nanotechnology, in order to cover all derivations of the word nano and include the different disciplines of nanotechnology, like nanomedicine, nanomaterials and nanoscience, the search word 'nano*' was used. However, the initial search provided an unsatisfactory, low number of articles. We therefore expanded the search by including all the papers' web publications as well as those of the web site of the Norwegian Broadcasting Corporation (NRK). This revised search resulted in 1419 hits. Due to the open-ended search word, most of these hits were not relevant for our purposes. In order to be included in the analysis, the articles had to make claims or provide knowledge about nanotechnology. After manually removing duplicates, articles that were only vaguely related to the field, and the matches that were the results of other Norwegian words beginning with nano, we were left with 187 articles.

In the case of biotechnology, the initial search using a diverse set of search terms designed to cover different kinds of biotechnology resulted in 3624 matches.[3] To obtain a similar sample of articles as with nanotechnology, we restricted the search to one month per year (02/2010, 04/2011, 06/2012, 09/2013, and 11/2014). However, this restriction gave very few hits on synthetic biology, so we did a separate search of this field for all months of the five years. After applying the same criteria as with nanotechnology in the manual selection of articles to be analysed, we ended up with 173 articles. This included fifteen articles addressing synthetic biology. Since the latter group of articles proved to be quite similar in framing and content to the other biotechnology articles, we do not present them as a separate category in this paper.

We performed two kinds of analysis. One was a simple quantitative content analysis where we counted articles according to article category (news/commentary by journalists, letters to the editor, interviews, chronicles, other), author category, articulation of ethical concerns (yes, no, unclear), direction of argument (supportive, critical, a mix, unclear), type of knowledge presented (technical (fact-like), epi-knowledge, a mix), and ideas about the use of the technologies (yes, no). Given that the samples were too small for statistical analysis, we present the findings

1 See also http://kyber.blob.core.windows.net/nmd/2049/mediedager-publikum_rapport_2017.pdf (downloaded 2018-02-17).

2 Circulation numbers found at https://www.mediebedriftene.no/tall-og-fakta/opplagstall/

3 We used the word combinations "bioteknologi or biotek* or biomed* or systembio* or "syntetisk bio*" or genmod* or genman* or GMO or genter* or gentek* or fosterdiag* or stamcelle* or "preimplantasjonsgenetisk diagno*" or PGD or kloning*.

in qualitative terms, like 'some', 'many' or 'the majority'. The second kind of analysis was a thorough qualitative reading of the articles. The first stage was a rough sorting according to their main topics in order to map the text corpora. In the next stage, the articles were read two more times with close attention paid to the arguments presented, the actors visible in the statements, and how meaning ascribed to the two fields became evident through this process of assembling arguments and actors. The resulting typology that we discuss in the analysis part of the paper is not a categorisation of articles but of arguments.

In the next section, we present the results of the quantitative content analysis, before proceeding with an outline and discussion of the qualitative investigation. The reader should note that we consider all mention of bio- and nanotechnology to be relevant to socialisation, even if socialisation work with respect to or wider reflections about these technosciences apparently was not an explicit goal of the author(s). We assume that all mentions may have effect and counts as input to social dialogue; at the very least they cultivate an awareness of the existence of the emerging technosciences among readers.

Mapping the socialisation of bio- and nanotechnology in newspaper articles

Bijker and d'Andrea (2009) highlight the importance of scientists as socialisation actors. However, our analysis also shows that a variety of other actors play key roles in conducting socialisation work. Interestingly, the variety of actors was more prominent with respect to bio- than nanotechnology. This indicates that biotechnology has met with more comprehensive public engagement than nanotechnology, which may be or at least has been a more specialised concern. Furthermore, approximately half of the nanotechnology articles were interviews, primarily with scientists. A similarly large proportion came from journalists reporting on the development of nanotechnology, usually drawing on scientific reports or making use of scientists as sources. Thus, journalists engaged prominently in what we call the socialisation work regarding nanotechnology, without necessarily considering themselves as socialisation actors. Moreover, they often did so in conjunction with scientists. Citizens, policymakers and industry stakeholders appeared to be more marginal as contributors to this social dialogue.

Regarding biotechnology, the pattern was different. The number of letters to the editor and chronicles authored by other actors than scientists was substantially higher than in the nanotechnology sample. Scientists remained important as interviewees and sources of knowledge and information. However, in the biotechnology sample, citizens, policy-makers and industry stakeholders supplemented or replaced them altogether, reflecting a clear reduction in the number of articles that made explicit reference to technoscientific information or knowledge. Instead, a much larger share of the articles addressed mainly contextual issues and/or effects of biotechnology – what we call epi-knowledge.

Epi-knowledge was also important in the articles about nanotechnology but most of them combined epi-knowledge with some explanation of how nanotechnology works and described concrete technoscientific achievements. These differences suggest that biotechnology was already socialised more extensively than nanotechnology because many of the biotechnology articles took some form of technoscientific framing for granted. However, this technoscientific framing did not preclude controversy.

The dominant image of nanotechnology that resulted from the technoscientific framing of the newspaper articles was as a positive, promising development, in line with the previously reviewed studies. Still, we found quite a few critical contributions, mostly concerns that nanoparticles used in sunscreens and in new textiles were toxic. No article in our sample voiced a fundamental scepticism toward the development of nanotechnology or raised ethical concerns. The discursive landscape was markedly different with biotechnology, even if most of the articles were positive or neutral. Based on previous studies in Norway (Antonsen, 2017), we expected this to be an effect of ethical concerns. Such concerns played some role related to issues regarding human reproduction, above all abortion and surrogacy, but the criticism was mainly articulated in articles about genetically modified organisms (GMO). These articles did not frame GMO in ethical terms but as potentially harmful. This is in line with Bauer's (2002) finding about 'green' biotechnology.

To conclude this initial analysis, we want to emphasise that often, the technoscientific framing of the analysed newspaper articles was implicit. Many articles refrained from presenting or discussing bio- or nanotechnology at any length. On the contrary, many articles only briefly mentioned one of them (sometimes both) as an item in broader contributions to social dialogue regarding for example agriculture or future industrial development. This tendency shows that the main socialisation work of the newspaper articles tended to be through the technology in question as trivial, meaning that it appeared as a given thing and was presented in a matter-of-fact manner (Weingart, 1989). When, for example, articles listed biotechnology as a source of innovation or as part of agricultural policy, it seemed that the author(s) considered biotechnology as a mundane part of such discourse and sought to impose this view on the readers.

In the case of nanotechnology, articles often explained techno-scientific principles using an informational mode. With respect to both technosciences, the dominant role of epi-knowledge shows that the socialisation work mainly consisted of contextualisation, anticipation of future use, and sense-making

through reflexivity. Articles written in this mode could provide both positive expectations and controversy with a focus on risks. In the next sections, we analyse this in greater detail by focusing on the links that many articles made between nano- and biotechnology and other technosciences, as well as ethical, political and social aspects.

Nanotechnology: a hopeful technoscience?

As noted above, the analysed newspaper articles described nanotechnology chiefly in terms of benefits. They articulated expectations that the development of nanotechnology would help solve major social challenges, such as the need to increase the production of renewable energy. These articulations of nanotechnology as a hopeful technoscience typically explained that the general development of nanotechnology could lead to concrete beneficial applications. This contextualisation and the ensuing anticipations of potential benefits would typically be generated by journalists interviewing inside actors such as nanotechnology scientists and others with relevant expert knowledge. The following quote exemplifies how a professor of nanotechnology contributes to the sense-making of the nanomaterial graphene.

> I usually explain it like this. Graphene is like a decathlon athlete that has the world record in eight out of ten events. It makes the possibilities [of graphene] almost limitless if we only manage to make composite materials that won't reduce any of the original world record qualities of graphene. [This material] enables us to develop a fundamentally new generation of computational technology and photonic materials, like highly efficient solar cells, light emitting diodes, and transistors.[4]

In a similar way, a Norwegian nanotechnology research group, who was the first in the world to make semiconductors out of graphene, explained in an interview their discovery as a potential "revolution" for the computer industry, claiming that graphene might make traditional silicon-based semiconductors obsolete: "Graphene is cheap, transparent and flexible (…). When we now can make semiconductors out of graphene, semiconductors will not only become cheaper, but also more efficient".[5] The article further states how the innovation was developed by a Norwegian start-up company. In this way, the research was made sense of also by invoking commercial expectations.

In general, the sense-making of nanotechnology was characterised by promissory arguments about its game-changing potential and how it might improve existing products. In this way, the socialisation work constructed discursive links between the science and the solving of major social challenges. This was also evident from several articles that considered nanotechnology to be an important ingredient of the national strategy for research and innovation, anticipating possibilities of industrial development and moves towards a greener economy. Such statements often situated nanotechnology among other so-called enabling technologies, applying a broader technoscientific framing. An example of such generalised framing was the following statement: "New energy sources and enabling technologies like ICT [information and communication technologies], material technology, nanotechnology and life sciences will form the basis of our future industry!"[6]

We also found articles that explained nanotechnology with reference to both policy and desired applications: "The building block for success within highly efficient solar cells, new battery technology, cheaper and more secure storing of hydrogen, and energy efficient cars, boats and planes is smart materials and applied nanotechnology."[7] Quite a few articles created links between nanotechnology and developments within medicine, reporting anticipation of new treatments, new and better medical equipment, and improved drug administering: "A new, targeted cancer treatment based on nanotechnology can make it possible to attack cancer with higher concentrations of medicine without damaging healthy cells".[8] When articles about basic nanotechnology research mentioned medicine as a possible area of application, this was often to argue that such research deserved public support. A few articles developed the latter kind of socialisation work into more a speculative promissory discourse, for example, the anticipation of using nanotechnology to enhance the human body and prolong life. These articles were not critical but articulated optimistic views regarding the contributions of nano scientists.

Most of the articles with a positive framing focused on the ways in which nanotechnology promised to improve existing products and/or would provide commercial value in the future. Sometimes they offered odd examples. One article extolled the virtues of a new nano-coated bottle that supposedly was making the inside so smooth that "The big ketchup problem may be solved".[9] Often, articles with a positive framing were based on press releases from research groups or corporations engaged in nanotechnology. Thus, the majority of the scientists contributing to socialisation

4 *Aftenposten*, March 13, 2014 ('Framtidens supermaterial', p. 16)
5 *NRK web* (https://www.nrk.no/viten/revolusjonerende-hybridmateriale-1.8317912), September 9, 2012 ('Norske forskere med revolusjonerende hybridmaterial')
6 *Aftenposten*, August 13, 2013 ('Et intenst kappløp', p. 2)
7 *Dagens Næringsliv*, June 11, 2013 ('Sender nanopartikler rett i kreftsvulsten', pp. 10-11)
8 *Dagens Næringsliv*, July 7, 2011 ('Norge bør gripe sjansen', p, 36)
9 *Dagbladet Web*, (http://www.dagbladet.no/2012/05/24/nyheter/forskning/ketchup/ketchupeffekten/21751462/), May 24, 2012 ('Ketchup problemet er løst')

work regarding nanotechnology through promissory discourses in newspaper articles were insiders in the field.

The situation was different when the articles were concerned with risks. Usually, they were based on input from outsiders to the field, such as biologists, occupational medical scientists, and employees of the Norwegian Consumer Council. These articles framed nanotechnology by focusing on anticipations of negative health impacts for workers and consumers as well as worrisome environmental consequences of nanoparticles in commercial products. The authors mainly wrote about products that were already on the market, such as sunscreens or odour free clothing. They focused particularly on the toxicity of materials such as nano silver, discussing how such materials could affect the human body, accumulate in the environment, and damage biological systems. In a representative quote, the author argued: "The use of nanoparticles in everything from clothes to cosmetics is dramatically increasing. This worries scientists that fear serious health hazards both among people and animals."[10]

A few articles expressed health concerns related to nano food but also pointed to possible benefits, although with restraint. "While nano-food may give us tastier and less fattening food, there is every reason to follow the development carefully (...). It is best to be precautious".[11] In this way, many articles presented critical views of nanotechnology in an ambiguous manner. For example, when such authors foregrounded the issue of toxicity, they frequently qualified their viewpoint by claiming a lack of reliable knowledge and advocated a precautionary approach: "But how safe is it to fill the walls with nanomaterials? Lessons from asbestos show that there is reason to be cautious with materials that may produce microfibers that can be inhaled".[12] However, precaution was only infrequently part of the technoscientific framing of nanotechnology. Anticipations were usually positive and hopeful, although toxicity sometimes was a concern.

Thus, the observed socialisation work was mainly supportive of incorporating and embedding this technology in society but in an abstract manner. The critical articles tended to be the most concrete because the critique considered actual applications with potentially harmful effects. Moreover, as previously noted, we found next to nothing of ethical reflections or articulations of potentially negative social aspects in the articles mentioning nanotechnology. We assumed this to be different with biotechnology.

The news media socialisation of biotechnology: split-up and partial controversy

Were the socialisation work in the newspaper articles regarding biotechnology characterised by a greater level of controversy than nanotechnology? Relatively speaking, we found fewer unambiguously positive articles and a greater number of very critical articles in our sample. Still, the majority articulated promissory discourses regarding biotechnology. Biotechnology was anticipated to be an ingredient of a variety of beneficial future applications. Often, the articles were news briefs reporting on a promising scientific result, such as the following quote. "Scientists have come closer to treating blindness, by growing a retina from stem cells for the first time".[13] Articles could also present general, visionary statements, for example "[I]n the future, it will be possible to grow new organs inside the body using these [biotechnological] methods".[14] Thus, the positive framing of biotechnology tended to be anticipatory, similar to many articles about nanotechnology. Biotechnology was argued to be important to Norwegian research and innovation strategies due to the promise of new economic opportunities. "The research on biotechnology, with its emphasis on agriculture, is one of the hidden treasures of the agricultural sector. The goal is to build further on what we have been working on for several decades. It can contribute to establishing new businesses and jobs"[15]

Other articles provided positive anticipations of biotechnology by drawing on personal stories about illnesses where biotechnology developments could provide a promising new treatment. We encountered statements like "She hopes that the experimental treatment will save her life".[16] Such framing linked the promissory discourses of biotechnology closer to the present, grounding them in existing and evolving practices such as treating cancer through stem cell therapy.

Nevertheless, overall, we read the news media socialisation of biotechnology as ambiguous compared to the nanotechnology discourses, due to the higher frequency of critical statements. Critical articles framed biotechnology with pessimistic anticipations, detailing present and future risks to humans and nature. The most frequently mentioned application of biotechnology in

10 *Dagsavisen*, July 6, 2012 ('Nanofrykt blant norske forskere', p. 8)
11 *Klassekampen*, June 3, 2010 ('Nam Nam?', p. 11)
12 *NRK web* (https://www.nrk.no/viten/nanokuler-kan-bli-isolasjon-1.11262363), September 26, 2014 ('Dette kan bli framtidas isolasjon')
13 *Aftenposten*, April 13, 2011 ('Dyrket fram netthinne', p. 20)
14 *Aftenposten*, September 20, 2013 ('Stamceller inne i levende dyr', p. 33)
15 *Nationen*, September 3, 2013 ('Vedum med millionar til bioforskning', p. 6)
16 *VG*, November 23, 2014 ('Slik hjelpes hun', p. 6)

such discourses was genetically modified organisms – GMOs. GMOs were described as harming the environment and as unhealthy for the human body. Some articles also reported scepticism among consumers and argued that risks yet were unknown; thus, precautionary approaches were needed. "This technology [genetic modification] is still young, big questions related to health and the environment are still to be further explored".[17]

A corresponding worry was elaborated with respect to EU regulations that might allow GMOs into Norway, either directly or indirectly through animal foodstuff. These discourses were articulated by individual farmers, representatives of farmers' associations and environmental NGOs. "It is said that GMOs are not dangerous. No one can answer this question because there is a lack of independent research and because scientists who have been on the track of detecting possible health risk have been silenced".[18] These articles spoke to one of the rationales of governing science-society relations; the need of research and innovation to be considered responsible by the public; they did not see GMO research and innovation as sufficiently under control. However, in the newspaper discourses about biotechnology, articles about GMO were the main example of critical engagement with responsibility, articulated as a call for precaution.

A few critical contributions mentioned bioterrorism and other forms of misuse of biotechnological tools. Some discussed research on the manipulation of viruses, which provided interesting examples of ambivalent anticipations. On the one hand, developing so-called super-viruses might improve the understanding of how viruses mutate and help scientists developing vaccines against new viruses. On the other hand, artificially developed viruses could fall into the wrong hands and become weapons or be released into society through human error. One conclusion was that, on balance, the risks were too high. "(T)his is research we should not be conducting".[19] We could see this as an initiative of managing science-society relations, a reflexive intervention in a kind of biotechnological research.

The other category of articles that reflected doubts about responsible research and innovation in biotechnology emerged from ethical concerns, which were nearly absent in the nanotechnology discourses. Still, ethics was less prominent in the biotechnology discourses than we expected from previous studies in Norway (Antonsen, 2017). The main ethical controversies we observed concerned surrogacy and the use of ultrasound before week 12 of pregnancy. Here, religious arguments were mobilised. "[The Norwegian government] represents a devaluation of the Christian heritage and threatens the value of human life on several areas like the biotechnology legislation and early ultrasound".[20]

However, very few articles framed biotechnology in general as unethical or at variance with religious values. Rather, the scarce articles that raised ethical issues focused on applications related to human reproduction and members of the small Christian Democratic Party dominated such contributions. (The party received 4,2 % of the votes in the parliamentary election of 2017). In the articles, they wanted to achieve political importance by claiming biotechnology as one of their core concerns, voicing disbelief in the management of responsibility. "In this fundamental fight for human value as it now stands within biotechnology, only the Christian Democratic Party with its principle of the embryo's right to protection conducts a sustainable policy".[21]

Apart from GMOs and applications related to human reproduction, biotechnology was not controversial, politically or in terms of risk. This was evident from articles concerned with research and innovation policy. They explicitly or implicitly viewed biotechnology's place as an item in such policies as a given. It was anticipated to be one of the technologies of the future. Accordingly, we see that the framing of biotechnology rendered just a few fields as controversial, raising doubts about the management of responsibility of the involved actors. Thus, some newspaper articles split biotechnology into several sub-areas. This had important consequences for the framing and the socialisation work. When articles presented anticipations about biotechnology generically, they articulated promissory discourses about a beneficial field or as an unquestioned priority area of technoscientific development. Alternatively, they only used neutral characteristics of the field.

Compared to nanotechnology, we found a greater diversity of contributors to the socialisation work regarding biotechnology. Technoscientists certainly played an important role as sources of knowledge and expectations in both cases. However, with biotechnology, political parties, industry, interest organisations, and NGOs had a stronger presence. The latter group of actors provided most of the critical assessments, although some also offered positive or mixed views. Also, nearly all biotechnology articles engaged in the production of epi-knowledge, while a substantial part of the nanotechnology articles primarily provided technical information. These observations suggest that in the period we studied, the socialisation work regarding biotechnology was more mature than those related to nanotechnology.

17 *Klassekampen*, February 26, 2010 ('Nettverk for GMO-fri mat', p. 8)
18 *Nationen*, November 3, 2014 ('Den store GMO-forvirringen', p. 3)
19 *Morgenbladet*, November 7, 2014 ('Spredningsfare', pp. 8-12)
20 *Klassekampen*, April 30, 2011 ('Krever regjeringsskifte', p. 6)
21 *Vårt Land*, September 2, 2013 ('Gi oss større visjonar', p. 21).

Conclusion: Making technosciences mundane and responsible through socialisation work

This paper has examined newspaper articles about bio- and nanotechnology as part of the socialisation work related to these emerging technosciences and as a public enactment of science-society relations. We asked (1) what kinds of actors contribute, (2) what kinds of socialisation modes could we observe, with an emphasis on sense-making, anticipations and reflexivity, and (3) what lessons may we draw to reflect on the attention towards science-society relations in today's science governance? Responding to these questions, it has been our objective to further develop the concept of socialisation of technoscience, with a focus on the work that more or less unintentionally results in socialisation, and link this to discussions about managing science-society relations more generally.

To begin with, clearly, newspapers are an arena where socialisation work regarding bio- and nanotechnology takes place. This is in line with the medialization of science argument, which posits an increasingly closer relationship between news media and the sciences (Weingart, 1998). We have not studied the effects of this work on the public, but we have reasons to believe it is important. For example, the news media would likely lose interest in such topics if their readers were uninterested, which the news media measure through their web-based versions and the number of clicks.

Bijker and d'Andrea (2009) focused on scientists as socialisation actors. Our analysis shows the importance of a broader variety of actors, above all journalists, even if they frequently called upon scientists and scientific reports as sources. We observed that journalists played a crucial role as mediators and interpreters of the technosciences, particularly with respect to articles addressing nanotechnology. Overall, journalists and scientists were the most important contributors to the newspaper-based socialisation work related to the two emerging technosciences. Still, we also observed a wide spectrum of socialisation actors participating in the work, such as politicians and representatives of industry, interest organisations, and NGOs. This support our belief that science governance discourses, like the ones evolving around RRI policies, should broaden their focus on actors and practices in order to better understand how science-society issues are dealt with, in and by society.

We have observed four main categories of technoscientific frames, which articulated different anticipations that shaped the modes of socialisation work. First, a frame that highlighted possible benefits and invited public support. Second, a frame that emphasised risks, and in a few cases, ethical concerns. Third, a frame that invited ambivalent views. Fourth, a frame that trivialised the emerging technologies by avoiding the use of modalities as an indication that these new technosciences in some contexts such as science policy were mundane and uncontroversial (Latour, 1987). The first three frames are recurring observations in studies of media engagement with nano- and biotechnology. Arguably, they constitute the main 'grammar' of public discourses about new science and technology, which invites different forms of reflexivity. The trivialisation frame was used more rarely, although it resonates with common assumptions about closure of controversies about new technoscience.

We see each of the four frames as co-produced with one mode of socialisation work. The identified frames highlight the sense-making and anticipatory aspects of such work.

Mode 1 *Auspicious or hopeful socialisation work.* This imbued the technosciences with positive anticipations. Beneficial outcomes were in most cases described in general terms, often in the form of reflexive epi-knowledge concerned with social change and broadly conceived usefulness, although concrete new practices could be suggested, such as new medical therapies. Consequently, mode 1 represents work to mobilise support and pave the way for the appropriation of anticipated new products. It may be dominant in early stages of development, like with nanotechnology. However, as we saw, this mode of socialisation remained important also with respect to the more mature field of biotechnology. In general, this mode is important with respect to bringing new technoscience out of the liminal spaces in which they are developed, to become incorporated into society (Suboticki and Sørensen, 2021). Thus, this mode of socialisation work clearly was incorporation work.

Mode 2 *Anxious or critical socialisation work.* The underlying frame produced arguments that emphasised negative aspects, such as toxicity or ethical concerns, but it did not address nano- or biotechnology in general. Rather, critical socialisation focused on existing examples, such as GMO or the use of silver nanoparticles in clothing. Thus, the work singled out concrete applications to socialise them through sense-making intended to exclude them from society, to make the technoscience remain liminal and countering incorporation work.

Mode 3 *Ambiguous socialisation work.* Many articles combined positive and critical assessments, without taking a clear position. They invited reflexive engagement in an open manner, for example by invoking ambiguous epi-knowledge about anticipations regarding future results of bio- or nanotechnology development. Support for further research and innovation could be called for, but not in an unequivocal manner.

Mode 4 *Trivialisation.* This mode of socialisation work produced a matter of fact-like observations that were free of modalities. This was most frequently observed in articles about biotechnology and seemed to be a measure of maturity (see Latour 1987) as well as an indication of closure of controversy. Trivialising implied that bio- and/or nanotechnology in general or through concrete applications already were embedded in society; their presence was expected and not questioned. Usually, epi-knowledge was not needed and not articulated in this type of socialisation work. Maybe we could consider this mode of socialisation as rather opaque incorporation work.

Bijker's (1995) understanding of technoscientific frames assumes that they provide goals and ideas to guide action, thinking, interaction, and practices of an involved social group – in short, the socialisation work related to a given technoscience. However, we did not find that the technoscientific frames that were articulated in the newspaper articles, always were co-produced with an identified social group, even if they focused on a concrete artefact. Of course, there were exceptions. Articles about new medical treatments often suggested a relevant social group: patients with the targeted kind of illness. Usually, the implied relevant social group was people in general; a phantom public (Latour 2005). This could mean that the socialisation was less effective because anticipations related to bio- and nanotechnology did not identify relevant future actors. A ghost-like public is less inclined to engage, to anticipate and reflect.

One of the ambitions underlying science policy ideas like RRI is to create social dialogues about new technoscience to shape scientific developments according to the concerns of relevant actors as well as ensuring these actors about the responsibility of the involved research and innovation. The socialisation perspective we have employed in the paper, illuminates important aspects of these processes by highlighting the sense-making and the technological frames that are performed. First, as already noticed, the perspective helps to broaden the focus on the actors that may be party to the process.

Second, we observed different levels of participation of the groups of actors involved in the different modes of socialisation work. The actors engaging in the auspicious mode tended to be insiders in the scientific fields, either directly or indirectly through journalists following the developments. This contrasted with the anxious mode, where a much wider range of actors participated. Through contestations of existing practices and regulations, technologies were brought into social dialogues through the attention by key actors, such as political parties and representatives from religious communities. This may result in a more inclusive public participation in the sense-making, which gives empirical support to claims about the importance of issue creation in enabling inclusive political processes (see, e.g., Marres, 2014).

Thirdly, the socialisation perspective sensitises toward temporal aspects. Our study shows how temporality is a crucial characteristic of the observed differences in the practices of anticipation articulated in the newspaper articles. As we observed, future, not yet constructed applications were in most cases seen as beneficial and linked to the auspicious or the ambiguous mode. The main sources of these optimistic anticipations were as already noticed insiders; scientists and others engaged in such research and innovation. In contrast, negative anticipations mostly were explained with reference to technosciencies already in use. Here, the sources of such assessments were a broader set of actors, engaged in either the anxious or the ambiguous mode of socialisation. The trivialisation mode had an unclear temporal profile.

Lastly, science governance efforts to manage science-society relations have been criticized for being too occupied with early stage interventions in research projects and thus losing touch of issues related to the broader political economy that research and innovation is situated in (Solbu, 2018; Åm, 2018; Van Oudheusden and Shelley-Egan, 2021). Our study points to important aspects related to the temporal dimension of governance efforts, in particular that anticipation in the early stages of technology development tend to be singularly positive. Critical assessments, such as anticipations about risk, appear to be difficult to make unless the technosciences are closer to application. While there are exceptions, such as geoengineering where potential risks are easier to observe, scientists working in bio- and nanotechnology tend to complain about the difficulties of anticipating risks and benefits at an early stage of the research (Åm, Solbu and Sørensen 2021).

Moreover, our study clearly shows that when the new techno-sciences we have examined are closer to application, public engagement becomes more common. The critical reflections we observed towards reproductive technologies, technologies that have been used in Norway for decades, also show the relevance of science-society perspectives throughout the entire biography of technologies. Socialisation is a process with no clear end point. Thus, continued socialisation work may be needed, going through phases of re-actualisation related to changing societal circumstances, if the technoscience is going to be or remain incorporated in society. Thus, the focus on socialisation work as applied in this paper clearly suggests that policy instruments aimed at responsibly managing science-society relations should broaden their temporal focus beyond early stage interventions in research projects.

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References

Allern, Sigurd. (2017). The role of the media in Scandinavian politics. In Peter Nedergaard and Anders Wivel, eds. *The Routledge handbook of Scandinavian politics*, 174-186. New York: Routledge

Ancilloti, Mirko, Niklas Holmberg, Mikael Lindfelt, and Stefan Eriksson. (2017). Uncritical and unbalanced coverage of synthetic biology in the Nordic press. *Public Understanding of Science 26*(2): 235-250. https://doi.org/10.1177/0963662515609834

Antonsen, Marie A.(2017). *(U)Mulige medborgere: Engasjement, etikk og emosjoner i styring av human bioteknologi i Norge.* Doctoral dissertation. Department of Interdisciplinary Studies of Culture, Norwegian University of Science and Technology, Trondheim

Bauer, M. W. (2002). Controversial medical and agri-food biotechnology: a cultivation analysis. *Public understanding of science, 11*(2), 93.

Bijker, Wiebe E. (1995). *Of Bicycles, Bakelites, and Bulbs. Toward a Theory of Sociotechnical Change.* Cambridge, MA: The MIT Press

Bijker, Wiebe E., and Luciano d'Andrea, eds. (2009). *Handbook on the Socialisation of Scientific and Technological Research*. Rome: River Press Group.

Boholm, Max. (2013). The representation of nano as a risk in Swedish news media coverage. *Journal of Risk Research 16*(2): 227-244. https://doi.org/10.1080/13669877.2012.726243

Borup, Mads, Nik Brown, Kornelia Konrad and Harro van Lente (2006). The sociology of expectations in science and technology. *Technology analysis & strategic management, 18*(3-4): 285-298.

Callon, Michel. (1987). Society in the making: the study of technology as a tool for sociological analysis. In *The social construction of technological systems. New directions in the sociology and history of technology*, eds. Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch, 83-103. Cambridge, MA: The MIT Press

Davies, Sarah.(2008). Constructing Communication: Talking to Scientists about Talking to the Public. *Science Communication 29*(4): 413–34.

De Saille, S. (2015). Innovating innovation policy: the emergence of 'Responsible Research and Innovation'. *Journal of Responsible Innovation, 2*(2), 152-168.

Donk, André, Julia Metag, Matthias Kohring and Frank Marcinkowski. (2012). Framing Emerging Technologies: Perceptions of Nanotechnology in the German Press. *Science Communication 34*(1): 5-29. https://doi.org/10.1177/1075547011417892

Entman, Robert M. (1993). Framing. Toward Clarification of a Fractured Paradgm. *Journal of Communication 3*(4): 51-58

Heidenreich, Sara. (2017). Outreaching, Outsourcing, and Disembedding: How Offshore Wind Scientists Consider Their Engagement with Society. *Science, Technology, & Human Values, 25*(4): 449-472. https://doi.org/10.1177/0162243917726578

Hughes, Thomas P. (1979). The Electrification of America: the System-Builders. *Technology and Culture 20*(1): 125-139.

Jasanoff, Sheila (2015). Future imperfect: science, technology, and the imaginations of modernity. In Sheila Jasanoff and Sang-Hyun Kim (Eds.), *Dreamscapes of modernity: sociotechnical imaginaries and the fabrication of power* (pp. 1–47). Chicago: University of Chicago Press.

Kjølberg, Kamilla. (2009). Representations of nanotechnology in Norwegian Newspapers – Implications for public participation. *NanoEthics 3*(1), 61-72

Kjærgaard, Rikke Schmidt. (2010). Making a small country count: nanotechnology in Danish newspapers from 1996 to 2006. *Public Uncerstanding of Science 19*(1): 80-97. https://doi.org/10.1177/0963662508093090

Latour, Bruno. (1987). *Science in action. How to follow scientists and engineers through society.* Milton Keynes: Open University Press.

Latour, Bruno. (2004). Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern. *Critical Inquiry 30*(2): 225-248

Latour, Bruno. (2005). *Reassembling the social. An introduction to actor-network-theory.* Oxford: Oxford University Press

Levold, Nora. (2014). *Biopolitikk – Kropp, Kunnskap og teknologi.* Bergen: Fagbokforlaget

Marks, Leonie A., Micholas Kalaitzandonakes, Lee Wilkins, and Ludmilla Zakharova. (2007). Mass media framing of biotechnology news. *Public Understanding of Science 16:* 183-203. https://doi.org/10.1177/0963662506065054

Macnaghten, Phil. (2010). Researching technoscientific concerns in

the making: narrative structures, public responses, and emerging nanotechnologies. *Environment and Planning A, 42:* 23-37. https://doi.org/10.1068/a41349

Nelkin, Dorothy. (1995). *Selling Science: How the press covers science and technology. 2d ed.* New York: Freeman

Nisbet, Matthew C., and Bruce V. Lewenstein.(2002). Biotechnology and the American Media. The Policy Process and the Elite Press, 1970 to 1999. *Science Communication 23*(4): 359-391

Rip, Arie. (2014). The past and future of RRI. *Life Science, Society and Policy,* 10:17

Pinch, Trevor J., and Wiebe E. Bijker. (1987). The social construction of facts and artifacts: or how the sociology of science and the sociology of technology might benefit each other. In *The Social Construction of Technological Systems,* eds.: Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch, 17-50. Cambridge, MA: The MIT Press.

Rödder, Simone, Martina Franzen and Peter Weingart (2012) Exploring the Impact on Science Communication on Scientific Knowledge Production: An Introduction. In *The Sciences' Media Connection—Public Communication and its Repercussions,* eds. Simone Rödder, Martina Franzen, and Peter Weingart, 17-32. Dordrecht: Springer

Skjølsvold, Tomas Moe. (2012). Curb Your Enthusiasm: On Media Communication of Bioenergy and the Role of the News Media in Technology Diffusion. *Environmental Communication, 6*(4), 512-531. https://doi.org/10.1080/17524032.2012.705309

Solbu, Gisle. (2018). The Physiology of imagined publics: from a deficit towards an ambivalence model. *Science and technology studies,* 39-54.

Solbu, G. (2018). Managing Science and Managing Society in Norwegian Bio- and Nanotechnology Research. *PhD thesis*. 2018: 154. Trondheim: Norwegian University of Science and Technology

Stilgoe, Jack and Guston, David H. (2017). Responsible research and innovation. *Handbook of science and technology studies*, eds. Ulrike Felt, Rayvon Fouché, Clark A. Miller and Laurel Smith-Doerr, 853-880. Cambride, MA: The MIT Press

Stilgoe, Jack, Owen, Richard and Macnaghten, Phil. (2013). Developing a framework for responsible innovation. *Research policy, 42*(9)-1568-1580.

Strekalova, Yulia A. (2015). Informing Dissemination Research: A Content Analysis of U.S. Newspaper Coverage of Medical Nanotechnology News. *Science Communication 37*(2): 151-172. https://doi.org/10.1177/1075547014555025

Suboticki, Ivana and Knut H. Sørensen (2021). Liminal technologies: Exploring the temporalities and struggles in efforts to develop a Belgrade metro. *The Sociological Review, 69*(1): 156–173. https://doi.org/10.1177/0038026120918166

Sørensen, Knut H. (1991). The Norwegian Car. The cultural adaptation and integration of an imported artefact. *In Technology and everyday life: Trajectories and transformations*, eds. Knut H. Sørensen and Anne-Jorunn Berg, 109-130. Oslo: Norwegian Research Council for Science and the Humanities.

Sørensen, Knut H. (2013). Beyond innovation. Towards an extended framework for analysing technology policy. *Nordic Journal of Science and Technology Studies, 1* (1): 12-23.

Sørensen, Knut H., and Robin Williams. Eds. (2002). *Guiding Policy, Shaping Technology: Concepts, Spaces and Tools*. London: Edward Elgar

Tyshenko, Michael G. (2014). Nanotechnology framing in the Canadian national news media. *Technology in Society 37*: 38-48.

Van Oudheusden, M., & Shelley-Egan, C. (2021). RRI Futures: learning from a diversity of voices and visions. *Journal of Responsible Innovation, 8*(2), 139-147

von Schomberg, Rene. (2013). A vision of responsible research and innovation. *In Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*, eds. Richard Owen, John Bessant, and Maggy Heintz, 51-74. London: Wiley.

Weaver, David A., Erica Lively, and Bruce Bimber. (2009). Searching for a Frame. News Media Tell the Story of Technological Progress, *Science communication 27*(8), 869-879

Weingart, Peter. (1989). Grosstechnische Systeme - ein Paradigma der Verknüpfung von Technikentwicklung und sozialem Wandel. In *Technik als sozialer prozess*, ed. Peter Weingart, 174-196. Frankfurt aM: Suhrkamp

Weingart, Peter. (1998). Science and the media. *Research Policy 27*(8): 869-879.

Weingart Peter. (2012). The lure of the mass media and its repercussions on science. In *The Sciences' Media Connection—Public Communication and its Repercussions*, eds. Simone Rödder, Martina Franzen, and Peter Weingart, 17-32. Dordrecht: Springer

Weingart, Peter, Christian Salzmann, and Stefan Wörmann. (2008). The social embedding of biomedicine: an analysis of German media debates 1995–2004. *Public Understanding of Science*, 381-396. https://doi.org/10.1177/0963662506070188

Weigold, Michael F. (2001). Communicating Science. A review of the Literature. *Science Communication 23*(2): 164-193.

Østbye, Helge. (2008). The Norwegian Media Landscape. In *European Media Governance: National and Regional Dimensions*, ed. G Terzis, 157-168. Bristol: Intellect Books.

Åm, Heidrun, Gisle Solbu, and Knut H. Sørensen. (2021). "The imagined scientist of science governance." *Social studies of science* 51:2, 277-297. https://doi.org/10.1177/0306312720962573

Åm, Heidrun. (2019). Limits of decentered governance in science-society policies, *Journal of Responsible Innovation*, 6:2, 163-178, https://doi.org/10.1080/23299460.2019.1605483