Negotiating Plausibility: Intervening in the Future of Nanotechnology

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ABSTRACT: This paper investigates the challenges of negotiating plausibility in a national scenarios project- NanoFutures- focused on the social, political, economic, and ethical implications of nanotechnology initiated by the Center for Nanotechnology in Society at Arizona State University (CNS-ASU). The project involves novel foresight methodologies to develop plausible visions of nanotechnology enabled futures, elucidate public preferences for various alternatives, and using such preferences, help further refine future visions for research and outreach. In doing so, NanoFutures aims to address a central question: How to instigate deliberation about the social implications of a new technology whose outcomes are not known? The solutions pursued by the CNS NanoFutures project are two fold. First, NanoFutures limits the speculation of the technology to *plausible* visions. This ambition introduces a host of concerns about the limits of prediction, the nature of plausibility and how to establish plausibility. Second, to subject these visions to democratic assessment by a range of stakeholders, thus raising methodological issues as to who are relevant stakeholders and how to activate different communities to engage the far future. This article makes transparent the dilemmas posed by and decisions made about such methodological issues and articulates the role of plausibility in anticipatory governance.

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1. TECHNOLOGIES IN THE MAKING

We produce technologies that have a lasting impact on social and environmental systems and yet the long-term is not regularly considered in the choices we make about emerging technologies. Choices about emerging technologies are tricky due to the Collingridge (1980) dilemma: outcomes cannot be predicted until a technology is adopted, yet once path dependencies materialize and technologies get "locked in", control or modulation becomes difficult as rigidities in markets, cultural values, institutions and policy form. Our ability to confront this dilemma and responsibly govern the outcomes of our technological endeavors is lacking; how to create space for discerning dialogue, generating options, and setting priorities upstream requires further attention.

Efforts to more conscientiously assess and steer technological development face several problems. Assessments must involve a broad range of stakeholders that maintain different "epistemic cultures" (Knorr-Cetina 1999) or ways of knowing. Such diversity is evident in the natural sciences in fields such as nanotechnology that are comprised of material scientists, biologists, engineers, physicists and chemists. Further, scientific and technological knowledge are inseparable from social knowledge where a complex of values, experience, institutions, discourses and policies are woven tightly together to design, adopt, implement and use technology. Decades of research in Science, Technology and Society (STS) (Hackett et al 2007) has demonstrated how technology develops in concert with a broad range of actors and agendas in what Jasanoff (2004) calls the co-production of science, technology and society. However, a much more limited constituency, often with homogeneous interests, is often making decisions about technology. This leads to a narrow awareness of what choice options are available. Efforts to cultivate society's ability to better govern emerging technologies must convene disparate groups, with often contrary agendas, to increase the range of options considered and the sources of wisdom bearing on them.

Governance is also complicated by the speed of technological change. Emerging technologies, like nanotechnology, are outpacing regulatory structures, political response, educational systems, and the leveraging of social choice. The disparity between the speed of technological change and the speed of our governance systems and cultural understandings severely stress our ability to act responsibly in the present on behalf of future generations. As a consequence, the governance of technology is a complicated affair rife with public controversies, accidents, delays, and difficulties in prioritizing investments to produce positive social outcomes as evidenced by the GMO debate, controversies over nuclear energy, and the politics of stem cell research.

Governing emerging technologies faces two main challenges: 1) insufficiently diverse and reflexive decision making; and 2) a speed of technological change uncoupled from capacity for socio-political response. A key feature woven through these dilemmas is uncertainty which shows up on multiple levels. Emerging technologies, like nanotechnology, have uncertain developmental paths. Scholars characterize the new production of scientific and technological knowledge as "post-normal" (Funtowicz & Ravetz 1990) indicating that facts are uncertain, diversified value systems and diversified stakeholders lead to dispute, and that the stakes are high. Yet, it is not only technological knowledge itself that is shrouded in uncertainty, but crucially the social implications of emerging technologies are broadly unknown.

Regular ways of dealing with uncertainty through prediction are insufficient as scholarship has divorced the linear model of innovation which suggested that the past is a good indication of the future. We simply cannot predict the outcomes of technological change with any accuracy. Neither is the option to wait and see satisfying due to the way that path dependencies develop and often foreclose superior socio-technical systems (Arthur 1989). Guiding emerging technologies towards desirable societal outcomes and ensuring that the positive impacts outweigh the negative, requires upstream engagement (MacNaugten et al 2005), to evaluate new technologies at an early stage before lock-in limits the range of choices available.

Future-oriented tools and dialogues have the potential to build reflexivity into the design and development of emerging technologies and are a component of technology assessment described as "anticipatory governance" (Barben et al 2008): the ability to "collectively imagine, critique, and thereby shape the issues presented by emerging technologies" (992). The challenge is to employ and refine methodologies that seek to understand uncertainty strategically, in such a way to create social learning and contextual awareness which can lead to better solutions to complex problems.

While grasping future complexities and accounting for the ongoing myriad of interactions between values, machines and regimes has proven daunting for the social sciences (Williams 2006; Selin 2008), the practice of foresight (Irvine & Martin 1984; Grupp & Lindstone 1999; Tsoukas & Shepard 2004) has long dealt with reflecting on alternative, plausible futures. As methodologies born from future studies (Bell 1997), technology assessment (Rip et al 1996), and strategic planning (Wack 1984; van der Heijden 2005), foresight is a means to analyze the explicit and implicit stories embraced and circulated to cope with futures known and unknown. Scenarios are one time-tested foresight methodology for coping with uncertainties through instigating perceptual change and disestablishing entrenched modes of thought so as to enable public and private organizations and multi-stakeholder groups act more intelligently and more readily.

This paper describes how future-oriented methods are brought to bear in a national scenarios exercises conducted by the National Science Foundation funded Center for Nanotechnology in Society at Arizona State University (CNS) (see Guston and Sarewitz 2002). The key impetus for the NanoFutures project is spawned from the tasking of CNS: to investigate, through a suite of methodological tools, the implications of nanotechnology. This mandate is passed on from legislation (Public Law 108-153) that posits that social science should be conducted in cooperation with nanotechnology research itself in such as way to influence the outcomes in socially robust ways (Fisher et al 2006).

The question that immediately arises from this mandate is: how to study and encourage deliberation of implications of something that has yet to occur? That is, nanotechnology is largely about potential and future deliverables, promising to be revolutionary. But given the inchoate form of it, there are no completely reliable and grounded ways to talk about implications. This situation poses challenges for the social scientists who have been summoned to go into the lab, talk to policy makers and engage the public about nanotechnology. They must confront the future.

It is clear that "the future" is a conceptual landscape full of high stakes, filled with hopes and fears, and dreams for generations to come. When it comes to technological futures, representations are caught up with notions of progress, innovation and responsibility. Nanotechnology- as this decades 'revolutionary' technology- is not immune to futured discourse, rather it seems to thrive on it (Selin 2007). However, it is less clear how social scientists should conduct research and outreach around plausible futures. How to construct "credible" "data" about the future? What is the best way to convene actors in a future-oriented dialogue about the outcomes and embedding of new technologies? How can the co-production of technology and society be made visible and thus subjected to conscious choice and steering?

What arose for CNS in working to meet these challenges was the lack of clarity and scholarship around the concept of plausibility. While a full theoretical rendering of plausibility is premature, this article describes how plausibility was operationalized in practice. This article will describe and explore the trials of negotiating and establishing plausibility as well as the strategies to develop and deploy a future-oriented technology assessment. As such this paper traces how dealings in the future tense present theoretical predicaments and epistemological ambiguities. Further, the trespass into the future stresses questions of normativity and thus occasions- indeed necessitates- careful reflection by CNS researchers. This paper presents an occasion to make transparent the decisions and dilemmas posed by NanoFutures in an effort to expose some of the tensions of the future tense and how one social science project managed them.

II. NANOFUTURES: A VIRTUAL EXPERIMENT

NanoFutures works to bring the future into the present by allowing a broad range of stakeholders to consider plausible futures and think in advance of ossified technologies. If democratic deliberation through early intervention is the objective, then stakeholders must be activated to consider values, politics, and ethics in advance of the solidification of nanotechnologies' markets, products, policies and practices.

NanoFutures refers to both a research project and website. As a research project, NanoFutures utilizes a host of methodological innovations oriented towards capturing how different professional communities characterize plausibility and imagine social implications of nanotechnology. The website is a tool of outreach as well as a data collection vehicle that hosts a wiki platform and discussion forum that presents future technological products for critique by a broad range of stakeholders.

NanoFutures has three components: (1) Development: constructing the nano-enabled product scenes; (2) Vetting: establishing technical plausibility through multi-method investigations and interventions; and (3) Deliberation: presenting the scenes to a broad range of stakeholders for critique, expansion and discussion. Future products are co-created in the first instance with nanoscale scientists and engineers through vetting engagements and then opened up to broader scrutiny and collaborative authoring on the website. This intervention is an effort to ground the future and co-create scenarios of nanotechnological products in an iterative fashion in order to inspire debate and provide an opportunity for engagement around the social implications of nanotechnology.

A. DEVELOPMENT: CONSTRUCTING NAÏVE PRODUCT SCENES

Distinguishing characteristics of nanotechnology emerge more clearly in the context of specific applications and so the first step of the project was the creation of different *naïve product scenes*. These scenes are short vignettes that describe in technical detail, much like technical sales literature, a nano-enabled product of the future. One of the hallmarks of nanotechnology is that its products will impact aerospace, healthcare, electronics, military and a variety of consumer products and as such the scenes span a range of different application areas. In order to begin to narrow nanotechnology, selection criteria was developed on the basis of nanotechnologies relevant to Human Identity, Enhancement and Biology- a theme for the Center in 2007-2008- and which equally address nanotechnologies that draw on information technology, cognitive science and biology.

The task of selecting a set of prospective technologies around which to craft the scenes was a daunting one which required a rubric to lend structure and manageability. The subject of human enhancement helpfully limited the technologies yet also references a spectrum of technologies that either constitute enhancements or are enablers of human enhancement technologies. NanoBioInfoCogno (NBIC) is by far the more common rubric for discussing converging technologies and provides a further means to parse the human enhancement space. NBIC also makes

NanoFutures Scenes:
Engineered Tissues: *Using tissue printing technology, this system is able to build tissues with a vascular structure enabling the building of new organs.*
Living with a Brain Chip: a *cranial chip that features a data feed which puts information into the brain while the user is resting.*
Automated Sewer Surveillance: *Ultra fast sequencing technology is used to analyze the DNA in harvested waste water, thus screening large populations.*
Disease Detector: *a device that tracks an individual's protein levels to monitor changes that imply early stage illness or disease before symptoms emerge.*
Barless Prison: *a caged drug that is injected into prisoners that becomes activated by radio control if prisons cross designated boundaries.*
Bionic Eyes: *an optical implant that looks and functions like a normal eye yet has new enhancements enabling magnification, visualizing infra-red, and night vision.*

explicit cognitive science, one of the more controversial aspects of human enhancement.

The scenes were generated from documented claims in the published scientific literature, the popular science literature, and the science fiction literature (Bennett 2008). Through structured deliberation of a multidisciplinary CNS team, ten technical descriptions were created that suggested a reasonable mix between short, medium and long term developments.

The use of future products poses a tension in that we mean to introduce broad deliberation about society, values, ethics, and control yet do so within a limited framework of consumption. Though few would argue that values and consumption are unlinked, framing futures in terms of products does force a framework of capitalism and market forces that may be thought to undermine deeper reflections on, for instance, enhancement, identity and religion. Yet in order to hone in on technology in use, focusing on products seems a reasonable way put deeper ethics in context.

Evoking naivety in the development phase marks an innovation of traditional scenario methodologies. While scenarios have been used in many different fields, with different purposes and using a variety of methodologies (van Notten et al. 2003), the approach pursued here is novel. The product descriptions are intentionally called "scenes" to distinguish them from "scenarios". Scenarios are usually complete stories with a beginning, middle and end logically tied together with a plot. As a difference, the scenes feature an extreme focus on technology: rather than constructing elaborate worlds that include politics, social movements and economic systems- as scenarios traditionally do- scenes describe a nano-enabled product, unencumbered with explicit illustrations as to the social, political, economic and ethical implications of such products. This rendering of scenes as naïve leaves open and ambiguous the social implications of such technologies so as to invite others to frame their own issues and concerns in the deliberative thrust of the project.

B. VETTING: ESTABLISHING PLAUSIBILITY

The scenes were vetted prior to their dissemination to counter the lack of realism attending much of the popular discourse surrounding nanotechnology. Nanotechnology is a subject matter infused with wildly speculative discourse, and there is a tendency to dismiss future applications as "impossible" thus cutting discussions about upstream choices short.

The process of vetting follows three main lines: (1) focus groups with scientists with relevant expertise, (2) bibliometric analysis of key terms produced in the focus groups, (3) research roadmapping.

The vetting workshops aimed to expose the scenes to relevant scientists for their evaluation of plausibility, timeliness, and relevance. The invitation to the workshop explained

> "Some of the technologies exist today but are not scalable, while others rely on years of development - whichever the case, we are asking for leaps in imagination with the realism and measured judgment of expertise… Our goal is that you will challenge the scenes by looking for glaring technical reasons that the scene is invalid while hopefully suggesting alternative technologies and pathways to the eventual product. If the technical products look more or less reasonable, it would be helpful for us to know what sort of breakthroughs or technological advances need to take place for this to be realizable."

Participants for the vetting workshops were chosen from the ASU community based on how pertinent their scientific or technical expertise was to the technology described in the scene[2]. However, the scenes contain technological products that do not exist and often rely on the convergence of different disciplines for their manifestation. While the futuristic and interdisciplinary character of the scenes could have been obstacles, we found that, especially with scientists advanced in their career, interdisciplinary understandings existed and could come to bear on analyzing the future-oriented scenes.

During the vetting workshops, the scientists and engineers were asked if the scene is feasible and were asked to comment on the following parameters:

- Technical validation- Within the realm of current understanding, is this technology possible? Are the descriptions technically complete and accurate?
- Relevance- Does the scene capture what is interesting about this technological trajectory?
- Alternatives- Is there a more elegant or effective way of arriving at a similar function?
- Revisions- What changes should be made to the scene that makes it more plausible?

In addition to the vetting criteria, the participants were also asked to generate search terms. The prompt was: If you were going to begin a research project devoted to this application, what search terms would you use to discover the state of the art? These search terms were specific, eg. neuron chip or general, eg. bionano*. The terms were then shipped to Georgia Tech to scourer 4700 publications pulled from Web of Science, Science Citation Index (see Porter et al 2007). The search generated reports of top publications, research institutions, lead authors and countries.

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[2] However, getting the scientists and engineers to agree to participate in the vetting process was not easy. Our first attempt involved a mass mailing to ASU scientists with relevant expertise. After several attempts- including hand delivering the scenes- we decided to try the focus group approach, also requested by email which resulted in one vetting session. The subsequent vetting workshops were painfully arranged, and mostly involved scientists who knew the CNS or who had direct experience working with science policy and readily understood the Center's objective to cultivate broader engagement around the future of nanotechnology. In the end, personal contacts mattered a great deal.

A growing method of technology assessment, this data mining is another means of establishing that these scenes are relevant, have ongoing research, and while not commercially developed, are underway in the lab. In this way, in addition to the live vetting in the workshops, the scenes are connected to published research and existing research activities in real time, thus providing another layer of plausibility.

The last task of the vetting workshop was to produce a technology roadmap that answers: What kind of research is necessary to realize this product? A roadmap is an exercise in reverse engineering that:

- outlines and references current research
- specifies direction of research threads (relevant to the product)
- notes the technological obstacles that need to be overcome
- estimates the dates for solutions/breakthroughs along the way

The roadmaps linked current R & D with future R & D resulting in a chronological list of scientific problems and technical challenges. The roadmap serves as another means to frame conversation beyond "is this possible?" and asks researchers to specify their views. This structuring into time enables the focus group to explain in more detail the technical hurdles. In some instances, the construction of the roadmap has lead to other pathways of developing more elegantly the same product, thus revising the scene.

As deficient as this process of vetting may seem scientifically, we believe it is both technically and ethically robust compared to the more normal situation in which a technically trained individual offers an utterly ungrounded prediction of what additional funding in his or her area of research will do for society. The checking of one's view of the future against others in the workshop as well as validation through the other vetting mechanisms provided multiple avenues to check plausibility. This does not suggest comprehensiveness, but rather triangulation, an important concept in lieu of validation.

Vetting the scenes actually comes in two phases. In the first instance with the vetting procedures, and then again with the main deliberative thrust of NanoFutures through involving broader stakeholders reflecting on technological expectations via the website and other outreach activities of the Center.

C. DELIBERATION: OPEN SOURCE SCENARIOS

The deliberative component of NanoFutures is an attempt to discern how different groups of people assess and assign values to the technical scenes that we generate. While this component is an intervention in its own right, it also serves as a means of data collection as to how different communities assess plausibility. The hope is that communities working in and around nanotechnology engaging with NanoFutures will become better equipped to confront technological choice and understand more clearly the arguments of different stakeholders.

One of the rationales for NanoFutures begins with the idea that those involved in shaping nanotechnology not only hold different ideas of what nanotechnology is, but also what it will be. Creating a space for reflection on deeply- but often tacitly- held expectations is meant to serve as a corrective to myopia but also to force stakeholders to confront their own assumptions about the future.

The website is designed so that users from different professional communities can see each others' thoughts and critiques. Users can debate in a discussion forum where they are invited to critique the scenes and encouraged to address issues of governance and control, ethics and religion, and cultural, economic and legal change. Users can also further elaborate on the scenes in a wiki platform in such a way to add social context and complexity. This elaboration is meant to transform the scenes into scenarios, where the technical descriptions are fleshed out with attention to ethics and social dimensions thus animating the scenes and constructing stories around the technical descriptions. Users also have the opportunity to write their own scenes or scenarios.

The NanoFutures website is designed so that each participant can see others contributions in real time, thus in principle allowing an ongoing, transparent assessment of nanotechnology. The goal of the Deliberation phase of NanoFutures is to create clear thinking around the social implications of nanotechnology and as such open the future to critical reflection. We make clear that the scenes are fictional and not predictions of what nanotechnologies will actually do in the future.

The community of users invited to participate were:

- Social scientists: 4 S members
- Publics: ASU alumni, National Citizens Technology Forum participants[3]
- Nano-interested people: Foresight Institute members, the Center for Responsible Nanotechnology community, the CNS-ASU network
- Public policy folk: Consortium for Science, Policy and Outcomes community
- NGO's engaged with nanotechnology: identified through internet research
- Scientists and engineers: Awarded grants through National Nanotechnology Initiative (NNI)

Note that we do not consider the ASU alumni or the participants of the NCTF to be representative of the public at large, but rather of a sample that may have different stakes in nanotechnology than scientists, policy makers, or those advocating for nanotechnology. The first round of NanoFutures was launched primarily to US audiences, though scholars in Latin America and Europe have expressed interest in translating and using NanoFutures. Soon after the launch of NanoFutures (in May 2008), science teachers, an environmental advocacy group, defence analysts and museum professionals expressed

[3] The National Citizens Technology Forum are a nation-wide extensive and intensive form of public deliberation conducted by CNS-ASU. In March of 2008, CNS-ASU recruited a panel of citizens, provided them with detailed background information about NSE and access to NSE experts, and allowed them to develop a set of recommendations for decision makers, all with the support of the research team and a professional facilitator.

interest in using the site and the scenes in their respective professional activities. This response evidences the potential utility of the virtual outreach generally, and the value of the scenes for outreach and educational activities more specifically.

While there are obvious shortcomings with selecting these communities, we feel they will offer a reasonable range of perspectives.[4] We expect that these different communities maintain different epistemologies and as such will have different standards of plausibility and different ideas about governance, ethics and desirability. The forthcoming analysis of the website entries will begin to establish how plausibility and social implications are configured by different communities. [5]

Involving a wide range of stakeholders in deliberative technology assessment builds upon lessons of STS, particularly critical public understanding of science research that has shown that people immediately outside of technological development make sense of technology in surprising ways, ways that cannot be known by the analyst a priori. The idea with *open source scenaric thinking* is that as researchers we cannot presume to know what different communities make of implications so instead we should solicit their perspectives. Though employing naïve product scenes, we set the stage for “extended peer review” (Funtowicz and Ravetz 1990).

III. NEGOTIATING PLAUSIBILTY

An intervention that focuses on instigating debate about plausible futures suggests predicaments. What does plausibility mean for claims that are unable to be confirmed? In dealing with *anticipatory knowledge*- projections, visions and expectations- what counts as valid and trustworthy knowledge? Anticipatory knowledge is not about facts, historical evidence, nor presently observable phenomena. Instead, it is more about speculation and the sorts of precognition that are blatantly positioned in the future. This trespass of knowledge into the future renders impotent traditional measures of knowledge. We are accustomed to validating facts, confirming history, and observing events. While the notions of fact, history and events are regularly subject to interpretation, they are far more justifiable than anticipatory knowledge. What we loose are notions of evidence and proof. The question remains: with what consequence?

Through the vetting procedures, plausibility was negotiated, quantified, visualized and assessed through the vetting procedures. Plausibility was taken to means such things as feasible, realistic, possible, tenable, credible or defensible. Yet surprisingly fact and fiction were not heavily contested in the context of the vetting workshops. Caveats were regularly given when the vetting workshop participants were confronted with the scene. The scientists were quick to say “that work is currently not happening.” The facilitator would then ask, “if one technical hurdle was surpassed, would this device work?” Through an iterative dialogue, of ifs and thens, the scientists were able to specifically comment on

[4] We also note the obvious limitation of our sample via excluding people without internet access.

[5] The NanoFutures website was launched May 2008 and as such data on how plausibility is negotiated in this phase of the project is not available at the time of this writing.

what the technical hurdles are and what new lines of research or discoveries would be necessary. In lieu of proof for such developments, arguments were developed that maintained scientific credibility and conformity to current technical knowledge.

Many of the vetting sessions resulted in nominal changes to wording or slight changes in the technology. The scene about ultra fast sequencing technology used to analyze the DNA in harvested waste water was approved with a quick "yes, that is exactly how it would work" by a senior scientist and his lab. Another scene that describes a cranial chip with a data feed that puts information into the brain was modified from a single brain chip to a network of chips due to the lack of knowledge about where memory functions in the brain. In this case, uncertainty was figured into the technical description through the choice of a more robust technological pathway.

One scene was removed from the project due to the vetting session. This scene showcased adjustable tattoos created by injecting magnetically active ink under the skin which could then be shifted into a design using small electromagnets. When the CNS researcher approached the Center for Solid State Sciences to discuss the scene, an engineer explained that anytime you put that strong of a magnetic force on a particle, you would attract the particle directly to the magnet, effectively removing the particle from the tissue. Whereas the scene relied on the horizontal movement of the ink, the force of the magnet would move the particles along a more vertical vector. The engineer then proceeded to pull up a series of equations about the movement of particles under different magnetic field strengths. In this vetting session, the engineer was so engaged in the project, and so devoted to developing a solution, that after exhaustively explaining how the scene wouldn't work, he spent much effort developing another way for the magnetically based tattoo to function. The problem with the scene as originally proposed was that the particles would be sucked up laterally with the magnet, thus making it impossible to shift the design, but enabling a complete removal of the particles. He proposed using the same technology to inject the magnetic ink into a desired form and using the force of the magnet to remove all the particles, inventing a removable tattoo. Through known calculations, the new scene was deemed plausible.

Plausibility was also negotiated through a system of checks and balances, a sparring of imagination and reason. Post Doc Ira Bennett of the CNS, who conducted many of the vetting sessions, reflects on one of the vetting workshops held in a laboratory meeting:

> Students were eager to show their knowledge and ability to use it creatively while the faculty kept them in check concerning the practicality and feasibility of their ideas. Members of the laboratory group told me they felt as though the group had benefited from the experience as it provided some context to the students on where the technology could go into the future, past the day-to-day tedium of macaque models and algorithm development (Bennet 2008, 153).

In a quasi oral exam, plausibility was established through a balance of open ended, creative discussion and expert validation. The value to the laboratory group also displays how the vetting sessions were an engagement in their own right offering concrete outcomes in terms of productive interactions between social scientists and natural scientists.

The vetting exercises established a first layer of plausibility through engagements with local communities of NSE researchers. Yet the NanoFutures research lay beyond "technical" plausibility. The scenes are intentionally vetted on the technical front as a means to establish upfront the basis for a serious conversation about social implications that cannot be rejected out of hand for technical reasons. Thus establishing technical plausibility can be seen as a pre-engagement intervention and secondary to the broader plausibility that is explored in the deliberation phase of the project.

The key thrust of the project lies with the open source scenaric thinking that elicits what broader stakeholders say about plausibility. We believe the open-source approach should liberate more useful information about what is thought to be plausible among a wide, "extended" (Funtowicz and Ravetz's 2001) group of technical and lay actors. Deliberations through web activities are meant to establish community-determined plausibility to explore economic, social, political plausibility and presumably shift into questions of desirability more generally.

IV. TENSIONS OF THE FUTURE TENSE

Intervening on people's views of the future intervenes on the future. On the one hand, this is nothing new- interviewing people who have been abused often refigures the past in the mind of the abused- they come to write their history in a new way upon further reflection. Similarly, putting the future in clear view and explicating expectations provides an opportunity for reflection. Those engaged may come to view their ambitions, goals and acting in the world differently. Social science research that focuses on historical events or experiences can reconfigure memories, but social science research that focused on future events and desires can reconfigure intent and hence action now and in the future.

The proposition that NanoFutures may affect one's view of the future is not insignificant. One of the key rationales for the project is that expectations matter. NanoFutures is one way to try to articulate and challenge expectations that operate in a context of consequence. There is a significant- but too little explored- linkage between expectations and consequence. From Merton's (1948) self-fulfilling prophesies to more recent studies on the performativity of futures (Michael 2000; Brown 2003), we understand that such visions are not just rhetorical articulations of the future, but are actually constitutive of futures. While the recognition of performativity suggests a need for taking seriously expectations, it also interestingly draws attention to how interventions on the future mean to- and inevitably do to some extent- shape futures by highlighting choices previously unseen.

NanoFutures thus has an effect by intervening on futures, mainly through the deliberative component that initiates conversations. Stimulating debate always involves structuring and thus closing down particular avenues of concern. That is, we recognize that by seeding the conversation with one scene rather than another, we already direct the conversation. For this reason, we have been attentive to the balance of the scenes in terms of technology area and time frame to realization, as well as with some thought to a mix of "positive" and "negative" scenes. Clearly we cannot choose all good (or all bad) scenes, for that would be propaganda in its own right. Choosing a journalistic approach of balancing one "good" scene with one "bad" is a reasonable approach, but that would also mean substituting our judgment of what is good and what is bad for other actors in a complex system of evaluation. That, in essence, is the purpose of the open source styling of NanoFutures – to investigate different communities' evaluative schemes by focusing on specific instances of future nanotechnologies.

NanoFutures frames the future, and as such the intervention act in real time, in the present, and has the potential to reorient attention and modify action. Understanding the import of imagined futures in priority setting, technological design, and public acceptance suggests that creating stories of the future for social sciences purposes is about intervening in a contentious and influential debate. The CNS recognizes that by presenting scenes, we are also shaping the discourses surrounding nanotechnology. Depending on the reach of the site, scientists and policy makers may begin to think about their work in a different way.

Indeed, the CNS means to evoke a particular set of competencies in anticipatory governance (Barben et al 2008) with the aim to "build into the R & D enterprise itself a reflexive capacity that…allows modulation of innovation paths" that are more in line with social values (Guston & Sarewitz 2002, 100). Being able to grasp what those values are when it comes to technologies-in-the-making is the challenge and aim for NanoFutures. Yet by pursuing this inquiry, we likely modify what it is we are studying. The work of the CNS is in this sense normative and means to have consequence.

There are additional risks in employing the future tense in research. For example, there is a risk of avoiding or downgrading the present by centering debate in the future. Many of the societal issues posed by future nanotechnologies, like toxicology, equity, or access, can often be more meaningfully framed in the present. While the import of acting now should not be underestimated, utilizing the future tense builds upon a central idea captured in anticipatory governance: technologies follow paths characterized by early flexibility and later obduracy, and that technologies can be made more socially robust by instigating such deliberations in advance of potentially entrenched problems with technology. There is also the idea that distancing from the present by evoking the future provides some psychological comfort, divorced from the immediacy and urgency of quests for funding, agenda building and definitional disagreement. The future arises as common territory, a shared space that appears more open-ended on the one hand, but also makes more obvious the role of choice and human agency in the development of new technologies.

By creating a space for reflection on *plausible futures*, the CNS hopes to disrupt well rehearsed and entrenched notions of progress that typically attend perspectives on new technologies. Without reflection, technological visions tend to overestimate the speed of technological change and underestimate the speed of social adoption (or rejection) and cultural change (Geels & Smit 2000). Without reflection, it is difficult to enable inclusive reflexive decision making across society on issues of technology. Establishing plausibility appears as a crucial element of future-oriented deliberative practices. Though not without risks, establishing plausibility seems to enable the conversation to begin. In this project, plausibility was something that was locally-defined in the vetting workshops, triangulated with data mining and then extended broadly to stakeholder communities. This multi-method, real-time approach to plausibility captures the fleetingness of the future. Build into how plausibility was operationalized by CNS is an understanding that context matters and what is plausible now may not be in the future.

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