Researching technoscientific concerns in-the-making: narrative structures, public responses and emerging nanotechnologies

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Abstract: This paper engages with debates on technoscientific governance, narrative and emergent public attitudes. Building on a piece of social research addressing public responses to the social and ethical dimensions of emerging nanotechnologies, the paper develops a methodology and mode of analysis designed to take into account four distinctive features of nanotechnology discourse and its constitution in the public sphere, namely: its unfamiliarity; its promissory quality; its uncanniness; and its metaphysical assumptions of progress. Through an analysis of common narratives that shape and structure lay public responses to the technology, and in response to framings of how the technology and its applications are being crafted in the public domain, the paper argues that nanotechnologies offer a site for an intense future politics centred on dilemmas of body invasion, unanticipated risks, nature's revenge, control, inequalities and pace of change. The paper concludes with a set of reflections on the role of the critical social sciences in such a future techno-politics.

Key words: *nanotechnology, technoscientific governance, emergent public attitudes, narrative, metaphysics*

Introduction

In response to widespread public reaction to technological risk issues over the last two decades, we have witnessed a move internationally, and especially in Europe, towards state funded initiatives aimed at encouraging wider public engagement and societal participation in technoscientific processes as a means of improving relations between science and society. Such initiatives are developed for multiple and overlapping reasons, both instrumental and normative, and include the belief that they will, *inter alia*, help restore public trust in science, avoid future controversy, lead to socially robust innovation policy, democratise scientific governance, and render scientific culture and praxis more socially accountable and reflexive (Kearnes and Macnaghten, 2006; European Commission, 2007). While one can question the cumulative effect of such initiatives and whether they amount to, in effect, the new social contract between science and society that has been suggested in official documents (House of Lords, 2000; European Commission, 2000), one can nevertheless witness a new and significant role being crafted for the social sciences (Irwin, 2006; Hagendijk, 2004).

These developments are arguably most advanced in policy and governance debates on nanotechnology, both in the United States and in Europe, and for good reasons. Here is a technology with substantial and strategic levels of investment and expectation seen as in danger of running up against comparable adverse public reaction to that experienced with genetically modified foods and crops. Here, using the language of 'responsible innovation', social scientists are being asked not simply to characterise broader societal concerns in a

proactive manner, but also to integrate such considerations into nanoscience and nanotechnology research programmes at an early stage (Barben et al, 2007; European Commission, 2004; NSTC, 2004; Royal Society/ Royal Academy of Engineering, 2004). Alfred Nordmann has playfully characterised the role of science and technology studies (STS) within these debates, from the 'science wars' of the 1980s and 1990s to the 'love fest' of contemporary times (Nordmann 2007).

At the core of this paper is an attempt to engage critically and empirically with one hitherto under-researched element of this role: that of the need for innovation in methodology and analysis in the reflexive examination of technoscientific concerns – and citizens – in-the-making. Just as Rose and Novas has argued that the biosciences are reshaping the contours of contemporary subjectivity and citizenship through new understandings of minds, bodies and responsibilities (Rose, 2007; Novas and Rose 2000), so too can this dynamic be seen to be taking effect through nanoscience discourse and practice. However, my argument is more experimental and speculative. Given that the technology exists largely in terms of future oriented promise rather than as material reality, the methodological requirement for the research outlined in this paper was to produce a space in which lay technoscientific citizens could be produced through an innovative public engagement exercise, able to offer opinions, discuss the issues and reflect on future politics and their contingencies (Michael, 2006). The research outlined below was part of a wider project, conducted in partnership with the UK public policy think-tank Demos, designed to explore the role of the social sciences in contributing towards a more anticipatory and socially robust governance framework (Kearnes et al, 2006). There are four sections to this paper. First, the methodological challenges in fostering a public dialogue on the social and ethical dimensions of emerging nanotechnologies are summarised. Secondly, a methodology is outlined designed to respond to such challenges. Thirdly, the results from the public dialogue event are reported, focusing in particular on the narrative process that shaped and structured public responses to the technology. And fourthly, reflections are offered on the implications of the research for the institutional governance of emerging technologies and on the role for the social sciences.

So what are the challenges in negotiating a public conversation on the social and ethical dimensions of emerging nanotechnologies? Firstly, it is clear from the literature that most people are unfamiliar with the term and have little to no factual knowledge of what it is or of what it could be, a finding shared in survey research conducted in the United States (Macoubrie, 2006; Sheetz et al, 2005; Waldron, Spencer and Batt, 2006), in the United Kingdom (BMRB Social Research, 2004; MORI, 2005), and across Europe (Eurobarometer, 2005). One implication that derives from this finding is that if one is to understand emergent public attitudes to nanotechnologies one needs to pay particular attention to the underlying frameworks and dynamics that are likely to structure their development and evolution (for an elaboration of this approach with reference to biotechnologies, see Grove-White et al, 2000; Macnaghten, 2004).

A second complication arises from the fact that most nanotechnologies remain at an early or pre-market stage of development, existing largely in terms of their future-oriented visions of promise and abundance. The institutionally-endorsed rhetoric of a future enabled by nanotechnology is beset with references to its role in enabling breakthroughs across multiple sectors and applications, from electronics to materials, health care to pollution control, and of a market that has been projected to exceed $4.0 trillion by 2015 (Lux Research, 2008). The future-oriented and promissory character of nanotechnology has been noted by scholars, notably in relation to the speculative claims of its future potential

(Nordmann, 2007b), the ways in which expectations of a 'fantastic future' is driving current scientific practice (Selin, 2007), and the role of science fiction in shaping the moral imagination of nanoscientists (Berne, 2006) and the development of nanotechnology policy (Milburn 2004).

The third complication arises from the so-called 'uncanniness' of the technology (Nordmann, 2005). Not only is it a technology that operates at the unbelievably small: nanotechnology is commonly defined as the understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where comparative size of a nanometre to a metre is the same as that of a marble to the size of the earth; but it is also at a size where novel or unusual or surprising properties take effect. Nordmann (2005) has reflected on the incredible tininess of nanotechnology by speaking of it as a 'noumenal' technology, utterly beyond human action, perception and causal control.

The final complication arises from considerations of metaphysics. Following Popper's observation that all science rests on a 'metaphysical research program', a set of presuppositions about the structure of the world which are neither testable nor 'falsifiable' empirically, but which nonetheless play an essential role in the progress of science, analysts have begun to examine the metaphysical assumptions, tacit or otherwise, that tend to underpin national and international programmes of nanotechnology and related initiatives (see Dupuy, 2005). Kearnes at al, (2006) have analysed a set of 'programmatic imaginaries' that operate as meta-level discourses and that drive the development of the technology, including the foundational conviction that nanotechnology represents a new paradigm of scientific endeavour based on its ability to control and manipulate matter at atomic and molecular scales. While such metaphysical assumptions are unevenly distributed within and across nanotechnology's constituent scientific disciplines (Bensaude-Vincent 2004), and while there may be cultural differences between European and US versions of nanotechnology policy (Nordmann 2007a), there nevertheless can be seen to exist a strong and unified global programme of nanotechnology that is imbued with its own distinctive metaphysics. Central to its metaphysical programme are visions of control and precision (Kearnes, 2007), of abundance and escape from scarcity (Schwartz, 2004), of emulation and/or improvement of nature (Nordmann, 2005), and of a 'dream of reason' that is to overcome once and for all every given that is a part of the human condition (Dupuy, 2007).

Methodology: eliciting technoscientific concerns in-the-making

A methodology was developed aimed at responding to the challenges outlined above and thus at helping towards a contextual understanding of the factors likely to shape future public responses to nanotechnologies. A focus group methodology was chosen, designed to encourage discussion of potential issues arising for nanotechnology in an active learning setting, where the analytical task was one of examining the narrative forms and processes through which the unfamiliar was rendered familiar. Narrative was a key category of analysis (for accounts on the performative role of narrative in producing knowledge, see White, 1987; Taylor, 1992). What kind of stories would people tell about nanotechnology? To what extent would they be informed by direct experience with the world, or from mediated experience, from books, fables, movies, television, the internet, videogames, and so on? How would these narratives be drawn upon, argued over, and negotiated in the craft of producing opinions and attitudes? And in what ways would publics respond when confronted with narratives reflecting dominant institutional norms and aspirations?

This paper thus can be seen as benefitting from insights drawn from the sociology of expectations and from a body of scholarship that has examined how the future, as an analytical object, has been mobilised through discourse, motif and representation (Adam and Groves, 2007; Brown, 2005; Brown and Michael, 2003; Brown et al, 2000). The focus on lay public narratives structures offers a distinctive contribution to this literature and complements existing analyses of how new science is discursively narrated through expert media (e.g. for an analysis of role of the breakthrough motif in reporting new science, see Brown 2000).

Given the promissory character of most nanotechnologies, considerable thought was given to the institutional forms and narratives through which the technology is being introduced in the public domain (e.g. in the form of policy reports, newspaper articles, television documentaries, industry presentations, campaign materials, and so on). Two dominant frames were identified: one that interpolated nanotechnology as a new science that would contribute to projected breakthroughs across multiple sectors and spheres of application (European Commission, 2004; House of Commons Science and Technology Committee 2004); the other more avowedly utopian and revolutionary, with promises of how nanotechnology will extend and transform human sensory and physical capacities to transcend natural and physical constraint (Roco and Bainbridge, 2003). In addition, a third frame was added, derived from civil society actors and sceptics that focused on the potential and uncertain risks of the technology on human health and the environment, and of wider concerns of the technology running 'out of control' (ETC, 2003; Joy, 2000; Lloyds, 2007). These three visions were encapsulated in stimulus materials as reflective of three dominant frames – or styles of thought (Fleck, 1979; Hacking, 1992; Rose, 2007) – involving not simply what nanotechnology is, but what it explains, and what it represents. By exposing participants to the multiple frames characteristic of the emerging public debate, and by encouraging discussion and exchange on the credibility, legitimacy and authority of such frames, the design was intended explicitly to simulate the real-world dynamics through which nanotechnologies and their associated social relationships become co-produced.

The methodology further aimed to explore the 'uncanniness' of the nano world, and how it differed from the world of everyday experience. The participants were encouraged to develop a 'nano imagination' through design choices that included: extended time (the focus groups took place over two consecutive sessions, each session lasting two hours), a dedicated task between the sessions (people were asked to research for themselves the issue of nanotechnology, and to explore the topic with friends and colleagues, consulting websites, and keeping a journal for any reflections arising), an 'in action' focus (in which participants were encouraged to understand the arguments and debates surrounding nanotechnology as it was being practiced by actors in real-world circumstances), and a sample aimed at group enculturation (the groups, all non-expert in the field of nanotechnology, were chosen on the basis of common work or life histories – see also section below). To engage with the metaphysical dimensions of nanotechnology, the research was moderated in such a manner as to encourage discussion not simply on the technology as technique, but also on the underlying visions and motivations that appear to be driving the technology.

The sample consisted of five groups, recruited by professional recruiters on the basis of their existing participation in local community or political issues, but with no prior involvement or exposure to nanotechnology. They included a group of professional men (doctors, architects, civil servants etc.) – Group 1; a group of professional women (mostly employed as middle managers in business) – Group 2; a mixed gender group with

demonstrable political interests – Group 3; a group of women with children at school age – Group 4; and a mixed gender group all of whom expressed an interest in technology – Group 5. The groups were conducted in Manchester and London in the late summer of 2005. The groups were not recruited to be representative of British society in a formal sense. Rather, the groups were chosen for two intersecting reasons: to have shared life histories or work experience on issues that were seen as potentially relevant to the framing of response to nanotechnology (e.g. sharing interests in technology or politics; sharing know-how of raising children; sharing experience of business management or the professions); and to have relevant intellectual or social capital to develop collective imaginations of the nano world (e.g. the participants tended to take an interest in topical affairs, to have participated in higher education, and to be involved in local community matters). The fact that these groups were selected on these criteria did little to mitigate against the generalisability of the findings given the diversity across key factors (age, gender, location), and our interest in understanding the narrative dynamics through which 'uninformed' publics develop responses to nanotechnology.

Conceptualising public concerns to nanotechnology

Unsurprisingly, when participants were requested to offer an opinion on the term nanotechnology, there was little familiarity or knowledge, a finding that parallels attitudinal survey research as noted above. When pressed, participants tended to characterise nanotechnology as scientific, clever, small, possibly medical, strange, futuristic, and something associated with science fiction. Even for the more technologically literate participants who had heard of nanotechnology and of its 'uncanny' potential (Nordmann, 2005), it nevertheless was perceived as foreign, strange and other-worldly:

> **Alistair**: "It's almost the best of all the terms for being one where I know the idea that nanotechnology is really small technology and occasionally I'll read something in The Guardian or wherever about – 'it's amazing, these guys have written their names in atoms on something' and you're like, wow, that's cool. And you have this very nebulous notion that this is really clever and that there are … all these possibilities that are, you know, waiting to be unlocked in nanotechnology. But I actually have no idea you know what they're really doing and or what these possibilities are. I just have this very vague notion that it's very clever and it could be really important. And that's kind of the epitome of what we were talking about before, about not really knowing the detail."
> (Group 3)

This background and vaguely affirmative sensibility can help to explain the relatively positive perceptions of nanotechnology found in attitudinal surveys, where people may be responding broadly to the connotations of the term 'technology' without much understanding of the detail (Gaskell et al, 2005). This research sought to deepen this analysis through examining the narrative structures through which people came to develop collective and shared accounts of what was 'at stake' in the technology. Typically, the evolution of expressed attitudes followed a pattern roughly as follows: from a state of initial ignorance, to surprise at how much research and R&D was being invested by both governments and industry, to enthusiasm as to the potential for social good not least in the medical domain, to unease and anxiety that nanotechnology innovation might lead to largely unanticipated and disruptive problems in real-world circumstances, to pessimism over our ability to govern and regulate the technology for the common good. What led people to positions of unease and apprehension was not simply a consequence of realising that nanotechnology would

enable scientists and other actors to extend control radically over matter, nature and the human body; but that such control over the pace, scope and direction of change would be governed by powerful bodies, propelled by the logics of industrial capitalism, and where the lay public would be 'kept in the dark'. These perceived 'real world' dynamics led to predictions that nanotechnologies would exacerbate global inequality and facilitate evermore intense subjection of individual bodies. What emerged thus was a dense array of concerns; few specific or unique to nanotechnology but distinctive in their sheer breadth and convergence. For reasons that will be discussed later in this paper, nanotechnology appeared to have *intensified* response along familiar and consistent themes around the body, unanticipated risks, nature's revenge, control, inequalities, and pace of change.

For many people the anxiety potential of nanotechnology came to the fore in relation to the concerns of nanoparticles potentially violating bodily processes, either through cosmetics or foods. Just as genetically modified foods heightened concern on account of being undetectable by texture, smell or appearance (Adam, 1998), the invisibility of nanoparticles and their potential ubiquity into everyday consumer goods resonated with background fears linked to an enduring narrative of 'bodily invasion'.

Rosie: "I imagine. This face cream which has got very small nanoparticles in it, I don't know whether it's made of nanoparticles or whether it's just using nanotechnology. But if I rub that on my skin or someone's rubbing it into their skin and therefore there's things going into my skin I'm not aware of. We've already said this really but no-one knows exactly what that's going to do and it might have long term effects where, just imagine, free radicals which I'm sure you know potentially make cells get confused and breaks the genes in the cells and makes them grow out of control. Any little bit of dirt, like something that shouldn't be in there pops into the cell, messes with the actual sequence of what that cell does and you know - that's so scary."

Julie: "Yeah because it can happen without you realising, whereas before, things, if they were going to invade your body or invade something, you would see it happening."

Philip: "It's the invisible threat."

Julie: "Yeah, that's it."

Helen: "Because you cannot see it…"

(Group 5)

A visceral example of this dynamic was voiced in the London group of women with young children. In the initial session these women had clearly enjoyed the proposition that nanotechnology might visibly and demonstrably ameliorate signs of ageing through newly potent anti-wrinkle creams. Now, when confronted by acknowledged uncertainties as to the potential toxicological effects of nanoparticles, the conversation shifted in tone:

Rochelle: "Since last week I've completely changed my approach to these creams. When you said it had those 'nanosomes', I thought, 'oh great, fantastic, I'd use it' – [now] I wouldn't touch it now with a barge pole [even] if you paid me money to put that stuff on my face now. It's so frightening."

Victoria: "I think we're very trusting as buyers in the market, or in general, the public, we're very trusting of the products we're given and, the thing is, now you find out afterwards – we're suddenly having to become very sceptical because things come out afterwards."

Renee: "Well, you sort of assume it's always been tested."

Karen: "Yes."

Renee: "Which clearly obviously things like cosmetics don't have the controls that the drugs do."
Rochelle: "But surely wouldn't they be better to sort of like say, right, we don't know enough, and until we know enough, or we've changed our regulations, or whatever, then we don't let it go on the market."
Victoria: "There's too much money in it I think."
(Group 4)

The potential for harm – for example in the unknown toxicity of nanoparticles – was commonly seen as symptomatic of the wider phenomena of advanced technology proceeding in the face of natural limits and processes. GM foods, MRSA, mad cow disease and others, were presented as examples of technological innovation that had been developed in the face of unanticipated risks of a complex and uncertain nature. Beck's 'Risk Society' had become an everyday reality for our participants (Beck, 1992). Nanotechnology was seen as a further and worrying extension of this dynamic, led, as it appeared to be, through a hubristic sense of its perceived ability to transform both society and nature:

James: "They will find new bacteria and we will be more resistant. Antibiotics and things are becoming resistant. There will be more diseases that will come. We will never completely get rid of disease."
(Group 5)

Neil: "I think it's accelerating the evolution of disasters… You were going on – on the board there – about accelerating the evolution of human systems, brain power and healing powers and stuff. It'll get 'out of the cage', I'm sure, and evolve through various bio-strains and mechanisms and it will be adapted, possibly. There are cases with GM super weeds now."
(Group 1)

The metaphysical explanation

So why did nanotechnology present such troubling visions. There are perhaps three interlocking explanations. First, people responded to the metaphysics embedded in the radical and utopian vision of nanotechnology as cause for alarm. The metaphysical project, common in this particular narrative of nanotechnology, presents the technology as an enabler of human capacities, needs, desires and potentialities. Through nanotechnology, the argument runs, people will be able to transcend their material and 'natural' constraints and thus realise full liberation and emancipation. While such a narrative has been given most visible expression in the National Science Foundation report on Converging Technologies (Roco and Bainbridge, 2002), it nevertheless represents a wider emergent style of thought characteristic of much of nanotechnology especially in the US policy context (Nordmann, 2007c), and reflective more widely of characteristically American ideals of technology (Noble, 1999). Below is how one of the groups attempted to express what they found troubling in this vision:

Neil: "If you actually took that wholly on board, everything that's printed on there, it's quite a frightening scenario, isn't it. So this wonderful nanotechnology is going to be a cure all for all human ills, it's going to make us all super brilliant and clever and work that much better, our transport's going to be far better even though the fact that nobody will be dying of old age, nobody will be dying of any illnesses so we won't be able to move on this planet. Yet we'll be able to move about quicker because the

trains or whatever will be much more efficient. It's – a lot of what is written there is really [is] in effect going against nature isn't it, it's trying to beat nature at its own game and going back to what I said before about the medical side of it, it is rather frightening I think. It is very welcoming if it's used to treat cancers and stuff like that but I think that somewhere along the line we're getting into this Brave New World scenario here where everything's [pause], it's this ideal world where everyone lives forever and everybody has everything, everybody can do everything… It's [a] very, very frightening scenario."

Steve: "Well there's echoes of science fiction coming through, Brave New World, to space exploration, super new transit systems and just human evolution as well, being accelerated."

Neil: "But going back to our earlier conversation about the pace of change and there doesn't seem to be any stopping it, this is only 10^{-9}, so 20 years on are we on 10^{-12} and 10^{-15}, this is just the next step …"

Barry: "Exactly. When do you get to that final point, the absolute if you like? They may be nearly there but they may not be."
(Group 1)

These were not gut reactions to some rather optimistic claims of the benefits of a particular technology. Rather, they represented deeper unease with the metaphysical programme driving the technology, its embedded assumptions of what constitutes human progress and improvement, and its potentially troubling implications for wider society. However, perhaps even more than biotechnologies, here was a technological programme based on a style of thought that conceives of nature and humans as infinitely malleable, and which presents a thoroughly questionable view of human improvement as a given. For Dupuy, who has developed perhaps the most systematic critique of the metaphysical programme that underpins radical nanotechnology, the most conspicuous element of the nanotechnological dream is its dissatisfaction with the world as inherited through 'bricolage' and 'hit and miss' evolutionary process (Dupuy, 2009). By contrast, the world – and its component constituents of living and non-living matter – is in principle reconstructable and thus available for redesign and improvement, literally from the bottom-up, atom by atom (NSTC, 1999). This can thus be seen as an extension of a biopolitical style of thought, engendered through biotechnological innovation, in which the biological can no longer be assumed to impose limits to human endeavour and well-being (Franklin 2003; Rose, 2007). Indeed, nanotechnology's much cited goal of 'controlling the structure of matter' through interventions at the nanoscale (from 1 – 100 nm), is at that precise scale at which the distinction between life and non-life has lost all meaning. For Dupuy (2009) this represents a clandestine attempt to blur a fundamental distinction that has until now been a significant source of everyday moral judgement and ethical reason.

The imputed ideal of a hyper-technological age involving radical 'improvements' in bodily function and capacity was debated in other groups. While superficially appealing to some, these developments were seen to raise substantial moral and social issues, not least the ability for governments, industry and other darker forces to exercise sufficiently robust forms of control and oversight over its mediation on everyday life activities. The consensual response was to appeal for such innovations to 'slow down' to ensure that scientific advance was properly in tune with wider public values and societal oversight. The discussion below highlights the sensed dangers of technology proceeding *as if* it, and we, were was not part of life and natural process:

Sally: "I find it quite daunting actually, I find it a bit scary."

Rochelle: "This is the vision of the robotic environment with everything controlled for you and everything 100% perfect and plastic."

Renee: "It's like even the food… Food has got a process the same as we've got a natural process you know, you're born, you get older, you get wrinkles, you die. Same as fruit, you buy a piece of fruit it's healthy, after a piece of time it wrinkles you throw it away or whatever and that is a natural process and I think in some ways it's kind of fiddling with that natural process."

Moderator: "So you think skin should be allowed to wrinkle?"

(Group 4)

How should one characterise the ethical character of concerns that are being appealed to? As with Davies' (2006) characterisation of ethical talk on xenotransplantation, it is apparent that nanotechnologies have the potential to blur key distinctions through which social life is ordered. This constitutes the second explanation and includes, *inter alia*, the blurring of the idea that enhancement is distinct from therapy, that we can never completely get rid of diseases, that humans live and die, that humans and machines are fundamentally distinct, that matter can be made from the bottom up, and that everything can be made, unmade and remade[1]. It is the perceived neglect of such boundary work within the broader nanotechnology community – or what Dupuy (2009) calls a false humility that consists in denying that anyone has been done out of the ordinary - that people found disturbing, as illustrated in one particular apt remark by a participant in Group 5: '*It's like nanotechnology is the new God'.* This comment, deploying the 'false humility' narrative, reflects not simply the perceived lack of limits in much of nanotechnology talk, but the more troubling perception that nanoscientists were proceeding with little regard or understanding or even awareness of the endeavour in which they were participating. In particular, and making use of an older set of metaphysical assumptions premised on the notion that there exists a wider patterning and order to life which we ignore at our peril, were expressed concerns about the 'unnaturalness' of the undertaking. One way in which this was expressed was in arguments on the likelihood of 'nature's revenge': that the more radical and interventionist the attempt to control and intervene in nature the stronger and more potent the likely retort. The exchange below articulates the use of such a 'Promeathean' narrative, and of nature taking vengeance as a direct consequence of human interference and meddling:

Julie: "That's the problem, is what we're interfering with again is nature, the natural cycle of things, which is where I have a problem. It's partly that it is sort of right that sometimes crops are wiped out, there's sort of a reason for everything I think."

Rosie: "I wouldn't trust nature not to seize upon it as it's done with these super-weeds…" (Group 2)

An interesting variant of the above critique were accounts arising from the mechanistic metaphor that tends to imbue much nanotechnology rhetoric. Bernadette Bensaude-Vincent analyses the ways in which molecular biology and materials science converge on a thoroughly 'artificialist view of nature'. She sets out the multiple ways in which nanotechnologies rely on a conception of biological life and the human body using mechanistic concepts and metaphors: most notably around the cell and its molecular components as nanoscale machines (Bensaude-Vincent, 2004). Using George Canguilhem as inspiration, she argues that that such a project has demonstrable ethical components, and that the mechanization of life is inseparable from a project of instrumentalization of life and control over nature. In our discussion groups, the extreme mechanization which

[1] I am indebted to Alfred Nordmann for this observation.

nanotechnology represents was also seen as connected to forms of government and corporate control and their propensity for new and more direct forms of subjection and surveillance. This unease, making use of such 'artificialist' narrative, was voiced eloquently by the one of the London groups, that, 'we're turning into robots':

Renee: "I mean it's exactly what somebody over here said before, we're turning into robots. That is exactly what it sounds like…"
Renee: "When it comes directly to human beings and trying to make them…, it's like trying to make a perfect race again, going to that."
Karen: "We just don't know the long term effects do we, that's the problem."
Renee: "But you have to know the side effects and what we're letting ourselves in for."
Toni: "So basically our generation's going to be like the ones that they test this all out on, if it all goes horribly wrong, we'll be the guinea pigs."
(Group 4)

Again Dupuy provides a metaphysical explanation to such commentary arguing that precisely when 'being human' is reduced to the status of an object that can be fashioned and shaped at will – the very conception of mind as machine that enables us to imagine our ability to recreate life and matter in our own image – we lose much of our ethical capacity for critical reflection (Dupuy, 2009). Without ethical boundaries grounded in a conception of social order the concept of self limitation loses meaning. In such an ethically restricted world there is little reason to presume why nanotechnologies will not be deployed to extend control and reduce autonomy. The exchange points to the forms of subjection that a programme of human enhancement was seen as likely to engender:

Paul: "I think the worrying thing for me… is that it's almost as though we lose control of what's going on because the technology itself is capable of almost taking, replicating, and almost making, you know, pretty much making its own decisions."
Philip: "I think that is a big problem. It's like the thing you were saying with the creativity as well. If the human controls the technology that's fine, as soon as it becomes the technology making all the decisions then that's when you have a problem, because… humans are completely different from a computer."
Paul: "There's some scary dark futures where you have strains of children who are, and are not enhanced in some way, and that's a really dodgy thing. I mean enhancement, the ageing process and things like that…"
James: "Do you have your kids injected at birth to enhance their, the way their muscles grow and things…"
(Group 5)

The above dynamics contributed to the sensed difficulty of developing robust and effective systems of governance and regulation. One the one hand, there was a perceived requirement for wise and strong forms of government and oversight. Yet, on the other hand, there was a shared concern that governance structures and requirements would be compromised, inevitably, by 'real-world' contingencies arising from the constraints of living in a globalised economy as well as the sensed intractability of nanotechnology's metaphysical programme.

Conclusions

I conclude by reflecting on the reflexive politics of this particular piece of research, and on its contribution to debates on the institutional governance of emerging technologies. It

could be argued that this piece of public engagement research is limited for two reasons: for being too 'upstream' and thus not reflecting solid public opinion (see Rogers Hayden and Pidgeon 2007 for a version of this criticism); and for having had little demonstrable direct input into matters of practical governance. However, in response, the purpose of the research was not intended to inform directly public policy. Rather, the purpose was to seek to *characterize* emergent public opinion, and to develop a methodology and mode of analysis for researching technoscientific concerns in-the-making (see also Macnaghten et al, 2005). The subsequent results were indeed shaped by the research design but again that was precisely the point: to expose participants to the styles of thought in which the technology is being framed in the public domain such as to reflexively examine the power of such narrative forms. Finally, while the research process may have inadvertently masked difference within the public groups it nevertheless presented a picture of emergent public opinion characterized by a dense array of issues that remain woefully under-represented and marginal to public policy discourse. Indeed, notwithstanding the recent move in critical public engagement studies, away from emphases on talk and discourse and towards a focus on the embodied and performative dimensions of deliberative practices (see, for example, Chilvers, 2008; Davies and Burgess, 2004; Irwin, 2006), this paper suggests that innovative and theoretically-informed group talk offers an enduring medium to critically engage with a future-oriented techno-scientific politics.

Perhaps most significantly the research offers an explanation as to why people expressed such bleak and pessimistic views on the future prospects of the technology; that just when we as a collectivity require strong ethical and regulatory governance structures to guide and shape the development of nanotechnologies in socially progressive and responsive directions, that very possibility appears to be denied by a socio-technical system that believes that nothing special is being undertaken, that considers its dreams of control and improvement to require little external endorsement or explanation, and that is embedded within a set of master narratives in which science and technology are staged unambiguously as the solution to a range of social ills (European Commission, 2007). Faced by such double-blind it is inevitable that people respond to what is at hand, mobilising the range of cultural resources and 'folk theories' through which they can make sense and render familiar a strange, uncanny and potentially transformative set of technologies (Rip, 2006). For this reason the research sought to articulate the kinds of narrative strategies used by participants to justify their positions.

Parallel research has outlined several prominent tropes and narratives underpinning public responses to nanotechnology: ranging from the 'slippery slope' narrative, that technological advances that seem beneficial now will inevitably evoke further technological steps and applications that are morally doubtful; the 'colonisation' narrative, that technology will spread out and ultimately colonise life denying autonomy and agency; the 'Dr Strangelove' narrative, that advanced science designed for 'good use' will become corrupted and manipulated by evil people for evil purposes; the 'Trojan Horse' narrative, that innovations developed for progressive purposes will in the long term have unforeseen and potentially irreversible effects; and the 'it's out' narrative, that involves the accidental release of harmful substances often due to technological and/or human failure (Swierstra and Rip, 2007; Rejeski, 2007). In the research we can add at least five further narrative variations. These include: the 'kept in the dark' narrative, that nanotechnology reflects a further instance of not being able to participate in decisions that will structure future social relationships; the 'bodily invasion' narrative, that involves the introduction of invisible substances that subsequently violate natural processes; the 'Promethean' narrative, involving nature taking retribution on nanoscience's hubristic sense of its ability to transform

both nature and humans to its own will and in violation and disregard for evolutionary process; the 'artificialist' narrative, that inadvertently instrumentalises life and human relationships through conceiving of biological and mental life purely as machines; and the 'false modesty' narrative, involving the pretense that nothing special is being undertaken.

These narratives are by any means new. Many have their origins in ancient classics and philosophy and have found on-going and enduring expression in the form of fables, morality tales, literature and more recently in films, science fiction and video games. However, just as Jon Turney (1998) has analysed the long shadow of Frankenstein in debates on the new genetics, one needs to understand why certain narrative forms continue to resonate and why they continue to provide an enduring resource for contemporary political argument and thought. My argument is that it is precisely these kind of narratives that will continue to shape popular perceptions of science and technology, and which will provide the landscape over which future techno-politics will be articulated. Of course, there exist counter narratives too, around technology as progress, science as salvation and enabler through heroic discovery and breakthrough, and so on. But such narratives will be played out on the larger cultural stage whose interplay will depend on complex institutional dynamics where the telos of scientific endeavour – its purposes, priorities and imaginings – will come to be increasingly scrutinised.

There is a further reflexive element that warrants attention. Bensaude-Vincent (2004) has highlighted a marginal voice within the nanoscience community – comprising largely of chemists such as George Whitesides and Richard Smalley and in stark opposition to the hard engineering paradigm promoted by Eric Drexler – who advocate a different model of nanotechnology and its relationship with nature. Unlike Drexler's machines with their underlying and driving aspirations to emulate and improve on nature, Whitesides and colleagues posit nature as 'art', and of nanotechnology as offering ingenious and artful solutions to complex problems in nature. Such an understanding of what nanotechnology is proposing to do with regards to nature fits within a historical tradition of human technique (or arts) working in harmony with nature, as revealing the powers inherent in nature, and as mimicking the tricks that nature actually uses to solve our own problems. It remains an open question whether this different configuration of nanotechnology's metaphysical project would offer a differing ethical response. If such a metaphysical programme were to rise in prominence, and to be given official recognition in institutional programmes of nanoscience, we might question the enduring coherence of nanotechnology's future-oriented visions, and indeed, of the very meaning of the category of emerging nanotechnologies.

Finally, there remains the thorny question of the relationship between emergent public attitudes and the institutional governance of emerging technologies. In a previous research project on emergent public attitudes to genetically modified crops and foods, conducted in 1996 in the UK two years prior to the public controversy that took place between 1998 and 2000, public groups were found to express profound ambivalence towards the technology (Grove-White et al, 1997). This arose for multiple reasons that included: shared perceptions of inevitability and fatalism; mistrust in the integrity and adequacy of government regulation; unease about the apparent transgression of moral boundaries for no apparent 'good reason'; and disquiet about the limits of 'expert' knowledge in anticipating conceivable and potentially irreversible mishaps. The relationship between such emergent public attitudes and the subsequent and unprecedented political rows of 1998-1999 is complicated and uneven. However, what is undoubtedly the case is that the institutional handling of the controversy – notably its denial of adverse public responses as reasonable – created the conditions under which public reactions and subsequent mobilization came to

be significant, *inter alia*, through NGO campaigns, media coverage, food labelling, supermarket purchasing, consumer boycotts, and subsequent political debate (Grove-White et al, 2000; AEBC, 2001). Another way to read this dynamic was as follows. While the research process had fostered the creation of the 'technoscientific citizen', who became authorised to hold opinions on the social, ethical, environmental and health dimensions of the technology, the subsequent and novel opportunity structures authorised the creation of the activist technoscientific citizen who was now able to enact such opinions through an array of everyday consumer and lifestyle practices.

The message for policy institutions is that public reactions to emerging nanotechnologies have the potential to become significant so long as the questions that appear to underpin emergent public attitudes remain occluded from public dialogue and processes of decision-making. One role of the social sciences is to examine the dynamics through which a nanotechnological gaze opens up new configurations of minds, bodies, relationships, responsibilities, subjection, surveillance, finitude, choice, risk, self-limitation, autonomy and much more. Key questions in this vital politics include: the question of limits to intervention on nature and associated assumptions of control; the ability for advanced technology to transgress moral orderings; the inadvertent social effects arising from an artificialist account of nature and what an alternative might look like in practice; and to whether it is prudent to experiment with technologies likely to produce irreversible effects. Developing the conversation, in partnership with the wider scientific and policy community, and with an eye towards long-term shifts in R&D practice, will be a major endeavour in which the policy-oriented critical social scientist has a distinct role.

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