On Reflections and Reflexivity: Unpacking Research *Dispositifs*

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Abstract. Science and Technology Studies (STS) scholars increasingly engage with science and technology (S&T) practitioners, scientists, engineers, and the like. The actual dynamics of these engagements differ from one project, framework or school to the next. However, to be reflexive, such engagements need at some point to deal with the ambiguous relationship between 'engager' and 'engaged'. In an attempt to disambiguate these interactive ties, this chapter takes inspiration from Vinciane Despret, a philosopher of science who has provided ethnographic studies of ethologists. It specifically draws on two of Despret's arguments about experiments on animals, more precisely rats, and the paradoxical relationships to which they give rise. By means of analogy, it then illustrates the similar ways in which we, as STS scholars, might happen to frame our interactions with S&T practitioners. It argues that any experimental research *dispositif* necessarily implies a specific relationship dynamic with whoever is engaged. This should not be considered as an obstacle, but instead an opportunity for learning—yet only if the *dispositif* is open to protest. The analysis here took shape during an engagement study conducted at a large-scale R&D center in Flanders, Belgium. It is informed by ongoing involvement in a broader research project (STIR) that aims at fostering reflexivity among S&T practitioners.

Keywords. Reflexivity, Dispositif, Engagement.

Introduction: STS scholars engaging with practitioners

In his 2001 presidential address at the 4S annual meeting in Cambridge, Massachusetts, Wiebe Bijker, who pioneered the social constructivist approach to technology (Bijker et al. 1987; Bijker 1995), described a threefold agenda for Science and Technology Studies (STS). One segment of this agenda was about intervention. Bijker called for further "in-depth SSK [sociology of scientific knowledge] types of case studies, at a micro level if you wish", because "only through such studies are the detailed insights gained that form the necessary basis for addressing the larger issues". It is, he argued, "a way for individual STS researchers to conduct *political interventions*" (emphasis added). He dubbed this form of intervention the "STS kiss", in the sense that actual engagement with science and technology (S&T) practitioners may generate greater awareness on all sides about the qualities of scientific and technological cultures. Bijker has provided evidence from two empirical case studies he conducted, arguing that intervention results from "mirroring" STS-like analysis to the actors: "Seeing themselves in these new ways may lead to self-conscious changes in behavior" (Bijker 2003, p. 446).

The goal of reaching such self-awareness among S&T practitioners is quite ambitious. It resonates with the discourse on "integrated knowledge", a kind of co-produced knowledge that transcends disciplinary boundaries. In this chapter, I unpack how the commitment to "integrated knowledge" happens to play out in practice, especially when aiming to deliver the "STS kiss" to practitioners. As it turns out, increasing the reflexivity of the actors themselves seems a privileged option for achieving more socially desirable outcomes (Barben et al. 2008). After challenging the contested meanings of "reflexivity" in the SSK tradition, I focus on actual means of translating such a concept into practice. At some point, it does require some form of interaction, which necessarily leads to a paradoxical relationship between the STS "engager" and the "engaged" practitioner. Using arguments from the philosopher of science Vinciane Despret, I address the frame of such interactions and why it matters. The second part of the chapter, I engage with the paradoxes and ambiguities of these interactions. In the third part, I briefly suggest productive ways to overcome potential shortcomings.

1. Dealing with nanotechnologies

1.1. From new commitments to integration

This approach has attracted much interest in the community of STS scholars. It takes place within larger shifts of the relationships between policy, science, and economics, a somewhat new "mode of knowledge production" (Davies et al. 2010, p. 2; Nowotny et al. 2001; 2003). These processes of (re-)configuration allow space for STS interventions at some point. But the increasing involvement of STS scholars is directed by a desire to not only "deconstruct" or describe, but also to actively engage in the "policy room" (Webster, 2007). Intervention into actual decision-making processes is legitimated and promoted through agendas for social sciences (Macnaghten et al. 2005). Following this evolution, many STS scholars are now willing to commit themselves to push forward a particular interventionist agenda, such as "sustainability", "responsibility" (Ferrari 2010), or "reflexive governance" (Voss et al. 2006).

In the particular case of nanosciences and nanotechnologies, it is assumed that such a challenging commitment should happen at an "upstream stage" of development, while the technologies is still in its infancy (Macnaghten et al., 2005; Rogers-Hayden and Pidgeon 2007). It is yet unclear which are the exact ways to materialize and/or operationalize this commitment. However, most of the actual possibilities in this respect can be understood in terms of the "anticipatory governance of nanotechnologies", a research agenda that encompasses foresight, engagement and integration (Barben et al. 2008). This chapter deals with the latter figure of intervention, "integration". As Loibl puts it, as part of a genuinely reflexive governance process, "The integration of academic knowledge with knowledge from practical actors has special relevance, because problem definition, goal formulation and the development of strategies include normative assessments" (Loibl 2006, p. 307).

According to Barben et al., "sociotechnical integration" is meant to build societal knowledge (for instance, issued through foresight or engagement exercises) "into ongoing sociotechnical processes to shape their eventual outcomes" (2008, p. 988). To them, integration occurs by means of extended or, say, political ethnographies. Through such engagements, a genuinely integrated knowledge could be achieved

among the community of nanoscientists. Integration, as it were, would "develop the capacity of nanoscientists to reflect on the wider societal dimensions of their work" (Barben et al. 2008, p. 988). This idea echoes Collins and Evans' call for a third wave of science studies (Collins and Evans 2002). It basically states that the active co-construction of a shared kind of knowledge could be, and should be, pursued among different "categories of expertise". In this perspective, when it comes to nanotechnologies, the confrontation of different cultural perspectives leads to the shaping of "trading zones". Such trading zones are interdisciplinary in character, confronting for instance scientists, engineers, ethicists, and social scientists (Gorman et al. 2004). In addition, nanotechnologies present complex and multidimensional disciplinary issues (Wienroth 2009), which would make them more likely to integrate different disciplinary perspectives, including those of the social sciences and humanities. In any case, it is now clear that "integration", independently of how it is considered, implies a particular dynamics of interacting with nanoscientists and engineers.

This trend toward "integrated knowledge" is not limited to academia anymore. It expands to policymakers and public policies. A significant number of policymakers have endorsed collaborative processes that can be characterized as "soft", as opposed to top-down "hard" policies. This move is part of the broader trend towards the "responsible development" of nanotechnologies. It results notably in actual policy mandates promoting in-depth interdisciplinary collaborations over social and natural scientists. For example, the U.S. 21st-Century Nanotechnology Research and Development Act of 2003 advocates the integration of "research on societal, ethical, and environmental concerns with nanotechnology research and development" (U.S. Congress 2003). More recently, the European Commission renewed its call for "integrating science in society issues" (European Commission 2007), which notably resulted in the "European Code of Conduct for Responsible Nanoscience and Nanotechnologies" (European Commission 2009). Moreover, the European Commission funded several research programs to explore a variety of paths for organizing responsibility (see also von Schomberg and Davies 2010), including a specific reflection from the Commission that focuses on the role played by scientists and engineers (von Schomberg 2010, especially pp. 61-62). In short, it is widely assumed that scientists and engineers may include broader societal dimensions or concerns in their daily practice through sustained interactions with scholars from social sciences and humanities, in a mutual learning process. This way, S&T practitioners would gain increased awareness of broader dimensions of their work, which would eventually contribute to better technological development and more desirable societal outcomes. In this respect, I take it that "integration" aims at rendering S&T practitioners more "reflexive". In such context, how do we define reflexivity? How do we realize "reflexive" or "integrated" knowledge, in practice?

1.2. On reflexivity and its uses

The theoretical concept of reflexivity has sustained longstanding debates in the sociology of scientific knowledge, from Bloor's principle of reflexivity to Bourdieu's late works. To start with, a broad array of literature in SSK struggled with the manifold meanings of "reflexivity", generally understood as a capacity to bend back on oneself. So it broadly implies a circular relationship between a cause and an effect. Such authors as Ashmore or Woolgar notably attempted to disentangle the various meanings

of the notion (Ashmore 1989; Woolgar 1988; 1991). They established an inventory that Lynch developed yet further (Lynch, 2000). If I were to locate this chapter within Lynch's categorization of reflexivity, I would argue that it deals with "methodological reflexivity", which brings into light the relations to the groups studied, namely S&T practitioners in this case (Lynch, 2000, p. 29). However, more generally, it echoes Garfinkel's ethnomethodological program that mixes up theoretical, substantive as well as methodological approaches to "reflexivity" (*ibid*., p. 33).

Obviously, most debates on reflexivity became contentious as they questioned the status of science and sociology. Bloor made a seminal argument for a general "principle of reflexivity", according to which sociologists' epistemological positions on science should be equally applied to sociology of science itself. Ashmore demonstrated it was hardly put into practice by SSK scholars, of what he terms the "tu quoque" arguments (Ashmore 1989). About twenty years later, Bourdieu was still making the same diagnosis that reflexivity is not taken seriously by SSK (Bourdieu 2001, pp. 41-43).[1] When reflexivity is pushed to its radical consequences, it could potentially affect the status of science itself and contribute to a widespread relativism—which Bourdieu strongly warns against. These passionate debates culminated in the so-called "Science Wars" of the late 1990s. It then cooled down and, as I would argue, lead to more cold-blooded, instrumental approaches to reflexivity that carefully escaped from overly focused empirical discussions, i.e. on interactionism or hermeneutics.[2] A move might have occurred back then toward a rather "systemic reflexivity" that "[identifies] reflexivity as an organizing principle in late modernity" (in Lynch's terminology; see Lynch 2000, p. 28).

One good example of this development that strives to *use* reflexivity is the move toward "reflexive governance"—a concept that obviously operates on much larger scales. Following Beck's seminal work on reflexive modernization (Beck 1994), an impressive body of literature developed around the concept of "reflexive governance". Typically, this concept is about "the organization of recursive feedback relations between distributed steering activities" (Preface in Voss et al. 2006, p. xvi). Stirling (2006) provides an effort to disambiguate the competing meanings of "reflection" and "reflexivity". Reflection, he argues, refers to a mode of representation where attention is paid to a "full range" of attributes, which somehow mirrors everything that possibly "lies in the field of view". Reflexivity, by contrast, goes beyond reflection insofar as it involves the self (self-awareness, self reflection), which necessarily leads to a diversity of perspectives and representations. The concepts therefore differ in two significant ways. First, reflexivity typically entails "social contingency", that is, "different disciplinary perspectives, institutional interests, cultural values and economic priorities" (and so do policy appraisals—Stirling 2006, p. 230). Second, unlike reflection, a genuinely reflexive approach deals with pluralism and uncertainties, so that "intrinsic indeterminacies" are taken into account. The idea of the self, or the transformation of the self, is core to the concept of reflexivity, as Bijker also suggests above. In this respect, I now discuss the actual design of interaction with S&T practitioners that seeks to achieve some level of increased reflexivity. I will argue that attention should be paid, whenever engaging with practitioners, to the actual implications of any particular mechanism, protocol, or means of interaction.

[1] Bourdieu made an explicit exception for Ashmore and Woolgar.

[2] At some point, reflexivity "turns back on" itself, leading to the potential "threat of infinite regress" (Ashmore 1989, p. 100 onwards). Pinch also identifies this danger to "turn, turn and turn again" in his thorough critique of Woolgar's "turn to technology" (Pinch 1993; Woolgar 1991).

1.3. How to interact? About research dispositifs

Each kind of experimental research setup implies or frames a specific kind of relationship, ambiguous and problematic as it may be, which deserves a fine-grained understanding. For this purpose, I draw on a critical analysis of research *dispositifs* provided by Vinciane Despret. As a philosopher of science, Despret is mostly known for her ethnographical studies of ethologists (scientists who study animal behavior). For example, she observed two scientists observing birds in the Negev desert, in Israel. The birds (Arabian Babblers) engage in very complex dancing movements, similar to a ballet, where one of the birds gets dangerously exposed to predators. Despret followed the two ethologists while they observed these Babblers, bringing to light what, in each scientist's view, made the birds interesting or not. In doing so, Despret made visible and perceptible the way these two scientists were interested in different interpretations of the birds. One of them offered a rather simple understanding of this complex behavior demonstrated by the Babblers, which he apprehended mostly in the terms of a struggle for domination. The second one was rather interested in testifying to the exceptionality of such a behavior, and consequently, he developed a far more sophisticated version of the birds' dances. In this sense, Despret underlines an *a minima* interpretation, which she distinguishes from a more textured one (Despret 1996). Through this critical perspective on how research is made, Despret teaches us the necessity of dealing with the complexities and ambiguities of any experimental research setup, what she calls a *dispositif*.[3]

The notion of *dispositif* certainly draws from Foucault's insights, as he popularized and contributed to the important success of this concept in social sciences and humanities. To him, the *dispositif* was foremost a network, a system of relations among heterogeneous elements (Foucault 1977, p. 299). Here, the focus is on one particular relationship dynamic, the one that exists between an STS engager and an engaged S&T practitioner. In this respect, I use Agamben's definition of the *dispositif*, as he understands it more broadly as "literally anything that has in some way the capacity to capture, orient, determine, intercept, model, control, or secure the gestures, behaviors, opinions, or discourses of living beings" (Agamben 2007, p. 31). This echoes Despret's conception of the *dispositif*. In her view, any situation where a scientist "interrogates" living beings stands as an "artifact". The living beings not only react to what they are being asked to do, they also actively interpret it and seek the most appropriate ways to answer it. As a matter of fact, any *dispositif* will *induce* some answers and foreclose some others (Despret 2009).

By means of analogy, it is interesting to apply this critical understanding of how research is made to the kind of relationships STS scholars are seeking to initiate with S&T practitioners. Of course, the actual dynamics of engagement differ from one project, framework, or school to the next. However, one might find it interesting to step back from the research engagement and think about the question: what do I ask or expect from the participants to this research? How could this induce specific answers, and exclude some others? Such reflection is important as, I argue, it allows for genuinely reflexive learning. This chapter focuses more specifically on two arguments from Despret, the ones published in her book *Penser comme un rat* (*Thinking like a*

[3] In this chapter, I'd rather avoid using the terms "apparatus" or "device", which are mundanely used to translate the word *dispositif* from French. Not only does Despret use this word in French, but I also understand the *dispositif* as being more inclusive in its scope than the apparatus or the device. Unless otherwise noted, translated quotations of Despret's French texts are my own.

rat) (2009) and her essay "Sheep do have opinions" (2005). Relying on Despret's two critical arguments, this chapter correlates them with the practical dimensions and implications of a particular research *dispositif*, which I engaged with throughout a five-month empirical study conducted in a large-scale R&D center in Flanders, Belgium (from February to June 2010). This study, as part of a larger collaborative effort called "Socio-Technical Integrated Research" (STIR), aims at fostering learning and enhancing the reflexive awareness of nanoscientists and nanoengineers.[4] The research here involved weekly interactions with two PhD students (one electrical engineer, one biologist) and bi-weekly interactions with two senior researchers (one chemist and one electrical engineer), in addition to pre- and post-engagement interviews with the research manager and other members of the team.

2. The constraining power of an experimental *dispositif*; or, how does the "subject" interpret expectations?

2.1. What am I being asked? Argument on ad hoc *answers to perceived questions*

We learn from Despret something about the constraining effects of any experimental setup, what she calls a *dispositif*, and the way experimental subjects answer according to these constraints or, rather, according to their interpretation of these constraints. A *dispositif* is "by nature artifactual" (Despret 2009, p. 33). Any experimental setup is designed in such a way that the experimenter actually expects a specific answer out of his or her research subject. In this respect, it "frames" the research more or less narrowly. Despret takes the example of the naturalist Jacob von Uexküll and his pioneering work with rats. Behaviorists put rats into labyrinths and measure the time they would take to establish a path through it. Hence, this process involves a neutral artifact (a labyrinth) suited for an abstract entity (a rat). Von Uexküll made this picture a little more complex by adding to it the notion of *Umwelt*, understood as a whole living organism in relationship with its *milieu as experienced*. For not only do the rats perceive the material environment that surrounds them through their sensorial organs, but they also invest it with different meanings, and they interact with this whole perceived environment accordingly. Despret relies on this notion of *Umwelt* to show the way in which the rat "makes world" of what surrounds it, not only passively but also actively, through the active construction of a particular meaning in relation to its material environment. It populates its *milieu* with perceptive objects (Despret 2009, p. 29). Only by considering what the rat perceives, or how it "makes world" out of a *dispositif* such as a labyrinth, can we attempt to answer the question of what a labyrinth *really* means to the rat.

In this particular sense, the notion of *Umwelt* would look more like "reflexivity", as defined above, than mere "reflection". It is about the rat itself diving into a whole new environment and trying to make sense out of it. On the one hand, this *Umwelt* implies some degree of reflexivity as it involves an *act of perceiving*, rather than a

[4] Socio-Technical Integrated Research (STIR) is a project lead by the Center for Nanotechnology in Society at Arizona State University. It involves ten PhD students from all over the world, each providing two comparative "laboratory engagement studies". These studies address the relevance of engaging and interacting with S&T practitioners to achieve an improved "responsive capacity" of their laboratories and, henceforth, to modulate the sociotechnical outcomes of R&D processes to some extent. More information can be found at *http://cns.asu.edu/stir/* (accessed January 30, 2011).

passive perception. This grants the "subject" (the rat) with the cognitive ability to perceive, to actively produce meaning. On the other hand, it entertains a complex and iterative relationship with all the elements that possibly populate the environment as experienced, including time, space, place, paths (in the labyrinth), houses, smells, enemies, and so forth. Therefore, it is pervaded all at once by multiple dimensions, which the rat constantly redefines—or to use STS vocabulary, *enacts* or *performs* (see Law and Urry 2004). To put it otherwise, Despret makes the point of clearly dissociating "whatever the scientist observes" from what "constitutes an answer, a judgment, an opinion from the animal about what is suggested to it by the one who interrogates it" (2009, p. 7). It should be understood that specific answers are induced by any *dispositif*. Some caution is then needed when it comes to providing evidence in the form of observations, as in this understanding they result from a partial caption of meanings or perceptions actively constructed by the "subject". Despret's argument therefore reads as follows: *the "subject" of any experimentation actively interprets the way it is expected to behave and acts accordingly to this interpretation*.

This argument applies even more easily when it comes to human beings, for unlike rats, humans are in principle barely denied cognitive capabilities. Obviously, the participants in the kind of engagement studies mentioned above have their own perspective, their own understanding of things and even their own strategic agenda. In this picture, it might be that "they" grant "us"—STS engagers—with intentions, trying to understand what is it we are looking for, or striving to understand, and act or answer accordingly. It should also be noticed that engagement with S&T practitioners hardly takes the shape of a material artifact, such as a labyrinth, even though it could certainly be the case.[5] However, interaction *per se*, even mediated by an artifact, necessarily expands over it. Arguably, any kind of interaction is framed, even loosely, for instance through an interview protocol or a similar apparatus. In this sense, it embeds certain expectations that induce specific answers. For example, if an experimental setup explicitly aims at enhancing the engager's or the practitioners' reflexivity on broad societal concerns, there is a fair chance that manifestations of such reflexivity might be observed. In other words, the argument here is that S&T practitioners, engaged as they are by STS scholars, may infer what they are actually being asked and try to answer to it adequately. I shall illustrate this with a reflection upon a research program I was involved in, which precisely follows this objective.

2.2. Illustration: We see what we look for

The research program called "Socio-Technical Integrated Research" (STIR) puts into action the concept of *midstream modulation of technology*. "Midstream" refers to the timeliness of the research, which needs to happen neither too early (upstream), when broad research orientations are not decided yet nor too late (downstream), when consumer products are already being released on the market (Fisher et al. 2006). The concept of "modulation" is borrowed from the literature on Constructive Technology Assessment (CTA), and stresses the possibility to actually (softly) influence powerful scientific and technological trajectories, "quasi-autonomous dynamics of science", rather than attempting to their forceful shaping (Rip, 2006). Modulation occurs

[5] A broad array of research methodologies does strictly mediate the relationship with S&T practitioners with a rather material setup. See, for example, methodologies such as the focus group (which might be located, for example, in the workplace or in various different locations, which obviously contributes to shape different outcomes) or the Delphi study (which can be conducted online or not, for instance).

anyway, whether consciously or not. It is mostly shaped *de facto* (Rip and von Amerom 2009), spontaneously, which means that in R&D processes, "collective actions emerge from smaller scale networking and small groups, which are ultimately affected by the 'everyday' practices and interactions of individuals" (Fisher et al. 2006). In this respect, the STIR program can be understood as an attempt to modulate the technology at a midstream stage of development, by means of "integrating" socially relevant knowledge into the technicalities of R&D practices. It investigates and assesses the possibilities for actually "modulating" socio-technical trajectories of laboratories and/or R&D centers.

To do so, the framework of the STIR program operates mostly at a micro-level, through individual practices, although it provides a contextual analysis that takes meso- and macro- levels into considerations (and informs them eventually). It does so especially by initiating a feedback loop, a dynamics of interaction between STS engagers and engaged S&T practitioners, which follows a three-steps process. This approach starts with careful observation of ongoing practices and daily routines (*observe*). Then, it reflects an understanding of these elements onto practitioners, so as to potentially enhance their reflexivity, their awareness of the cultural dimensions of their work (the *de facto* modulations that occur anyway), or more generally, their attention to broader societal considerations (*reflect*). Lastly, if ever this process results in cognitive or material shifts, that is, in greater awareness of contextual variables, those should be documented (*document*). The observation and reflection stages are mediated through the use of a "decision protocol", which takes into consideration four sets of different factors: considerations, opportunities, alternatives and outcomes. Without getting too much into details, the aim is to unpack the technical decisions as they are being practiced in everyday *routines*. The idea is to point out the moments and points of inflexion, when a different decision could have been made in the course of the research, potentially improved with respect to "societally relevant" sets of criteria. This "decision protocol" is used as a tool to initiate interactions with practitioners on the grounds of technicalities, their work, and what they do. It might also bring other extrinsic elements into these technical decisions, or lead to broader debates and matters of concern.

Eventually, the STIR program aims at interfering with ongoing sociotechnical developments, by means of interacting with S&T practitioners. It seeks to achieve improved awareness and enhanced reflexivity. In that respect, according to Despret's argument, such proactive interference would be rooted in the research *dispositif* (observe / reflect / document), which will forcefully affect the relationship between engager and engaged. This perspective helps the investigator to make way through the numerous, complex, and iterative statements of the participants involved. Then, looking ahead to a better reflexivity leads to particular *stimuli*, which induce specific answers accordingly.

For example, I once teased one of the "engaged scientists" who was trying to grow olfactory cells (quite scarce nasal cells that enable the sense of smell). These experiments were intended to contribute to new generations of biosensors. I asked this practitioner about the ethical issues of such devices that could "smell like a nose". Although this scientist would spend most of his days working on such devices, he confessed he had never thought about it. Then, we discussed potential applications, and issues such as control and surveillance society. All this was very interesting, but my point here is that these elements would probably never have come up spontaneously. Similarly, we discussed dead mice, career strategies, ethics of research and failed

experiments, replication of cells, and so on. In most cases, I brought up the stimulus or impulsion that called these elements forth, otherwise they probably would have remained hidden. It also happened that this practitioner came up with themes that he identified as "social", that is, relevant to the social scientist with whom he was interacting on a weekly basis. Symmetrically, many issues were left unaddressed. I might have raised a whole bunch of different issues, if only different perspectives or interests were at stake. In this sense, what came out of the discussion was meant to happen, as the result of a specific intersection between my particular interests in interacting with this practitioner, and his own particular perspective on the course of these interactions.

I argue here that any STS engager needs to deal with his or her own particular position, which depends on an irreducible normative standpoint. Although the question of normativity and politics in STS remains problematic in many respects (Latour 2004a; Latour 2004b; Law 2010), it is inescapable. Here, by "normative", I narrowly refer to everything that does not limit itself to a mere description of reality, but rather deliberately attempts to act upon it.[6] It may be that the normativity arises from the setup of the research itself: for instance, if the aim of engaging practitioners is to render them more reflexive, it arguably assumes that *they should be more reflexive about what is it that they do*. Another possibility consists in the engager pushing forward a normative agenda in terms of content, such as responsibility or sustainability, depending on his or her personality and beliefs. In any case, personal expectations play a key role while interacting with practitioners.

2.3. Do not construct knowledge on the back of those you study, allow them to protest

So far, it has been argued that a rat *actively* answers to a labyrinth, experiences it, "makes world" out of it (as Despret puts it), rather than passively reacts to it. Similarly, S&T practitioners find themselves engaged in something they cannot entirely grasp: what does this social scientist expect from me? *What would he like me to answer*? This is not something new. Longstanding research, notably in experimental psychology, pointed out this phenomenon. To cite but one example, Martin Orne highlights a certain kind of complaisance from the subjects: they do what they do because they have been asked to do so. This statement is valid whether or not the object of research has been hidden or undisclosed. Orne makes this finding accidentally: his subjects were asked to accomplish an "absolutely absurd, repetitive and very boring" task, on and on. They couldn't stop, in order to not make their performance invalid. Orne actually had to give up first. He found out they obey just because they are asked to do so and want to please the experimenter, by interpreting what they are expected to do, even if this is hidden from them (Despret 2009, pp. 13-14). They keep on executing absurd tasks also because they trust the scientific setup and the authority of the experimenter. In other words, in our case, we should never exclude the possibility that engaged S&T practitioners do not answer the questions we ask them but rather *the questions they think we are asking them*, in their interpretation.

In this perspective, a first lesson is to be easily drawn. One should make full disclosure of one's research objectives, including one's underlying assumptions or normative expectations. It is crucial to make explicit the role we expect S&T

[6] Which leaves aside the question of whether the real is "enacted" or "performed" through social inquiry and its methods (see Law and Urry 2004; Muniesa and Callon 2009).

practitioners to play, for them to be able to actively accept it. Making this happen can prove challenging enough, yet vocabulary issues render it even more complicated: a scientist or an engineer is highly unlikely to understand concepts such as "reflexivity" and "responsibility" in the same way that STS scholars would do.[7] In a way, it is almost a matter of deontology to be as clear as possible when it comes to displaying the goal or objectives of a particular research program. This basic methodological honesty could be considered as mere "informed consent", so to say. But I argue that it goes further. Rather, for the engager, it is yet another kind of normative commitment: a commitment to what Despret calls "the virtue of politeness" (Despret 2006). To put it plainly, it is a way to avoid enrolling "the others" we engage, without asking their permission beforehand, or even during the ongoing interaction.

However, this commitment to transparency, or disclosure, has deeper extensions, insofar as full disclosure of the research *dispositif* also implies a *de facto* possibility for the engager to contest it. In this case, it might be that the S&T practitioners do not agree with the assumptions or expectations of the engager. For instance, they might disagree that practitioners are not reflexive enough in the first place, or they might contest the plan for interaction, or they might demonstrate interest in other topics, other formulations of the question, and so forth. The key here is "to avoid '*constructing knowledge behind the backs of those I am studying*'" (Despret 2005, p. 361, emphasis added). To avoid this pitfall (insofar as one is committed to the 'virtue of politeness'), it is necessary to allow engaged S&T practitioners to effectively protest, which "means above all to testify". In this understanding, on the condition of opening up the research *dispositif* to effective contestation, and only on this condition, the STS scholar who engages with practitioners can be granted *spokespersonship*.

This process involves more than merely extending "permission". Rather, it reconfigures the whole dynamic of interaction between engager and engaged. As Despret puts it: "The idea is now to make an inventory and to assess the multiple conditions through which the person asking the question can claim to be authorized by the person being questioned to say a particular thing on his or her behalf" (Despret 2005, p. 363). It is not much anymore that we (engagers) persuade them (the engaged) to endorse our terms or research goals, but rather that the relationship becomes, in Latourian terms, *re-articulated*. Moving beyond initial assumptions or expectations, the twofold condition I have described (do not construct knowledge on the back of those you study, and allow them to protest) eventually cultivates the soil for differences and interesting learning opportunities to bloom.

Let's look at an example. During my stay at the R&D center in Flanders, Belgium, all but one of the practitioners I engaged questioned me about what I was doing there. I felt much more comfortable explaining what the STIR program was about, its scope, its comparative reach, its worldwide dimensions, by using state-of-the-art technical vocabulary: words such as "midstream", "modulation", "engagement", "reflexivity", and so on. Mostly, I was provided with a polite reaction ("ha…", "hum…") before the discussion went on. However, these interactions would feel quite frustrating, as I could tell that the scientists were not really coming to grips with *what I was actually doing*—at least, in regard to STIR's intention of triggering the reflexivity of S&T practitioners.

More recently, I had a chance to make up for the earlier efforts when, in December 2010, I started working with another scientist from the University of Louvain-La-Neuve, Belgium. This time, I straightforwardly disclosed the purpose of my presence

[7] If only STS scholars would eventually agree on the meaning of these terms!

in the laboratory, making sure not to use any word that he might not fully grasp in the same way I would. I basically told him that we (social scientists) used to think that they (natural scientists) would never sufficiently consider the societal impacts of their daily practices and the greater outcomes of ongoing R&D processes. Of course, this was purposively a little bit provocative. What happened then was very interesting. This scientist somehow inverted the terms of the discussion, as I had framed it. He responded quite naturally that most scientists in his department were actively engaged ecologists and were more likely to reach "environmental friendly" outcomes, whenever they could. In effect, he was pointing to already existing spaces where reflexivity was expressed or practiced, and he was therefore challenging any tacit assumption that practitioners would lack reflexivity. In this sense, this scientist was protesting against the *dispositif* by challenging its very grounds. If I was attempting to enhance reflexivity in laboratories, he was protesting by making visible, as the discussion went on, many spaces where practitioners *are already being reflexive*, acting as citizens, taking care of their health (for instance, working cautiously whenever manipulating carbon nanotubes, in case inhalation might prove dangerous), and so on. If I, as a STS scholar, were to write about practitioner's "reflexivity", I could not ignore or simply elude such moments that already demonstrate actual reflexivity, otherwise I would not be a reliable spokesperson for these S&T practitioners.

3. Reconfiguring interaction: on the productive possibilities of an experimental *dispositif*

3.1. From restriction to variations: an argument in favor of blooming diversity

Enabling those engaged to protest the terms of engagement, by any means, is a messy process that necessarily makes it impossible to direct the outcome (see Law 2010). Despret strongly opposes the reductionist view that aims to eliminate, if not even eradicate, every possible slight variable outside the experimental setup. For doing so reduces, neutralizes, the engaged S&T practitioner to whatever the STS scholar seeks to bring into existence, for instance, a perception of reflexivity. Therefore, the complex outcomes of interaction should not be restricted to clues or traces of reflexivity that neatly fit the research frame. Of course, during the engagement, both STS scholars and S&T practitioners have their own perspectives. However, I argue that if the 'engaged' practitioner is enabled to actively protest, the uptake of the research *dispositif* will bear the "intrinsic indeterminacies" that Stirling takes to characterize "reflexivity" (Stirling 2006, p. 230; see also Lash 2003). In other words, engagement should seek to trigger *reflexivity* rather than mere *reflection*. For reflection presupposes two distinct entities: the social scientist or STS scholar (who knows about the social) *versus* the S&T practitioner (who possesses technical knowledge but is socially ignorant). By merely reflecting on societal concerns, environmental problems, or ethical implications, social knowledge would seemingly flow unilaterally from the one who knows toward the empty receptacle—and vice versa, with regard to technical issues. Reflection would then imply a closed dynamic of reciprocal expertise. By contrast, reflexivity arises whenever interactions leap out of frame, taking unexpected paths and constituting multidimensional relationship dynamics.

In this understanding, each perspective provides a chance for genuine learning that needs to be unpacked to let a variety of meaningful insights flourish. The argument

here is that interaction is about variations in the first place, rather than about confronting (eventually mutually exclusive) subjective stances. We learn from Latour that it is not anymore a question of accuracy of (conflicting) statements, but rather a matter of renewed *articulation*. It intrinsically depends on the relationship initiated and sustained between engager and engaged. Latour nicely distinguishes between "the same obstinately boring subject" and the "articulate subject", "someone who learns to be affected by others". The former, the "inarticulate subject", is "someone who whatever the other says or acts always feels, acts and says the same thing". The latter, on the other hand, becomes articulate insofar as the issue becomes "interesting, deep, profound, worthwhile". This can be achieved only, Latour argues, "when it resonates with others (…), is *put into motion*" by new entities (Latour 2004a, pp. 208-210). Let's suppose that the STS scholar could be such an entity. If we admit the conditions stated above, then we now see that it becomes a matter of "articulating" the dynamics of the relationship between engager and engaged. With her own terms, Despret's formulates it as a second argument: "*Of interest is he or she who makes someone or something else capable of becoming interesting*" (Despret 2005, p. 365). "Articulating" the S&T practitioners we engage with, making them interested and "interesting", necessarily opens up room for the unexpected to happen, which I argue suggests a second condition for genuine reflexive learning.

3.2. Smarts, idiots and villains: on taking the other seriously

What does Despret mean when she wishes to render an entity *interesting*? She illustrates this with the well-known example of the research conducted by a behaviorist, Rosenthal, back in the 1960s. Rosenthal showed, by deceiving his research subjects, that the answers they provided were actually conditioned by the overall setup of the research. He asked two groups of students to provide comparisons between two genealogies of rats: one selected over generations of brilliant rat ancestors (supposedly smart), the other made out of the rats left aside by this process of selection (supposedly idiots). Both groups of students conducted the same tests on these two populations. It happened that the "smart rats" impressively accomplished the test as opposed to the "idiot" rats. The problem was, of course, that all rats had been randomly purchased at the store next door and the "selection" process was a fake construct. The students induced these results according to some sort of "predictive effect"—smart versus idiot. Rosenthal argued for a multiplicity of slight variations that would embody this "predictive effect", and that would need to be erased from the setup (Rosenthal 1966, in Despret 1996).

Erasing every possible slight variation, so as to reach perfect neutrality: Despret considers this to be the *a minima* option, a facile solution which is either illusory or a mere chimera (Despret 2009, p. 39).[8] The alternative is another interpretation of variation that is certainly more ambitious, and which considers any variation a further opportunity for learning. Such an interpretation is much more demanding, as it deals with complexity and heterogeneity, rather than simplistic frames. In this sense, it also challenges the potential generalization of the research outcomes. In the particular case of engaging with S&T practitioners, it is a matter of *not restricting the other*. One shall

[8] This solution may even have resulted, in the past, in some sophisticated forms of torture, for instance when rats have their sensorial organs ripped off, because sight, smell, or any extraneous perception could "bias" the perfect homogenization of the results. Fortunately, we're not there anymore! (Despret 2009).

rather testify an openness to whatever one may learn from interaction, rather than simply expecting something precise from the process. It might be that one is more or less normatively committed, for instance, to the idea that practitioners' reflexivity should be enhanced, or to a general idea of responsibility or sustainability. There is no issue here as long as this commitment is not kept hidden. But one need not stick to one's agenda, up to the extent of overlooking unexpected issues, missing out on learning opportunities that necessarily flourish during discussions. It is not necessary to evade interesting elements that come up while interacting, which might be the case whenever the process bounds out of frame. Interactions may be perfectly mediated through an artificial experimental setup such as the "decision protocol" I introduced above. But such a tool may be used either to play down differences, or to reach quite straightforward outcomes, or, on the contrary, to trigger such differences. To put it otherwise, this setup may be used in an ambitious fashion, rather than a restricted one.

3.3. Advocating heterogeneity

I argue that such an ambitious interpretation is both suitable and desirable in the case of the STIR program, as I outlined it (observe / reflect / document, through a decision protocol). As pointed out above, engaging with human beings instead of rats proves even more complex, as it brings together two different "human entities", each with different backgrounds, perspectives, and cognitive frames. In the dynamics of interaction, there is no set of variable criteria that could be identified, insulated, and then controlled (or suppressed). It actually goes the other way around. Through engagement, the investigator is surrounded by variations, depending on manifold factors such as the moment, the mood, shifting or evolving perspectives, and the like. Furthermore, it has long been recognized that, typically, S&T practitioners (just like STS scholars) are "not one person, but a composite" (Thorndike 1967, quoted in Galison 1997). Notions such as "responsibility" can cover different meanings for the very same person, depending on which "side" of this person a particular responsibility speaks to (von Schomberg 2008). Engagement with practitioners, I argue, operates within certain constraints: the inner locality of the place and the somewhat artificial setup. Such a setting should not be considered, to paraphrase Latour, as a "mere intermediary" but rather "as what allows, *because* of the artificiality of the instrument, the differences of the world to be *loaded into* what appeared at first arbitrary sets of contrasts" (Latour 2004a, p. 210, emphasis in original).

This implies (but also results from) a second condition, which is to *take the other seriously*—that is, not as a mere means to fulfill one's own research agenda. A reciprocal shaping of the investigator and the participant occurs and has to be acknowledged, as it enables further opportunities for learning. In this respect, the "other" need not be considered as an empty entity onto which one could project his or her goals, questions, *dispositif,* and the like in an unilateral, unproblematic and straightforward way. This would lead to mere reflection, in the manner I have described it. Rather, the investigator needs to pay full and careful attention to everything the other may express, either explicitly or implicitly. To make it clear, it is very important not to screen too much, or to apply overly strict filters to the process of interacting. Otherwise, opportunities for learning could be restricted, or squandered. In order to avoid such pitfalls, I call for a general principle of bi-directionality of exchange. The principle is general, as it should apply to every element that comes out during the process of interaction, and especially the elements that are unexpected. But

its application depends on the emergence of such elements, in such a way that the directionality of exchanges is never pre-determined. This way, we come closer to the definition of "reflexivity" that Stirling proposes.

So, engaging interactions with a particular scope is not a problem to get rid of, but preferably represents an opportunity for knowledge that needs to be taken on. It takes a basic acknowledgment of the irreducible complexity of insights one gets out of engagement. It demands that one agrees to open the *dispositif* and therefore to put oneself in danger, which cannot be genuinely achieved if the participant is not taken seriously.

4. Conclusion

In this chapter, I explored the interest to reflect on the research *dispositif* that one mobilizes while engaging with S&T practitioners. I took inspiration from the way the philosopher of science Vinciane Despret critically engages with research *dispositifs*, mainly asking the question of *what we ask* from the person with whom we engage. I tried to tie this up with the complex relationships dynamics I witnessed while engaging with S&T practitioners. First, I tried to identify the tacit assumptions of such engagements. Second, I argued that these should be made explicit and, insofar as possible, open to contestation, so as to put my own research frame or *dispositif* to the test. This is a condition for reliably speaking on the behalf of S&T practitioners. Then, I briefly elaborated Latour's concept of *articulation* to show that, in practice, allowing for protest is a valuable alternative to erasing or neutralizing variations that necessarily occur in the course of this kind of research.

In this way, one can expect truly heterogeneous answers from the S&T practitioners one engages. Such intrinsic heterogeneity, when acknowledged, fits with Stirling's understanding of the notion of *reflexivity* as "involving" the self and entailing contingency. It then sidesteps the rather restrictive stance of simple reflection. This leads directly to the consequence that it is, by definition, impossible to direct the outcomes of a genuinely reflexive engagement. "Changing order" takes a particular epistemological commitment that may drive the STS scholar to engage with S&T practitioners. It results most likely in soft perturbation, interference (Law 2010), or disturbance (Mesman 2007), which *may result* in genuine learning. But if pushing a directed agenda too hard and not acknowledging it, STS scholars could end up "moralizing" the S&T practitioners they engage with. With Swierstra and Jelsma (2006), I argue that it would be more interesting, for example, to reverse the question of reflexivity so as to ask practitioners under which conditions or structures they find themselves unable to prove reflexive.

In the absence of boundaries and on condition of being explicit about what we ask, it then becomes possible to positively and reflexively challenge practitioners. If the idea is to deliver an "STS kiss" to a practitioner, due permission needs to be granted, and the kiss needs to be *interesting*, which is to say, textured and complex.

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References

Agamben, G. (2007) *Qu'est-ce qu'un dispositif?* Paris: Rivages poche.

Ashmore, M. (1989) *The Reflexive Thesis. Wrighting Sociology of Scientific Knowledge*, Chicago: University of Chicago Press.

Barben, D., Fisher, E., Selin, C. and Guston, D. (2008) Anticipatory Governance of Nanotechnology: Foresight, Engagement, and Integration, in: Hackett, E. J., Amsterdamska, O., Lynch, M., and Wajcman, J. (eds.) *The Handbook of Science and Technology Studies* (3rd ed.), Cambridge, Mass.: MIT Press, pp. 979-1000.

Bourdieu, P. (2001) *Science de la science et réflexivité*, Paris: Raisons d'agir.

Beck, U. (1994) The reinvention of politics: towards a theory or reflexive modernization, in: Beck, U., Giddens, A. and Lash, S. (ed.) *Reflexive Modernization: Politics, Tradition and Aesthetics in the Modern Social Order*, Cambridge: Polity Press, pp. 1-25.

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

Bijker, W. E. (2003) The Need for Public Intellectuals: A Space for STS, *Science Technology & Human Values*, **28**(4), pp. 443-450.

Bijker, W. E., Hughes, T. P. and Pinch, T. (eds.) (1987) *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, Cambridge, Mass., MIT Press.

Collins, H. M. and Evans, R. (2002) The third wave of science studies: Studies of expertise and experience, *Social Studies of Science*, **32**(2), pp. 235-296.

Davies, S., Macnaghten, P., Kearnes, M., Ferrari, A., and Nordmann, A. (2009) *Reconfiguring Responsibility: Deepening Debate on Nanotechnology (A research report from the DEEPEN project)*, Durham: Durham University.

Davies, S. R., Fiedeler, U., Ferrari, A., and Coenen, C. (2010) Understanding Nanoscience and Emerging Technologies, in: Fiedeler, U., Coenen, C., Davies, S. R. and Ferrari, A. (eds.) *Understanding Nanotechnology. Philosophy, Policy and Publics*, IOS Press: Heidelberg, pp. 1-8.

Despret, V. (1996) *Naissance d'une théorie éthologique. La danse du cratérope écaillé*, Paris: Les empêcheurs de penser en rond.

Despret, V. (2005) Sheep do have opinions, in Latour, B. and Weibel, P. (eds.) *Making Things Public: Atmospheres of Democracy*, Cambridge, Mass.: MIT Press, pp. 360-370.

Despret, V. (2006) Anthropo-ethologie des non-humains politiques, *Social Science Information Sur Les Sciences Sociales*, **45**(2): 209-226.

Despret, V. (2009) *Penser comme un rat*, Paris: Quae.

Despret, V., and Porcher, J. (2007) *Être bête*, Paris: Actes Sud.

European Commission (2007) *Integrating Science in Society Issues in Scientific Research: Main Findings of the Study on the Integration of Science and Society Issues in the Sixth Framework Programme*, Luxembourg: Office for Official Publications of the European Communities

European Commission (2009) *Commission Recommendation on a Code of Conduct for Responsible Nanosciences and Nanotechnologies Research & Council Conclusions on Responsible Nanosciences and Nanotechnologies Research*, Luxembourg: Office for Official Publications of the European Communities

Foucault, M. (1977) Le jeu de Michel Foucault, *Dits et écrits. Tome II*, Paris: Gallimard, pp. 298-329.

Ferrari, A. (2010) Developments in the Debate on Nanoethics: Traditional Approaches and the Need for New Kinds of Analysis, *NanoEthics*, **4**, pp. 27-52.

Fisher, E. (2005) Lessons Learned from the Ethical, Legal and Social Implications Program (ELSI): Planning Societal Implications Research for the National Nanotechnology Program, *Technology in Society*, **27**, pp. 321-328.

Fisher, E. (2007) Ethnographic Invention: Probing the Capacity of Laboratory Decisions, *NanoEthics*, **1**, pp. 155-165.

Fisher, E. (forthcoming) Responsible Innovation: Blending Social Aspiration and Micro-Practices into Organizational Capability.

Fisher, E., Mahajan, R. L., and Mitcham, C. (2006) Midstream Modulation of Technology: Governance From Within, *Bulletin of Science, Technology & Society*, **26**, 485-496.

Fisher, E., and Miller, C. A. (2009) Collaborative Practices for Contextualizing the Engineering Laboratory, in: Christensen, S. H., Meganck, M., and Delahousse, B. (eds.) *Engineering in Context*, Palo Alto: Academica Press, pp. 369-381.

M. E. Gorman, J. F. Groves, and J. Shrager (2004) Societal Dimensions of Nanotechnology as a Trading Zone: Results from a Pilot Project, in: Baird, D., Nordmann, A., and Schummer, J. (eds.) *Discovering the Nanoscale*, Amsterdam: IOS Press, pp. 63-76.

Guillemin, M., and Gillam, L. (2004) Ethics, Reflexivity, and 'Ethically Important Moments' in Research, *Qualitative Inquiry*, **10**(2), pp. 261-280.

Hackett, E. J., and Rhoten, D. R. (2009) The Snowbird Charrette: Integrative Interdisciplinary Collaboration in Environmental Research Design, *Minerva*, **47**(4), pp. 407-440.

Lash, S. (2003) Reflexivity as Non-Linearity, *Theory Culture & Society,* **20**(2), pp. 49-57.

Latour, B. (2004a) How to Talk About the Body? The Normative Dimension of Science Studies, *Body & Society*, **10**(2-3), pp. 205-229.

Latour, B. (2004b) *Politiques de la nature. Comment faire entrer les sciences en démocratie?* Paris: La Découverte

Latour, B. (2010) Avoir ou ne pas avoir de réseau: that's the question, in: Akrich, M., Barthe, Y., Muniesa, F., and Mustar, P. (eds.) *Débordements. Mélanges offerts à Michel Callon*, Paris: Presses des Mines, pp. 257-268.

Law, J. (2010) The Greer-Bush test: on politics in STS, in: Akrich, M., Barthe, Y., Muniesa, F., and Mustar, P. (eds.) *Débordements. Mélanges offerts à Michel Callon*, Paris: Presses des Mines, pp. 269-282.

Law, J. and Urry, J. (2004) Enacting the social, *Economy and Society*, **33**(3), pp. 390-410.

Loibl, M.-C. (2006) Integrating perspectives in the practice of transdisciplinary research, in: Voss, J.-P., Bauknecht, D. and Kemp, R. (eds.) *Reflexive Governance for Sustainable Development*, Cheltenham: Edward Elgar, pp. 294-309.

Lynch, M. (2000) Against Reflexivity as an Academic Virtue and Source of Privileged Knowledge, *Theory Culture & Society*, **17**(3), pp. 26-54.

Macnaghten, P., Kearnes, M. B., and Wynne, B. (2005) Nanotechnology, Governance, and Public Deliberation: What Role for the Social Sciences? *Science Communication*, **27**(2), pp. 268-291.

Mesman, J. (2007) Disturbing Observations as a Basis for Collaborative Research, *Science as Culture,* **16**(3), pp. 281-295.

Muniesa, F., and Callon, M. (2009) La performativité des sciences économiques, in Steiner, P. and Vatin, F. (dir.) *Traité de sociologie économique*, Paris: PUF, pp. 289-324.

Nowotny, H., Scott, P., and Gibbons, M. (eds.) (2001) *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty*, Cambridge: Polity Press.

Nowotny, H., Scott, P., and Gibbons, M. (2003) Introduction. 'Mode 2' Revisited: The New Production of Knowledge, *Minerva*, **41**, p. 179-194.

Pinch, T. (1993) Turn, Turn, and Turn Again: The Woolgar Formula, *Science, Technology & Human Values*, **18**(4), pp. 511-522.

Rip, A. (2006) A Co-Evolutionary Approach to Reflexive Governance—and its Ironies, in: Voss, J.-P., Bauknecht, D. and Kemp, R. (eds.) *Reflexive Governance for Sustainable Development*, Cheltenham: Edward Elgar, pp. 82-100.

Rogers-Hayden, T. and Pidgeon, N. (2007) Moving Engagement 'Upstream'? Nanotechnologies and the Royal Society and Royal Academy of Engineering's Inquiry, *Public Understanding of Science*, **16**(3), pp. 345-364.

Schomberg, R. von (2010) Organising Collective Responsibility: On Precaution, Codes of Conduct and Understanding Public Debat, in: Fiedeler, U., Coenen, C., Davies, S. R. and Ferrari, A. (eds.) *Understanding Nanotechnology. Philosophy, Policy and Publics*, IOS Press: Heidelberg, pp. 61-70.

Schomberg, R. von and Davies, S. (eds.) *Understanding Public Debate on Nanotechnologies: Options for Framing Public Policy*, Luxembourg: Publications Office of the European Union.

Schuurbiers, D., and Fisher, E. (2009) Lab-Scale Intervention, *Embo Reports*, **10**(5), pp. 424-427.

Stirling, A. (2006) Precaution, Foresight, and Sustainability: reflection and reflexivity in the governance of science and technology, in: Voss, J.-P., Bauknecht, D. and Kemp, R. (eds.) *Reflexive Governance for Sustainable Development*, Cheltenham: Edward Elgar, 225-272.

Swierstra, T. and Jelsma, K. (2006) Responsibility without Moralism in Technoscientific Design Practice, *Science, Technology & Human Values*, **31**(3), pp. 309-332.

U.S. Congress (2003) 21st-Century Nanotechnology Research and Development Act, Public Law 108-153.

Voss, J.-P., Bauknecht, D. and Kemp, R. (eds.) *Reflexive Governance for Sustainable Development*, Cheltenham: Edward Elgar.

Webster, A. (2007) Crossing Boundaries: Social Science in the Policy Room, *Science, Technology & Human Values*, **32**(4), pp. 458-478.

Wienroth, M. (2009) Disciplinarity and Research Identity in Nanoscale Science and Technologies, in Ach, J. S. and Weidemann, C. (eds.) *Size Matters. Nanobiotechnology and Nano-Medicine: Ethical, Legal and Social Aspects*, Berlin: Lit Verlag, pp. 157-177.

Woolgar, S. (ed.) (1988) *Knowledge and Reflexivity: New Frontiers in the Sociology of Knowledge*, Thousand Oaks: Sage Publications.

Woolgar, S. (1991) The Turn to Technology in Social Studies of Science, *Science, Technology & Human Values*, **16**(1), pp. 20-50.

Zuiderent-Jerak, T. and Jensen, C. B. (2007) Editorial Introduction: Unpacking 'Intervention' in Science and Technology Studies, *Science as Culture*, **16**(3), pp. 227-235.