The Physiology of Imagined Publics: From a Deficit to an Ambivalence Model

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Abstract

This paper draws on the concept of imagined lay persons (ILP) to investigate how scientists working in the fields of bio- and nanotechnology perceive the public and how these imaginaries facilitate or hinder engagement activities. Based on 37 in-depth interviews with bio- and nanotechnology scientists, I explore how scientists construct imaginaries of publics that may shape the ways in which they address the public, perceive the benefits of public engagement activities, and form communication strategies. The paper argues that scientists' accounts of the public are characterised by ambivalence regarding what the public is, the public's knowledge and the public's ability to take part in scientific processes. Thus, the paper proposes a more comprehensive approach to understanding ILPs than provided by previous studies, which have focused on the attribution of knowledge deficits and related fears of protest and resistance.

Keywords: imagined lay persons, deficit-model, public engagement

Introduction

Since the early 2000s, developments in European science policy discourses have shown increasing attention paid to science society issues. For example, the recent Framework Programmes have addressed such concerns. In Horizon 2020, this is articulated through the concept of Responsible Research and Innovation (RRI), which has become a major cross-cutting issue (see Felt et al., 2013; Felt and Wynne, 2007; Owen, Macnaghten and Stilgoe, 2012; Siune and Markus, 2009; Stilgoe, Owen and Macnaghten, 2013; Von Schomberg, 2011, 2013). This development in science policy discourse is not just talk. With the implementation of RRI as a main normative element in science governance, substantial interventions are expected in established research practice. To receive funding from Horizon 2020, all projects must, in principle, consider measures to involve societal actors in the research design and reflect on the potential implications of the project outcomes, in order to make science better aligned with the 'values, needs and expectations of society' (European Comission, 2016).

Thus, scientists are increasingly expected to incorporate public engagement and participatory activities in their research. This raises interesting questions regarding how scientists understand and interpret this requirement, including how they perceive the public and the public's capacity to engage with science. Such knowledge is needed to assess the viability of RRI. To help fill this knowledge gap, this paper introduces and applies new perspectives on the way in which scientists think about the public and public engagement in science.

Previous studies have shown that scientists tend to employ what is commonly described as a 'deficit model' in their accounts of the public's perception of science (Barnett et al., 2012; Besley and Nisbet, 2013; Heidenreich, 2015; Maranta et al., 2003; Walker et al., 2010). This deficit model is primarily a concept that signifies the widespread assumption of an epistemic divide between those who know – scientists – and those who do not – lay persons (Maranta et al., 2003). Thus, the public is seen to lack scientific literacy, and this knowledge deficit is considered the source of irrational and sceptical attitudes towards science and new technologies (Bauer, 2009). While the deficit model has been shown to produce a misunderstanding of the public's relation to science and scientific expertise, studies suggest that this way of thinking is widespread among scientists (Irwin and Michael, 2003; Irwin and Wynne, 1996; Wynne, 1992, 1995). This paper questions the role of the deficit model in scientists' accounts of the public and suggests a more diverse and complex understanding of them.

In the following, when analysing scientist's accounts of the public, I will focus on two main issues. The first is what 'knowledge' means in the context of scientists' ideas about the public's relation to science. Bruno Latour's (2004, 2008) distinction between 'matters of fact' and 'matters of concern' may be invoked to suggest what is at stake here. The concept of 'scientific literacy' – often referred to in relation to the deficit model – usually focuses on the need to understand matters of fact, such as elements of physics or chemistry (Bucchi, 1998). We should ask: to what extent are scientists concerned with scientific literacy, compared to wider aspects of science, such as values and impacts? The second issue is what 'participation' means in the context of scientists' ideas about the public's relation to science. The tenets of RRI push for an early integration of a wide range of societal actors into the research process. Previous research has shown that due to a deficit model understanding of the public's understanding of science, scientific institutions are reluctant to involve the public in scientific processes beyond communication activities and open up the research to public dialogue and deliberation (Marris, 2015: 85). Thus, it is pertinent to ask how scientists understand participation.

This paper investigates these two questions by exploring scientists' accounts of their research practices within the fields of bio- and nanotechnology in Norway. In the Norwegian context, bio- and nanotechnology are two fields that are of a special interest regarding science and society relations. Both bio- and nanotechnology are considered new enabling technologies. Consequently, they are ascribed great transformative powers and given an important role when articulating Norwegian sociotechnical imaginaries (Kjølberg, 2014). Because of this imagined transformative potential, these two fields have also gotten special attention from the Research Council of Norway regarding ethical, legal and social aspects (Nydal et al., 2016).

Through 37 in-depth interviews with scientists working within these fields in Norway, this paper studies the way in which scientists understand and construct images of the public. It analyses the main discursive dynamics in the scientists' imaginaries of the public, providing a more complex understanding that goes beyond the features of the deficit model. To clarify the theoretical point of departure, I introduce a more detailed analytical framework and explain more thoroughly the concept of 'imagined lay persons' (hereafter ILP) (Maranta et al., 2003).

Exploring imaginations – the public as a phantom

This paper's approach to the study of the science society relation is indirect. It does not study the public as a group of physical actors in concrete engagement activities, but turns the attention to scientists' imaginations of the public. Already in the pragmatist thinker Walter Lippman's (1925) work of the 1920s, we find a description of the public that focuses on aspects of imagination instead of physical appearance and utterances. He introduces the metaphor of the phantom, which has been used by Bruno Latour (2005) and Noortje

Marres (2005, 2007) to show the diverse ways through which the public is present in democratic institutions. Marres describes the 'ungraspability' and vagueness of the public as important characteristics of the public's agency. In her own words:

> In this way we may appreciate that ungraspability may be an aspect of agency and also that the agency of rather ungraspable entities may make things happen that wouldn't otherwise. We then say that what makes a public such a special agent is that when specific actors get organized into one, they may evoke the anonymous, collective, virtual, somewhat mysterious creature we call public. And maybe it is precisely in this capacity of a phantom that a public may generate that virtual, somewhat mysterious thing called 'pressure', which can then be directed at specific instances, to induce shifts in their habits, policies, regulations, commitments (Marres, 2005: 216).

Recognition that the public display such phantom qualities is important for my study in two ways. First, it means that we should acknowledge that the public always is present in some way – at least in an abstract sense. Accordingly, scientists have to position themselves in relation to the idea of the public, even when they are not directly involved in public engagement activities. Second, the recognition suggests the need to explore these imaginations of the public in order to understand how these imaginations may shape science society relations. Considering that the public exists in this mode of ungraspability has made others, such as Gottweis, Chen and Starkbaum (2011), pursue the task of giving flesh to the phantom. However, this paper's approach is different. It makes no effort to uncover the phantom, but explores the public, as it exists in the mode of the ghostly and omnipresent; as a mental construct of scientists.

While the metaphor of the phantom suggests that the public is vague and difficult to explicate – almost mystical – the concept of ILPs introduced by Maranta and colleagues (2003), aims at grasping and conceptualising the way in which these imaginaries inhabit and influence scientific practice. With the concept of ILPs, they present a main argument similar to Lippmann's. The public is not just taking part in and influencing scientific practice when they are engaged directly, like being consulted, invited to dialogue meetings or through participation in democratic decisions. The public also influences scientific practice, like through public pressure on specific lines of research, as an abstraction and mental construct of scientists (Marres, 2005).

In this paper, I employ the concept of ILPs to explore the practices of scientists. To do so, I link the concept to previous efforts to study technology and its users, and the way in which these users, consumers and the public influence the development of new technology. For example, Akrich (1995) and Woolgar (1990) studied how designers of new technologies imagine potential users and how they will make sense of and use their designs, applying these imaginaries when constructing or configuring new artefacts. In this manner, these studies show that the process of developing new technology is one in which future users and their use are constructed (Walker et al., 2010: 933). In this sense, technologies are always constructed from assumptions about future users and use, even if these assumptions turn out to be incorrect (Lie and Sørensen, 1996). In this sense, the public takes part in shaping technology (Bijker, 1995; Bijker and Law, 1992; Woolgar, 1990)

While Akrich and Woolgar studied technologies with a specific and targeted public, scientists' attentiveness towards the public may not be obvious with respect to basic research. However, Maranta and colleagues (2003) extend the argument of the public's influence from the explicit and physical to the abstract and imagined. This makes for an interesting progression of thought that ties the concept of ILPs to the study of imaginaries and their performativity. The latter field of study shares a focus on the performativity of discursive constructs. They may be collective visions, established and maintained in society in the broader sense and captured by concepts such as 'sociotechnical imaginaries' and 'folk theories' (Jasanoff and Kim, 2009; Rip, 2006) or strategies and objectives on a micro level, like those investigated through the sociology of expectations (Borup et al., 2006; van Lente, 2012). The main argument, also found in Maranta et al. (2003), is that discursive constructs, like imaginations and previous experience of actors and expectations of how they will behave, shape behaviour.

Still, previous studies of ILPs have focused mainly on fields of expertise that seemingly directly have implicated the public. Maranta and colleagues (2003) explored experts working in science centres, public consultations within environmental studies, and experts engaged in GMO regulation and labeling. In each of these case studies, orientation towards a particular public was prominent. In a similar manner, ILPs have been explored with regard to public acceptance of renewable energy technologies; for example, in studies of scientists' imaginations of the public attitude towards offshore windmills and the influence of this perception on decision-making (Burningham et al., 2015; Heidenreich, 2015; Walker et al., 2010). This body of work has shown that ILPs can fulfill a functional purpose in the interaction between different knowledge communities (Maranta et al., 2003: 150). ILPs have been shown to influence the way in which scientists address and communicate with the 'real' public as well as the issues that receive research attention. These studies have highlighted differences in capabilities in the expert public relationship. While these studies offer valuable insight into scientists' imaginations of the public on specific scientific issues and their imagined differences between experts and laypersons, we need a more comprehensive approach.

In this regard, the work of Sara Heidenreich (2015) may serve as a stepping-stone. While she, like previous studies, identified a deficit model in scientists' accounts of the public, her findings expose ambiguity regarding the extent to which this imagined knowledge deficit actually was a concern. Actually, the dominant narrative of the interviewed scientists was about a positive public. However, there was also a continued presence of narratives of irrational public resistance, based on a kind of cultural pessimism. Furthermore, Heidenreich (2015) observed a disembedding of the technology under development, which rendered public engagement less relevant.

This paper follows Heidenreich's lead, but further questions common assumptions about the appropriateness of the deficit model as way of making sense of scientists' accounts of the public and what these accounts suggest regarding the shaping of research and innovation. This means to go beyond the belief that such influence is the result of a physical presence, for example, when public engagement activities are implemented in research projects. First, the paper analyses the public's role in scientists' work as "conceptions of lay persons as they are manifested in the products and actions" (Maranta et al., 2003: 151) of our interviewees. What is the content of these imaginaries? Second, it studies what it means to argue that these mental constructs should be considered "just as much an artefact of the knowledge production as is the more technical part of the solution proposed" (Maranta et al., 2003: 151). Third, previous studies of ILPs have shown that scientists tend to employ a deficit model in their accounts of the public. Following Latour's (2004, 2008) clue regarding the distinction between what he calls matters of fact and matters of concern, this paper explores the gains of transcending the common focus on knowledge primarily as scientific literacy. Are there other accounts of knowledge and participation that shape scientists' interpretations of the public's understanding of science and the public's ability to take part in research processes?

Methodology

The three above-mentioned research questions are pursued drawing on semi-structured in-depth interviews with 37 scientists. The interviewees were selected to cover five field sites within what can broadly be defined as nanotechnology and biotechnology: 1) nanomedicine (five interviewees), 2) genetic medicine (nine interviewees), 3) synthetic biology (seven interviewees), 4) nanomaterials in energy research (seven interviewees) and 5) other fields (nine interviewees). The fifth field site was labelled 'other' because those interviewees worked on projects topics that clearly were related to either bio- or nanotechnology, but did not quite fit into the other four field sites nor constituted another well-defined category. Within the five sites, interviewees were chosen to cover a range of academic positions, varying from PhD research fellows to senior scientists, research group managers, and professors. All were working in Norway, at a university, a private research institute or a biotech or nanotech start-up company.

Table 1. Interviewees categorised by field site, interview number, academic position and gender.

Field site	Interview nr.	Academic position	Gender
Nano-medicine	NMIW3	Professor	Man
	NMIW6	Professor	Woman
	NMIW13	Post-Doc	Man
	NMIW19	PhD research fellow	Man
	NMIW22	Researcher	Woman
Genetic medicine	GMIW10	Professor	Man
	GMIW15	Professor	Man
	GMIW16	Professor	Woman
	GMIW17	Professor	Man
	GMIW18	PhD research fellow	Woman
	GMIW28	Professor	Man
	GMIW30	Professor	Man
	GMIW36	Professor	Man
	GMIW37	Professor	Man
Synthetic biology	SBIW7	Professor	Man
	SBIW8	Associate professor	Man
	SBIW12	Researcher	Man
	SBIW20	Professor	Man
	SBIW26	Researcher	Woman
	SBIW31	Associate professor	Man
	SBIW32	Associate professor	Man
Nano-materials in energy	NEIW2	PhD research fellow	Woman
	NEIW4	PhD research fellow	Woman
	NEIW5	Researcher	Man
	NEIW24	Professor	Man
	NEIW25	Post Doc	Man
	NEIW34	Professor	Man
	NEIW35	Researcher	Man
Other fields	OFIW1	Professor	Man
	OFIW9	PhD research fellow	Man
	OFIW11	Professor	Woman
	OFIW14	Professor	Woman
	OFIW21	Researcher	Man
	OFIW23	Professor	Woman
	OFIW27	Post Doc	Man
	OFIW29	Researcher	Woman
	OFIW33	Professor	Man

Table 1 shows the selection of interviewees categorized by interview number, field site, academic position and gender.

All of the interviews were conducted individually and lasted 40 to 110 minutes, most lasting just over 60 minutes. 25 interviews were undertaken by Dr. Heidrun Åm and the author together, Dr. Åm did four interviews singlehandedly, while the author did eight. The interviews were conducted as part of the project "Performing ELSA - Governance of and governmentality in biotechnology and nanotechnology research", with Dr. Åm as project manager. However, the analysis has been conducted by the author.

The interviews took place at a location chosen by the interviewees. All but one gave permission to audio record the interview. In the case where permission was not given, the interviewers took written notes during the interview and wrote a rich synopsis immediately afterwards. The recorded interviews were transcribed and all interviewees were made anonymous. Then, we categorised them according to their respective field sites and provided an identification consisting of a unique number and two-letter abbreviation to identify their field site. Nano medicine was shortened to NM, genetic medicine to GM, synthetic biology to SB, nanomaterials in energy research to NE, and other fields to OF.

A central feature of the research design was that the topics we explored during the interviews were aimed to uncover the scientists' perception of the public and public engagement activities. In addition, we also inquired about how the scientists situated their research within a societal context and about what they experienced to be ethical, legal and social aspects of their work. In this way, the interviews generated accounts of the public that related to the scientists scientific work in specific and the public's scientific literacy. They also provided views regarding the publics' participation in science within a broader context and related to a more comprehensive understanding of knowledge than just scientific literacy.

I have analysed the data in three stages, inspired by an abduction-oriented form of grounded theory (Charmaz, 2006; Reicherz, 2007). This means that the analysis drew on the theoretical approach described in the previous section, which played an important part in structuring the interview guide, but also that empirically grounded concepts were developed continuously from the interview data. The choice of a grounded theory inspired methodology was based on the explorative nature of this analytical approach, and the wish to develop novel theoretical insights that was grounded in the empirical material. However, the approach also has its limitations. Grounded Theory inspired approaches have been argued to obscure the researcher's embeddedness and agency in the data interpretation. It was thus important to create awareness, and reflect upon my own position as a researcher during the analysis (Olesen, 2007). This was stimulated through the discussion with my collaborators in the project.

The initial stage of the analysis involved thematic coding of the transcriptions to identify statements and arguments that were relevant to the topic of imagined publics. This coding was conducted using the qualitative analysis software Atlas.ti. Following the coding, summaries of each interview were written, including all relevant quotes from the transcripts. While the interviewees had been selected to cover the five previously mentioned field sites, this initial stage of the analysis clearly showed that there were no remarkable differences between the groups. Thus, after this stage the interviewees were treated as one group in the analysis. In the next stage, a second round of coding was carried out in Atlas.ti; this coding was restricted to the interview summaries and paid greater attention to details in order to further explicate the findings of the initial round of coding. This final set of codes formed the basis of a matrix of all 37 interviewees, in which they were grouped according to their respective field sites. Then, each individual was linked to relevant information based on the interview transcripts. This systematisation helped identifying patterns of similarity and difference across statements and arguments, both within and between field sites. In the third and final stage, a final investigation of the full transcripts was conducted to contextualise and further enrich the preliminary findings.

The physiology of ILPs

How did the scientists imagine the public? In the following analysis, the concept of physiology is used as a structuring device. Within biology, a schoolbook definition of physiology refers to the dynamic and organic processes that take place within an organism (Physiology, 2014). Here, the organism studied was the ILPs, and their physiology includes the main discursive dynamics that the interviewees used in their accounts of the public. The use of the concept of physiology is with this respect intended to underpin the dynamic and procedural character of the ILPs' constituents. The term 'main discursive dynamics' refers to the recurrent core themes that the interviewees talked about when they were inquired about their views of the public. In the ILP physiology as it emerged from the analysis, I identified three main discursive dynamics: (1) knowing, (2) trusting, and (3) enabling. In the following, I elaborate in turn on these three dynamics.

Dynamic 1: Knowing

In line with previous research (Barnett et al., 2012; Heidenreich, 2015; Walker et al., 2010), (not) *know-*

ing was identified as one of the main dynamics in the interviewees' constructions of the public. This was considered a key aspect in shaping public attitudes. In other words, the interviewees' imaginations of the public's knowing partly overlap with the previously highlighted deficit model. The following example provides an illustration of this. One of the interviewees made a direct link between the public's low level of knowledge regarding his field of research and the public reluctance towards the new technologies he was developing and using to do genetic research. He had experienced the public to be sceptical towards the use of genetic modification techniques. In the interview, he talked about the difference between old methods of genetically enhancing agricultural products, and what was now possible through new techniques of genome editing. He also expressed his belief that if the public only knew about the advantages of this new technology, they would be positive:

> We actually do the same. We don't use radiation but we introduce exactly the same mutations but we do it selectively, so in this way I think if people become aware of that difference it could be that they after a while will change their attitude, but I think we have a long way to go. (SBIW32)

This line of argument was echoed among other interviewees who similarly experienced some degree of reluctance towards their work. If the public had sufficient knowledge, they would change their attitude. While scientific literacy was discussed as a key aspect in shaping attitudes – something that could suggest the need to initiate public educational campaigns – the scientists were still, in general, quite relaxed about this lack of knowledge. Their imagination of the public's inability to understand complex scientific matters seemed to curb pro-active communication strategies and efforts to inform the public about their research. An interviewee who was involved in a basic science project with the objective of developing new nanomaterials for fuel cells explained:

> One of the most difficult things we do is to explain things so that the world out there understands it, without lying I mean, without exaggerating, so […].We have to simplify it to such a degree that it usually becomes pointless to describe it, but anyway, we have to do it. As an example, I now work with fuel cells, but that is not the fuel cells that will be used in actual cars, but I have to jump that stage, because it is not in the interest of the general public to know. I work with fuel cells, and those cars will get here, that is how simple we put it. (NEIW34)

As this quote highlights, there is an obvious and expected epistemic gap between the knowledge of the expert and that of the lay public regarding scientific matters. However, it is important to stress that often, the scientists did not believe that this gap could be bridged. Rather, the scientists emphasised the difficulty in bridging it, as in the following quote. Here, a scientist working within molecular biology talks about how specialised her field is, and what is required to develop scientific skills.

> GMIW23: […] it is so specialised, that we know almost nothing about each other's fields, like... we have some general knowledge, but when it comes to the specific topics, it is very specialised.
> Interviewer: Do you think the public should know more?
> GMIW23: That is impossible because it is necessary to have five to six years of education to learn this, so that is not something you can expect. (GMIW23)

Thus, while the public's knowing – in terms of scientific literacy – was imagined to involve misconceptions and in some instances to cause reluctance towards new technologies, this knowledge deficit was not a major concern for the scientists.

While a knowledge deficit often was recognised when it came to scientific matters, this was not the only kind of knowledge that concerned the scientists in their imagination of the public. The scientists were also interested in how the public understood science as part of social development in general. For example, this was articulated by one of the interviewees when he explained why it was important for science to receive positive and contextualised media coverage:

> I think that it [positive media coverage] is very beneficial, because then the public is able to understand the benefits and understand that we try to solve big social challenges that lie ahead of us. (NEIW24)

In this regard, the fact that interviewees point to the public's understanding of the social context of science, questions the role of the deficit model in scientists' accounts of the public's understanding of science. Foremost, previous studies of ILPs have paid attention to how public knowledge, understood as scientific literacy, was imagined. In our interviews, we found in addition that a more general kind of knowledge was made essential in the scientists' accounts. This knowledge was about the social context of science, including wider aspects, such as science's impact on social development and values.

This is related to but not identical with what Latour (2004, 2008) calls matters of concern, because it refers to processes as well as the content of a particular way of public understanding of science. I propose the concept of 'epi-knowing' to characterise such knowledge and the process of gaining knowledge about matters of concern. The prefix 'epi' is here derived from the Greek preposition π, meaning 'nearby'. Regarding the scientists' accounts of the public, just like circles around an epi-centre, epi-knowing is the knowledge and competence that the scientists ascribed to the public regarding matters of concern; that is, in relation to more general issues that are situated outside the core scientific tasks of their daily practice.

The scientists' differentiation between the two kinds of knowing also meant that their beliefs about the public's attitudes and abilities varied according to the kind of knowing they were talking about. When it came to epi-knowing, the scientists' attitudes regarding the public often changed from exclusion to inclusion. With respect to such concerns, their imagined public had or could acquire relevant knowledge and competence. In this regard, the public's knowledge directly or indirectly was considered to influence the development of science through the priorities of political institutions and funding agencies. One of our interviewees talked about how he felt that institutions such as the Research Council of Norway were good at deciding what kind of research that would benefit Norwegian society. Thus, he felt that the direction of science should be a political decision:

> Like, overall, I guess the research council in Norway in a good way directs research that is useful for society. If you look at their programmes, they seem to be very relevant for the future, and what happens, and what could be problems that are arising in the future. (SBIW8)

Many of the scientists – while protective and excluding with regard to their own work – still imagined that the public played a part in the development of science at a general level. Further, they imagined that the public's epi-knowing shaped research priorities. This expressed a change of subject position for the scientists, compared to their subject position when imagining the public knowledge in terms of scientific literacy. Talking about scientific literacy, the scientists established a gap between themselves and the lay public, excluding the public from scientific procedures. However, when talking about issues of epi-knowing, the scientists actually situated themselves within the public, sharing social concerns and responsibility for scientific developments:

> I think that everybody who works with molecular biology, and also molecular medicine like we call it, are like every other human being. We are often husbands or wives, and often have children and we live in society. I am not a molecular biologist, like, I am a human being that works with molecular biology […] Of course you take part in society in the same way as everybody else, and not like an eremite. Me too, I want society to develop in a direction which is to the best for its citizens. (GMIW10)

To summarise, in the analysis of the interviews, I identified an imagination of the public that fitted well with the deficit model, wherein attitudes are linked to the level of scientific knowledge and scientists establish a gap between themselves and the public. However, another kind of knowing also emerged from the analysis of the scientists' account of the public. When scientists talked about what I call epi-knowing, the understanding of the social context of science, they created a common ground between themselves and lay people. Moreover, they imagined the public epi-knowing as a legitimate contribution within the broader scientific domain.

Dynamic 2: Enabling

The scientists' distinction between knowing and epi-knowing also influenced their imagination of the public's agency – that is, the public's ability to take part in and shape scientific trajectories. This is what I call the imagined *enabling* of the public. In this regard, the scientists made important distinctions between certain aspects of scientific conduct. When talking about how they imagined the public to take part in and contribute to research, the scientists ascribed varying degrees of agency depending on whether they were talking about their own specific research projects or the general development of science.

With respect to their own projects, very few of the scientists had any concrete experience in engaging with the public, and many argued that the public's ability to contribute to their work was very limited. In contrast to a main tenet of RRI, they could not understand how lay people could contribute to projects that required a high degree of expert knowledge:

> It's just talk [the policy of public participation]. It's just […] totally pointless, right? But, we very much want to open up our research in the sense that we want to explain what we do and why we do it, and the patients love us, so that is a very enjoyable task. But, that the patient should influence our research to make it better? They don't understand what we do, right? […] I can't imagine what they could contribute that would make us better at doing science, that I just have to say. It's perhaps a bit arrogant. (GMIW)

It is important to stress that often, the scientists' experienced their own agency also to be low. Especially those working within basic research described the scientific endeavour as unpredictable and difficult to direct towards a specific objective. The scientists worked within long timeframes. They were engaged in developing new knowledge that they did not expect to have any impact for maybe 20 to 30 years. Further, the interviewed scientists had difficulty specifying exactly what kind of impact this would be. Those doing basic research found it difficult to locate any legitimate space for lay involvement or engagement. They claimed actual scientific work was the only thing that could affect science in such early stages. One scientist, working in the field of synthetic biology, specialising in mutations in bacterial DNA, explained this position as follows:

> I have a problem understanding the things that I do and I don't expect, I mean WHO should come and tell me what to do while I have trouble understanding how these things operate […]. The things that we do, are […] not direct consequences of logical thinking. There is a lot of things that you just stumble across […] and this is due to intensive work […]. You never know what the outcome will be. (SBIW12)

Such imagination of agency, 'the slight surprise of action' (Latour, 1999: 266), in basic research seems to exclude the lay public. However, just as we saw that there were two different ways of understanding knowledge in the scientists' accounts of the public, they also displayed different ways of understanding agency. Their imagined public was considered able to contribute to the research process when they could be addressed as experts who could contribute specific knowledge, such as information about being a patient. Most important, the public was imagined to have a strong influence on the general development of science, due to their epi-knowing regarding science. When asked about how they imagined the public to contribute to their work, many scientists spoke about indirect participation, claiming that the public was already involved in discussions about science, at a general level:

> We do that [include the public] … but it's just that it's with respect to political decisions, it is the political parties that have the power and that people vote for. (NEIW24)

The interviewed scientists experienced their own research largely to be directed by research programmes and political decisions. In this way, they emphasised that society ultimately was 'the boss' (SBIW8). If the public was not considered part of the scientific process, per se, it was represented through the work of political institutions and funding agencies. One scientist, working on a basic research project to which she could not imagine any contribution of lay knowledge, stressed that the fact that this indirect participation existed was important to legitimise why they did not engage directly with the public. Accordingly, she explained that her supervisor had argued that "the public's needs, indirectly, are taken care of by the EU and the requirements of the research council [of Norway], that is supposed to be for the best of society" (NEIW4). However, the scientists did not reflect upon any limits to decision–making representative democratic processes may have when it came to dealing with complex socio-technical issues.

To summarise, when it came to actual scientific work, the public was imagined to have a low level of agency. The public was only imagined to be useful and contributory in relation to technologies that were close to application (about which the public could be consulted as users and consumers) or in medical research projects (wherein the public could be consulted as 'experts' on being a patient). However, the interviewed scientists thought that the public had a strong influence on the development of science through indirect participation as such as citizens electing politicians.

Dynamic 3: Trusting

The third and final main dynamic identified in the scientists' ILPs was *trusting*. For those working in fields that were somewhat controversial, such as genetic medicine, public misconception of their work was a real concern. One scientist working with DNA sequencing was nervous that lack of trust and misconception among the public could result in limitations on her own research. She argued that it was difficult for scientists to gain an authoritative voice in the public debate, and felt that research and development always were in danger of being misinterpreted. In the interview, she elaborated this point by explaining why she had been anxious before an interview with a national newspaper about a major breakthrough in her research:

> This technology [DNA sequencing] has (…) sometimes been given a very negative spin because it is the same technology that they use to check for, that you now can use to check the embryo if a child will develop Down's syndrome or not. So you can use it as an example in the debate about aborting embryos that will develop such diseases, and many of these kinds of negative debates, so everything has been mixed up together to a mishmash of a debate. And we who are engaged in this we just stand here and are frustrated, because everything is mixed up. (GMIW18)

Her imagined lack of trust in her scientific authority among the public made this interviewee attentive towards the communication of her work. She perceived the public as an obstacle because of the concern that possible misinterpretation could give her work a negative spin. The resulting public reluctance and mistrust could, she feared, lead to new regulations:

> If this technology had gotten very negative coverage, only negative coverage, then in worst case scenario […] it won't happen, but it could have been made illegal. (GMIW18)

Interviewees working within fields experienced as controversial were concerned in similar ways about public misinterpretation and mistrust. However, the dominant account was of a public that was trusting. The majority of the interviewees imagined a public that supported their work as scientists and believed that the public believed science contributed to solving social challenges. This perception of a trusting public is supported by a 2010 Eurobarometer survey on biotechnology that shows a very high degree of trust in scientists and university employees among Norwegian citizens (European Comission, 2010).

The belief in a supporting and trusting public was especially common among the interviewed scientists working with medical research. When asked about how she believed the public perceived her work, a scientist who had developed a new nano medical device answered as follows:

> I've not met anybody that has been critical towards it [my research], not a single person, and I'm actually a bit surprised by that because I'd actually thought that I should meet more [critical attitudes]. But everybody's really like, yes, continue with it, work with cancer research, do anything you want, just solve it. (NMIW22)

This quote illustrates a recurring narrative in the interviews: society is faced with a problem that science must try to solve, and in this process of problem-solving, scientists are trusted to do their best. Furthermore, in the accounts of trusting, scientific literacy was seldom a central element. Rather, the interviewees believed that the crucial issue was a shared interest in the outcome of scientific efforts. One scientist, who developed personalised cancer treatments, told that he was dependent on using biological material from cancer patients in his research. He explained that almost everyone agreed to participate in his studies, but he did not believe that they fully understood what they were agreeing to. The science was complex and difficult to explain, but the patients were often in a vulnerable position. He thought they agreed because they wanted research on their disease to progress, and they trusted the scientists to do their best:

> So I think most of them give their consent on a weak foundation. It's just a declaration of trust, end of story. They say that it's great, "I'm so happy that you are treating me, please, do research on my samples, it's all fine." (GMIW30)

A trusting public was considered important for recruiting participants to research, but it was also presented as a core motivation for doing science. The scientists explained that their experience of a public that trusted in science and believed in its usefulness made their scientific work meaningful.

To summarise, the dynamic of trusting was crucial in the scientists' accounts of the public. Some scientists worried that misinterpretation of their research could cause scepticism and mistrust. However, this anxiety was only articulated among scientists who worked within fields that were experienced as controversial. The majority of the interviewees imagined a trusting public. Moreover, this trust was considered crucial in establishing a legitimate space for the scientists to work as well as providing an important motivation for doing science.

Conclusion: the ambivalent imagination of the public of science and the importance of epi-knowing

This paper started from the observation that previous studies have argued that scientists tend to employ a deficit model in their accounts of their public and the public's ability to engage and participate in scientific processes (Barnett et al., 2012; Besley and Nisbet, 2013; Heidenreich, 2015; Maranta et al., 2003; Walker et al., 2010). Lack of scientific literacy has been considered to produce scepticism and resistance. My aim was to critically investigate the role of the deficit model in scientists' imaginations of the public. Inspired by the insights of Heidenreich (2015), I asked first about the content of these imaginaries. Second, I was concerned about what it means to argue that such mental constructs should be considered as emerging from the process of producing scientific knowledge. Third, I wanted to explore the gains of transcending the common focus on knowledge primarily as scientific literacy.

To begin with, this paper has shown that knowledge deficits definitively are features of the imagined public of scientists working within the fields of bio- and nanotechnology. Some interviewees linked a lack of scientific knowledge to sceptical attitudes toward science, but the most important effect of such deficit thinking was that scientific illiteracy made it pointless to include the public in research – in particular basic research characterised by uncertainties and 'slight surprises of action'.

However, as expected, the issue of ILPs turned out to be more complex among the scientists interviewed. I referred earlier to the concept of a phantom public, taken from Walter Lippman and employed by Latour (2005) and Marres (2005, 2007). This concept proposes that the public of science is what Marres (2005: 216) calls ungraspable and vague, leaving scientists to be puzzled. However, the findings in this paper suggest that ambivalence is a more adequate term than perplexity when we inquire into the "physiology" of ILPs. To the interviewed scientists, their imagined public is not an ungraspable but an ambiguous entity.

Exploring the ILPs of the interviewees, the paper identified three dimensions of the ambivalence of scientists: (1) knowing, (2) enabling, and (3) trusting. With respect to my research questions, first, they represent a way of describing main aspects of the content of these imaginaries – what I called the physiology of ILPs. Second, these dimensions as I have described them clearly show how mental constructs like ILPs intimately are linked to interviewees' understanding of the process of producing scientific knowledge. Third, as I will show in the rest of the conclusion, they provide tools of transcending the common focus on knowledge primarily as scientific literacy.

With respect to knowing, a deficit in the public's scientific literacy was acknowledged and also imagined to potentially cause reluctance. However, the interviewees did not expect to find – nor did they ask for – a high level of scientific literacy regarding their research topics. They were more concerned that the public should understand the social context of science and its contributions to society, that the public was engaged in what I call epi-knowing. Furthermore, most of the interviewees thought the ILPs' level of epi-knowing was satisfactory. The scientists experienced the public's knowledge relating to matters of concern and wider aspects of science, such as its value and impacts, as providing support for their research. With respect to epi-knowing, the epistemic split between the scientists and their ILPs regarding scientific literacy was dissolved. Everybody, also the scientists, were considered to be citizens.

Concerning the second dimension, enabling, the attention to epi-knowing was central in the scientists' understanding of the public's agency and, accordingly, the public's participation and engagement in science outside the core tasks of daily scientific practice. The interviewees, above all those engaged in basic research, argued that direct public participation in their work was of little relevance because of their own limited agency and the public's lack of scientific expertise. Even these scientists considered themselves unable to predict how their work would develop.

This was considered different when the focus was on epi-knowing and consequently on the context of their research. This context included issues like prioritising and funding of science, what we could call the policy dimension of the science society relationship. In this arena, the public was considered legitimate decision-makers; citizens with agency, for example with respect to voting.

The third dimension of ambivalence was trusting. Trusting was seen as a precarious quality of ILPs because it generated support for science but also because is motivated the scientists to do their research. The interviewees thought that a trusting public presupposed proper communication of scientific objectives and a common understanding of values and impacts; that scientists and the public shared epi-knowing with respect to science. There was also a widespread belief that the ILPs actually were trusting science and scientists.

The interviewees of this study were scientists working in Norway, thus also talking about their relation to a Norwegian public. This may limit the generalization of our findings to science society relations in other countries. However, as shown by Davies and Horst (2015), the language of RRI has an international character, and the EU funding system has a strong position in the dispersion of RRI measures. This means that scientists in several European countries now face similar demands of engaging with wider set of societal actors. The ambivalence model thus may hold potentially important lessons with respect to RRI and the changes in the science society dialogues required by this policy programme. We have seen that scientists strive to uphold their autonomy and engage in boundary work in a way that seems to counter basic RRI ideas of public participation (Gieryn, 1983). However, this position should not be confused with arrogance and lack of reflection. Rather, what is articulated is a high degree of ambivalence regarding what public engagement is supposed to be. This ambivalence should be considered carefully and not be dismissed as just another articulation of the deficit model.

As noted previously, the deficit model links lack of scientific literacy to scepticism and distrust in science. The findings in this paper as well as in Heidenreich (2015) suggest that many scientists do not see this link when describing their ILPs. Furthermore, as Alan Irwin (2014) argues, we should not dismiss that there are knowledge deficits and that such deficits are performative with regard to public participation. Instead, we should notice how the interviewed scientists point to epi-knowing as a common ground, an Agora (Nowotny et al., 2003) where science society dialogues may be performed to explore the context, values, and effects of research efforts. An interesting example of such dialogue is the Dutch initiative to involve the public in carving out the trajectory of the national research agenda. Through a national survey, the Dutch population was asked to submit questions about what they believed were important issues that their national research programmes should address. The project received 11 700 submissions which were used as a starting point to formulate research priorities (Dutch national research agenda, 2016).

With respect to the role of epi-knowing in science society dialogues, it is important to note how in such contexts scientists draw on their identity as scientists as well as multiple other identities – as parents, as caretakers for their students and, most importantly, as common citizens (see Merton, 1976). Perhaps the demands that scientists face – for example, through RRI – expand their roles and responsibilities in such a way that their conflicting positions become more evident?

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