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Discussing Nascent Technologies: Citizens Confront Nanotechnology in Food

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Abstract How does the public articulate its visions, expectations and concerns regarding a technology whose applications and ramifications are only just beginning to be worked out? Nanotechnology is an emerging technology on the brink of offering transformative applications to the food industry at every level, from food packaging to the nutritional quality of the food itself. But the very newness of the field has had a significant impact on efforts to establish a dialogue between scientists and the general public on issues surrounding the commercialization of nanotechnology. In such a context, facilitating a dialogue between scientists and the general public is a formidable task, and yet the idea of "upstream engagement" is gaining currency as an approach that may alter the present relationship between science and society. A series of critical questions arise. Will attempts to engage citizens in discussions of nascent technologies empower them? How will such attempts ultimately address the normative commitment of science and technology studies to the democratization of scientific and technological decision making? How do lay participants in such dialogues negotiate the differences in expertise between themselves and scientists? How do they establish the legitimacy of their assertions? How do nonscientist members of the public evaluate statements made by both scientists and nonscientists? The study offers a critical analysis of an experimental attempt at upstream engagement in the Japanese context and the social dynamics which hinder meaningful dialogue.

Keywords Nanotechnology in food · Social interaction · Consensus conference · Upstream engagement · Japan

1 Introduction

How does the public articulate its vision, expectations, and concerns regarding a technology whose applications and ramifications are only just beginning to be

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worked out? Nanotechnology is an emerging technology on the brink of offering transformative applications to the food industry at every level, from packaging to nutrition itself. But the very newness of the field has had a significant impact on efforts to establish a dialogue between scientists and the general public on issues surrounding the commercialization of nanotechnology. Relevant scientific data are in short supply, and a framework for evaluating or regulating risks is very much a work in progress. The public has not yet formed clear opinions about nanotechnology, nor has the mass media shown an interest in reporting stories on the topic. In short, it is too early for the public to have a say about the trajectory of innovation.

In such a context, facilitating a dialogue between scientists and the general public is a formidable task, and yet the idea of "upstream engagement"—bringing the public into the process of envisioning, evaluating, and influencing the trajectory of technological development at a very early stage, before the technology is fully developed—is gaining currency as an approach that may alter the relationship between science and society (Wilsdon and Willis 2004). Indeed, a considerable number of such programs have already been carried out, primarily in Europe and the USA. The interest in this approach is evidenced by a growing body of work reporting these attempts (Guston and Sarewitz 2002; Kleinman 2005; Gavelin et al. 2007; Kleinman et al. 2007; Toumey 2007, Pidgeon et al. 2009). Support has come from scientific institutions such as the US's National Research Council and the UK's Royal Society and Royal Academy of Engineering, each of which has issued a report pointing out the importance of engaging the public in the early stages of technological development and scientific research (Rogers-Hayden et al. 2007).

In Japan, the idea of upstream engagement by contrast rarely comes up. Instead, the government and the private sector have worked to foster public acceptance or to examine the ethical and social implications of nanotechnology. As for programs specific to food applications of nanotechnology, typically only experts are invited to participate, and they proceed from the assumption that it is up to the experts to decide which issues are important and how to frame the terms of the discussion. For instance, when Japan's Science and Technology Agency organized a conference on food nanotechnology in 2008, it invited experts—not laypersons—to identify the scientific and technological questions that needed to be addressed in the coming years (Center for Research and Development Strategy 2007). The conference did encompass themes related to the interface between science and society, but the focus was consistently on public perceptions of food nanotechnology, rather than on public involvement in making decisions about nanotechnology and its applications. More recently, a group of social scientists formed a group, I2TA, funded by the Science and Technology Agency; this group has carried out programs concerning food, medical, and environmental applications of nanotechnologies, but they have all focused on assessing technologies rather than conducting dialogues with the public.

Other food technologies, such as the genetic modification of crops, have been the subject of public discussion in several countries, including the USA, the UK, Australia, New Zealand, and Japan (David and Thompson 2008; Horlick-Jones et al. 2007; Hindmarsh and Du Plessis 2008; Kobayashi 2004), but can these programs be described as upstream engagement? No, because the programs attempting to engage the public took place after the technology was already in use: social impacts were already visible, and controversy had already erupted. I agree fully with the contention of Rogers-Hayden et al. (2007) that a great deal of definitional, conceptual, and methodological confusion surrounds the idea of upstream engagement, and that therefore the concept needs to be revisited for clarification. For the study described in this paper, the first attempt in Japan to involve the public in discussions of the food applications of nanotechnologies, we adopted the definition put forth by the Royal Society and Royal Academy of Engineering (2004), which states that an effort to engage the public in discussion of a new technology can be considered “upstream engagement” when (1) decisions related to funding and infrastructure for research and development have yet to be made, (2) impacts upon society have yet to be seen, and (3) the new technology is little discussed outside of specialist circles. When we consider that scientists are just beginning to explore the applications of nanotechnologies to food, that the social impacts of such applications have yet to be seen, and that the topic has received relatively little attention in the mass media, it is clear that an effort to engage the public at this stage will meet the definition. Research and development are already underway in Japan, but they are in their infancy. In 2007, the Ministry of Agriculture, Forestry, and Fisheries launched a project for producing food ingredients at the nano-scale, identifying new functions of food ingredients at the nanoscale, and evaluating the safety of such ingredients (National Food Research Institute 2010). The project is meant to run for 5 years. Very little relevant information is as yet available to the public.

A series of critical questions arise. Will attempts to engage citizens in discussions of nascent technologies empower them? How will such attempts ultimately address the normative commitment of science and technology studies to the democratization of scientific and technological decision making (Sclove 1995)? How do lay participants in such dialogues negotiate the differences in expertise between themselves and scientists? How do they establish the legitimacy of their assertions? How do nonscientist members of the public (including legislators) evaluate statements made by both scientists and nonscientists? Relatively little attention has been paid to the ways in which the deliberative processes are influenced by relations between scientific and other forms of knowledge. While studies of citizen dialogues that take into account power asymmetries have been carried out in the areas of medicine (Kerr et al. 2007) and biotechnology (Goven 2003), in both areas the significance of such asymmetries was already known: it was openly discussed when citizen engagement programs were first implemented. Within the literature dealing with citizen engagement on issues surrounding nascent technology, there has been an unexamined assumption that power relations among participants will have little influence over the dialogue because the issues are still so fluid and controversial. By insisting on the significance of power, we will be able to reflect critically on how to conduct an engagement program in the early stages of technological development.

In this paper I examine the “Mini”-Consensus Conference—a smaller-scale implementation of the consensus conference model—on food nanotechnology held in Sapporo, Japan, on September 6, October 4, and October 5, 2008, with a particular focus on how lay participants expressed their ideas and concerns when confronted with nascent technologies. While I focus on citizens’ responses to nanotechnologies and food, I also hope to contribute to a broader understanding of strategies for engaging the public, particularly when the technologies are in the early stages of development. I will first describe my analytical framework and provide background on the event. I will then analyze the nature of the dialogue at the conference. In my conclusion, I will suggest some broader implications of my findings.

2 Framework

This study examines the nature of the interactions between laypersons and experts and also among lay participants by exploring the content and context of dialogues observed at a Mini-Consensus Conference held in Japan, the focus of which was the application of nanotechnology to food. I argue that merely setting up a participatory program during the early stages of development is inadequate if one hopes that citizens will influence the technological trajectory, because hierarchical relations based on scientific and other forms of knowledge inhibit full and effective expression of public opinions and concerns. Dedicating an event to citizen engagement does not guarantee effective dialogue. As has been noted by Kleinman (2000), the scientists invited to this type of event generally represent economically, culturally, and politically powerful institutions that possess a great deal of prestige and influence—often they hold key positions in these institutions. Most have been awarded advanced degrees in the relevant disciplines and are known as experts on food nanotechnology among their colleagues, policy-makers, journalists, and industrialists. Although many of the lay participants at the conference I studied held college degrees and all were capable of articulating thoughtful comments, the power differentials were real. They could promote social dynamics that enabled some participants to influence others, blocking their efforts to voice their ideas. These power imbalances limited citizen engagement.

The event was part of a broader project entitled Civic Values and Nanotechnology Applications in Agriculture and Food. I was a member of the project and also served on the steering committee that organized the event.[1] My study draws on data obtained through participant observation and audio recordings, and on semi-structured interviews with participants conducted after the event. Field notes were taken and recordings were transcribed for analysis.

Comments made by participants were analyzed and coded as belonging to one of three categories: Scientific Knowledge, Individual Values, and Public Values. These represent the different epistemological bases used in interpreting food nanotechnology, namely, science-, experience-, and value-based. Scientific Knowledge refers to comments or questions derived from scientific sources—such as the formal background information lectures given by scientists—or from other scientific and technical materials, such as handouts distributed at the event or literature that the participants had previously reviewed. Individual Values refers to comments or questions based on individual needs and wants. Public Values refers to statements or questions about the ways in which food nanotechnology will affect the common good based on values and norms.

[1] The steering committee comprised six social scientists who specialize in such areas as studies of science, technology and society; science communication; and public policy regarding agriculture and food. They were responsible for designing and implementing the event. Independent of the committee, an advisor oversaw the program and an evaluator independently carried out data collection and observations.

For instance, a statement such as "You (i.e., a scientist who had given a lecture) told us earlier that changing the sizes of particles will transform osmotic pressure—how might this affect our digestive tracts?" was coded as Scientific Knowledge. Comments such as "Nanotechnology might make the texture of chocolate much smoother—I would like that," "I wonder if nanofood will taste good," and "To me, the taste of the food matters more than its safety" were classed as Individual Values. And comments such as "I believe that food nanotechnology is promising because it has lots of potential to revitalize industries in Hokkaido (Japan's main northerly island)" were coded as Public Values. Appendix 1 gives examples to clarify further how the data were coded. My analyses are based on the coded data and on the field notes taken during the course of the event.

3 Event Description

The consensus conference was one of three public dialogue events called NanoTRI. Organizers hoped to compare the results of the conference to a focus-group interview and a science café. In this paper I describe only the consensus conference; details on all three events have been provided by Mikami et al. (2009).

Unlike a conventional consensus conference, which generally involves 14 nonspecialist panel members and ten to 15 presentations by experts over 4 days, this event was reduced to 3 days to meet constraints on funding and scheduling. Our program had ten nonspecialist participants and five experts. The nonspecialists were found by distributing fliers and running advertisements in newspapers and on the Hokkaido University website for 3 weeks in August 2008. Applicants were evaluated to ensure a group with varied backgrounds. Those chosen from among 25 applicants included five males and five females whose ages ranged from their twenties to their seventies; they included a graduate student, a public servant, industry employees, a school teacher, and a part-time worker (see Table 1). The expert panel was recruited from a relatively small circle of specialists via snowball sampling techniques, and included scientists specializing in food engineering

Table 1 Demography of lay participants

Participants	Age cohort	Sex	Occupation
A	20 s	M	Graduate student
B	20 s	F	Employee of a private company
C	30 s	M	Part-time tutor
D	30 s	M	Teacher
E	40 s	F	Freelance writer
F	40 s	F	Part-time worker in a private company
G	40 s	F	Consultant
H	50 s	M	Teacher
I	60 s	F	Small business owner
J	70 s	M	Small business owner

(Experts 1 and 2), a scientist specializing in food safety evaluation (Expert 3), a scientist from a company carrying out research on and development of food ingredients and functional foods (Expert 4), and a representative of a nonprofit organization engaged in various outreach programs aimed at bringing more nonspecialists into scientific discussions (Expert 5). Though their jobs varied, the experts all knew each other prior to the event through collaborative research projects and academic meetings.

The venue for the event was Hokkaido University, chosen because two of the committee members were on the faculty there and because the university has graduate courses in science communication and was thus equipped to provide resources useful for the event. Though the choice of venue was thus rather instrumental, the site did not seem to represent the interests of any particular parties (for example, corporate sponsors of nanotechnology). The steering committee assumed that a university setting helped create a sense that the event was being held in a safe place with procedural transparency assured (Horlick-Jones et al. 2006). At the same time, however, holding the event at a prestigious university might have contributed to the sense that experts should not be questioned.

The program for the 3-day event was as follows:

Day 1:

1. Two background lectures were given by representatives of national research institutes, one by a food engineering scientist (Expert 1) and one by a scientist specializing in food safety evaluation (Expert 3). The lectures gave an overview of food nanotechnologies, including examples of nanotechnology applications in food and packaging, methods for measuring nanoscale particles, and research frontiers related to food safety. Talks by other specialists, such as health experts and nanotoxicologists, could have been helpful, but the limited scale of the conference ruled out adding experts with those backgrounds.
2. Question-and-answer (Q&A) session in which lay participants asked questions of an experts.
3. Lay participants drafted the key questions for the experts.

Day 2:

1. Responses were given by four experts (1, 2, 4, and 5) to the key questions generated on Day 1.
2. Group discussion among lay participants (two groups of five participants each) with no experts present.

Day 3:

1. Group discussion among lay participants in the presence of experts.
2. Drafting written recommendations.

4 Findings

To study participants' interactions and trace the evolution of the nonspecialists' interactions over the course of the event, I focused on three sessions out of the entire

3-day event: the Q&A from Day 1, the group discussion with no experts present from Day 2, and the group discussion with experts present from Day 3. The selection grew out of variations I noted in the intensity of expert-lay interactions.

Table 2 shows the numbers of comments made at each session, broken down by categories. The number of comments per minute is included in the table because it provides some idea of the intensity of the interactions. The values indicate that people spoke more frequently in the Day 2 Discussion than in any other session analyzed. The number of comments and the proportions of the types of comments against the total number provide some picture of the types of comments lay participants made. These figures suggest that during the Day 1 Q&A and the Day 3 Discussion, lay participants spoke more about scientific issues, whereas the nature of comments in the Day 2 Discussion was qualitatively different, in that participants spoke more about how they felt about food nanotechnology or how the present development of nanotechnology might relate to public values. Further details will be given in the next section.

5 Deference to Scientific Knowledge

Having outlined the data and offered a preliminary analysis, let me move on to describe the nature of the observed discursive processes. Firstly, I observed a dissonance between the ideals of the citizen-engagement approach and the discursive processes that prevailed at the conference. When nonspecialists had face-to-face interactions with experts, as in the sessions on Days 1 and 3, they were drawn to issues concerning food safety and scientific uncertainties. For example, Participant D spoke mostly about Scientific Knowledge (three comments out of three) in the Day 1 Q&A, when experts were present, but he shifted to Individual Values and Public Values (nine comments out of 16) in the Day 2 Discussion, when lay participants were left to talk on their own. Similar interactional dynamics are observed with Participant H, whose comments shifted from Scientific Knowledge in the Day 1 Q&A and the Day 3 Discussion (three comments out of seven and two comments out of two) to Individual Values and Public Values (19 comments out of 22) in the Day 2 Discussion, which included experts. These phenomena suggest that when scientists were present and activities were structured (as when an informational lecture is followed by questions and answers), the perceived hierarchical relations between scientific knowledge and other forms of knowledge were reinforced and participants tended to favor topics more specifically scientific and technical.

Table 2 Number of comments

	Duration of dialogue in minutes	Total number of comments made	Number of comments per minute	Scientific knowledge	Individual values	Public values
Day 1 Q&A	46	56	1.21	34 (60.7)	14 (25)	8 (14.3)
Day 2 discussion	41	75	1.83	13 (17.3)	43 (57.3)	19 (25.3)
Day 3 discussion	83	20	0.25	15 (75)	5 (25)	0 (0)

Further, particularly during the sessions in which experts were present, participants who had some background in science took on more prominent roles in the discussion, and those who felt they did not have relevant backgrounds hardly spoke. These imply that a science-based understanding operated in one set of circumstances, while an experience- or values-based understanding operated in other circumstances. The presence of experts invited lay participants to pose science-based questions, which, in turn, created an atmosphere that privileged scientific over other forms of knowledge, hence marginalizing participants who attempted to understand food nanotechnology from different standpoints. For instance, questions such as the following took center stage when scientists were present: "Materials will be reduced to nanoscale, which will cause the materials to have properties which were not present in the original materials, right? And then even if the nanoparticles are coagulated once again, the materials will not regain the properties possessed by the original materials, right? Does that mean that you will be creating something unexpected?"

On the other hand, comments based on everyday forms of knowledge were frequently dismissed by the experts. For instance, Participant I rarely spoke up at the event, but was keen on finding out whether gold flakes accumulate in the human body. Her question derived from her interest in cosmetics and health foods, topics of interest to the customers of her beauty salon. The response to her question was couched in scientific terms, and no connection was made between her life experiences and the scientific information presented. This clearly violated a basic tenet of the citizen-engagement approach, which calls on experts to shift away from technical explanations and connect with the life experiences of nonspecialists. Participant I did not pursue her question; she was unable to make clear to the others why she was interested in this and how gold flakes and nanotechnology were connected. Throughout the course of the event, this participant rarely spoke up, which gave others the impression that she did not have a lot to share. Nevertheless, in the post-event interview I conducted with her she was very attentive, had a great deal of experience to share, and had many questions about nanotechnology.

A sampling of this participant's unanswered questions along with some of the comments she made to me will illustrate the point:

> I was curious to ask that scientist representing industry—what is his name?—something because his talk was very interesting. I wanted to ask things like, if we only eat or drink foods that are nanoscale, I wondered how that would affect gastrointestinal motility. Without eating fiber, we will not be able to maintain a healthy life. If we did not have to chew or use our teeth, what would happen to us? I became very concerned. The more I heard from experts, the more concerned I became. But I did not say anything about my concerns. [. . .] I find it very difficult to voice my ideas. [. . .] I feel that I may sound rude.

She also commented: "I kept quiet because a person like myself who does not have a good education should perhaps not be there."

Additional evidence that the nonspecialists were influenced by a sense of limited competence comes in the form of hedges—a linguistic category that includes phrases used to signal uncertainty and deference (Brown and Levinson 1987). Identifying such comments helps us understand perceived power relations. While deferential hedges were not used with great frequency overall, it is noteworthy that the experts never made use of them, and several lay participants used them in the sessions at which experts were present. For example, comments such as “Sorry, but I would like to ask . . .” and “This might not be relevant to the present discussion because the idea has just popped into my head, but . . .” were heard in the sessions on Days 1 and 3 but not in the Day 2 Discussion. When a lay participant wanted to raise questions that were not purely scientific, he started off with an apologetic preamble. While these participants saw the issues concerning food nanotechnologies as multifaceted—hinging not only on scientific matters but also on economic, social, and political concerns—the setting made scientific issues seem most relevant. The following exchange supports this generalization:

> Participant E: My question is not scientific and it might not even be relevant, but there is one thing that I would like to ask, and perhaps you may know the answer. In your lecture, you mentioned that we already have foods that use nanotechnology, such as canola oil. Do you have any idea whether it’s more expensive than other types of oil, which do not use nanotechnologies?
>
> Expert 1: I am not familiar with that.

Even when the question did relate specifically to the information presented at the lecture, participants often appeared hesitant to raise questions. Again they sprinkled their statements with hedges, as this example illustrates:

> Participant A: This is a minor question. [. . .] Your handouts indicated that there are many products out there in the market that use the particle “nano.” An example that occurs to me is the iPod nano. Since I’ve learned the definition of “nano” from your lecture, I guess that the iPod nano probably does not really use nanotechnology. This is just one example, but I am sure that there are many other cases like this. I wonder if there are any international standards that will define which products in the market use nanotechnologies and which do not.
>
> Expert 1: I do not think there is such a standard at the moment. Industries use “nano” to imply that the item is small.

Evidence of questions asked and unasked, of unequal levels of participation among the lay participants, of apologetic or deferential language—all these show the great challenge of engaging lay participants in dialogue with scientists. Even when great efforts were made to foster an atmosphere in which participants felt equal, with a facilitator to ensure that everyone got an opportunity to voice ideas, the lay participants tended to defer to the experts. This echoes the conclusions of a study of an engagement program related to the siting of a nuclear power plant in Japan; there perceived power differentials between laypersons and government officials kept the former from thoroughly voicing their opinions (Juraku et al. 2007). In addition to the gap between lay and expert participants, it seems clear that power imbalances existed among the lay participants as well—backgrounds, especially education, age, and sex, created a certain hierarchy. If truly egalitarian exchanges are the ideal, we ought to address the important question of how to reduce such barriers to free expression.

The Day 2 Discussion sessions—lay participants interacting without experts—demand further analysis, as the proportion of comments either deriving from individual experience or hinging on public values is much higher than in the two other sessions analyzed. In addition, conversations were relatively intense. Observation of the deliberative processes in these sessions suggests that participants felt, in general, more comfortable expressing their ideas and trying out their opinions in these sessions than in other settings. Participants shifted from reactive to proactive engagement. Consequently, the range of issues and perspectives exhibited was more diverse and multifaceted. With no scientific lid on the discussion, different points were raised and freely discussed. A sense of trust became palpable. These discussions provided valuable insights into lay perspectives concerning food nanotechnologies, and there were good reasons to revisit the issues raised.

One of the recurring issues was the reasons scientists came up with the idea of using nanotechnologies in food and agriculture, a topic listed among the questions drafted by lay participants on Day 1. Lay participants had found earlier answers unsatisfactory, so the issue came up again in the Day 2 Discussion sessions. Here is an example of that sort of dialogue:

> I didn't think that nanotechnologies were ever used for food. I saw a TV program that talked about carbon nanotubes, so I thought nanotechnologies were for industrial use, never for food. The idea of food nanotechnologies seems to have emerged suddenly.
>
> I felt the same way, yeah. My impression is that scientists, without thinking too much about the social responses to it, have just come up with something that suited their scientific curiosity. The explanation we get feels like a story made up afterwards.
>
> I don't think we need to use nanotechnology in food. Why should we? There is no point in collecting food safety data if we decide not to adopt it, right?

A number of other comments had a similar tone. Some participants said that food nanotechnologies were not needed; others worried about how safety issues would be addressed if these technologies were commercialized. Yet others pointed out that the use of nanotechnologies in food and agriculture might dramatically alter Japanese customs and practices with respect to food.

Although these issues routinely came up in the Day 2 Discussion sessions, the final report that lay participants drafted at the end of the final session on Day 3 (see Appendix 2) did not reflect these discussions. Doubts and questions were replaced with phrases that explicitly and implicitly affirmed the advancement of nanotechnologies in food and agriculture. For instance, the first chapter of the recommendation document, entitled "Eating Is Both the Source of Life and One of Life's Joys," includes the following passage: "If nanotechnologies are to be used in food, we suggest that they not impinge on our enjoyment of life. The passage ends by saying 'an opportunity to consider the social implications of food nanotechnologies has given us a chance to revisit our food traditions." Nothing in the chapter reflects the sense of uneasiness that showed up during the group sessions.

Other chapters in the recommendation document presented lay participants' suggestions for social prescriptions, all predicated on the assumption that food altered by nanotechnology would appear on the market. This suggests that the interactional dynamics between expert and lay participants obscured potential confrontations. This phenomenon, in fact, supports those who have said that an upstream engagement program is fully compatible with a linear model of scientific and technological development (Joly and Kaufmann 2008; Stirling 2008), the very model that citizen engagement programs are attempting to overcome. The very fact that a consensus conference is structured to funnel open-ended discussions into a set of written documents may, by its very nature, exert pressure on participants to come up with questions and recommendations that seem congruent with the dominant discourse—in this case, a discourse characterized by deference to the scientific perspective. It is ironic that this may be especially true when an attempt at dialogue is being made during the early stages of scientific and technological development, because the extent to which people can anticipate the consequences of such technologies in relation to their lives is minimal. It is precisely when the salient issues have not yet been identified and conflicting ideas are not clearly defined that a scientific discourse can override other forms of knowledge and marginalize any alternative views of food nanotechnology.

6 Conclusions

This paper has presented an analysis of discussions between experts and lay participants and among lay participants at a Japanese consensus conference on food nanotechnology in order to shed light on how perceived hierarchical relations between scientific and other forms of knowledge influence the nature of interaction. The analysis suggests that the perceived power hierarchy between forms of knowledge created real constraints on citizen engagement by inhibiting at least some lay participants from fully voicing their ideas and questions. Deference to scientific knowledge was prevalent, a finding which runs counter to the objective of a citizen engagement approach (as set forth, e.g., in Joss and Durant 1995). Interactional dynamics masked potentially useful confrontations. It would be worth looking into whether similar kinds of exchanges are observable at similar events held in other countries. It may very well be that the phenomenon that I have observed occurs most frequently in Japan, where expressing personal feelings in the public sphere contradicts certain strongly held cultural values. This suggests that upstream engagement through consensus conferences may not suit the Japanese context. The challenges such events face in Japan are no doubt complicated by interactional dynamics defined not only by perceived hierarchies between experts and non-experts but also by social hierarchies.

A number of studies have considered a range of approaches to citizen engagement to identify methods best suited to specific contexts (Leroux et al. 1998; Rowe and Frewer 2000; Rowe et al. 2004). Indeed, that was how the NanoTRI, an event that involved three different approaches, was initially conceived. Though this paper has examined only the consensus conference, my preliminary analysis of the data generated from all of the NanoTRI programs suggests that the deliberative methods thought to encourage citizen engagement face a set of challenges. These need to be seriously considered.

The present study confirms the suggestion that because nanotechnology is in its early stages of development, engaging those who are affiliated with citizen groups instead of individual citizens might be an effective device for encouraging the public to articulate its ideas (Deng and Wu 2010), enabling citizens to help shape research and the development (or constraints on development) of emerging technologies. Furthermore, sensitivity to the applications of nanotechnology is also an important dimension to be considered when designing a program. As has been pointed out by Pidgeon et al. (2009), the ideas expressed at public engagement programs devoted to nanotechnology and energy differed markedly from those expressed at nanotechnology and health forums. Studies by Michael Siegrist et al. (2007, 2008) also indicate that the public acceptance of nanotechnology varies depending on whether food applications or food packaging applications are at issue. These studies suggest indirectly that when organizing a dialogue program, instead of introducing the overall field of nanotechnology as a theme and then attempting to focus in on multiple potential applications, organizers should begin with a specific application. This will foster better articulation of laypersons' ideas and concerns.

The study of consensus conferences shows how difficult it can be to get laypersons to engage with nascent technologies when scientists are still formulating potential applications. The problem appears to be inherent to attempts to exert a social control over nascent technologies (Collingridge 1980). However, once the technology is fully developed it will resist external efforts to influence its trajectory. In order to meet these challenges, we will need to revisit the roles of social scientists in shaping a technological path that is culturally and socially sensitive (Macnaghten et al. 2005). My own experience suggests that, rather than acting merely as observers or as analysts of social phenomena, we social scientists find ourselves in a position of greatly increased responsibility to help the public to articulate visions, expectations, and concerns about nascent technologies.

The frequent implementation in Japan of a range of public engagement programs on various themes, such as citizens' juries, consensus conferences, and science cafés, suggests an increased awareness that citizens should have a say in the course of scientific and technological endeavors. Trying out a range of approaches will raise public awareness and provide valuable insights, breaking the technocratic monopoly on decision making. Still, we should not assume that redesigning the engagement model and the implementation of related events instantly democratizes science and technology.

Many questions remain to be addressed about the various meanings attached to food nanotechnologies, and we must learn more about the distinct epistemological bases lay participants turn to. Where does this leave us? If we wish to realize the basic objectives of the public engagement model, we need to reconsider how to design a model that will fit the Japanese sociocultural context. It is crucial that we draw on empirical evidence to design new strategies for public engagement, all the while considering how power imbalances influence the quality of the deliberation processes and how the wider social context facilitates or constrains meaningful participation in the dialogue.

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Appendix 1: Examples of Coded Data

Scientific Knowledge

1. If nanoparticles get into cells or cell nuclei, do they affect the functioning of the cells?
2. I understand that when foods enter our systems, the food will be digested to the level of the nanoscale by enzymes. When you use the same terminology, "nanoscale," for industrial applications, how small are they?
3. I am aware that some of the products that contain nanoparticles are already on the market, but you mentioned that you are still carrying out experiments to assure its safety. Does this mean that our market will be filled with products using nanotechnology that have not been tested for safety?
4. You have mentioned that you will use nanotechnology for fertilizers. Does that mean that plants that use those fertilizers will grow big [. . .] one-and-a-half times bigger than conventional plants? Where would that lead us? To monster plants?
5. We can get protein from petrol, and we can make meat from soybeans. Would those products be categorized as nanofoods or something else?

Individual Values

1. Problems with genetically modified food have surfaced through food labels, but problems with nanofoods have not appeared. We might even be eating them without being informed and without knowing. That is a scary thing.
2. No one explained to us which companies are trying to make money with nanotechnologies. Are many industries involved already, or is it a wait-and-see situation?
3. I wonder whether nanofoods taste good. Everyone may not agree, but I do not mind eating foods that are not 100 percent safe. If they are tasty, that's what counts. I would prefer to die early from eating tasty foods than living longer by eating safe foods.
4. Hearing this talk about nanotechnologies, I remembered that sunblock sometimes has a label that says "nano." How is it regulated? Because it worries me.

Public Values

1. I do not think we need to use nanotechnology in food. Why should we? There is no point in collecting food safety data if we decide not to adopt it, right?
2. It sounds like nanotechnologies for food will help get sufficient nutrients while eating little. It sounds like an improvement in gas mileage. I think maybe with these technologies we might be able to feed the world.
3. Why is it necessary to use nanotechnologies? If nanotechnologies will not bring about tremendously good things, there is no point in using these technologies. Maybe it could be useful in medicine.
4. The information distributed by the national research institute is too complex for us to understand. I felt that we all need to learn more about nanotechnologies, so clearly informational packaging has to be put together. Is anyone working on this? This information in this leaflet is really complex: you'd need a background in chemistry and biology to understand it.

Appendix 2: Excerpts from Recommendations

Ordering the "Food of the Future"

Recommendations from the Mini-Consensus Conference Regarding the Application of Nanotechnology to Food[2]

October 5, 2008
NanoTRI Mini-Consensus Conference
Members of the Citizens' Panel

At the most recent mini-consensus conference we, the ten members of the Citizens' Panel, reflected on and debated the applications of nanotechnology to food, taking into consideration the observations of experts from various fields. The ten of us spent approximately 24 h over 3 days discussing the following questions: Can nanotechnology produce foods that we want to eat? Taking into consideration the current status of the application of nanotechnology to food, what do we want from the "food of the future"? On the first day of the meeting, September 6, 2008, several experts provided us with basic information about the relationship between food and nanotechnology, and we summarized the doubts and problem areas that we perceived with respect to that information: these were our "key questions." On the second and third days of the meeting, October 4 and October 5, we held a question-and-answer session and exchanged views with four experts regarding these key questions. Then we, the ten members of the Citizens' Panel, shared our concerns and opinions and debated them. Finally, we compiled our recommendations in this document. Based on the 3 days of debate at the NanoTRI Mini-Consensus Conference, we, the members of the Citizens'

[2] English translation of the recommendations was done by a professional translator supported by the funding from the RISTEX's project entitled 'Developing and Introducing Methodologies for Technology Assessment'.

Panel, hereby make the following recommendations regarding the application of nanotechnology to food.

Chapter 1: Eating is Both the Source of Life and One of Life's Joys

Eating is a primordial act that supports human life, and over many centuries the world's ethnic groups have each preserved their own unique food cultures. When people chew their food they sense how delicious it is, and when they eat delicious food they feel happy. When conventional food-processing techniques are used to preserve food, the ingredients retain their original shape; therefore, the appearance of the food conjures the taste and texture of the ingredients to the consumer.

The development of new food-processing technologies such as nanotechnology has yielded products that enable the consumer to ingest nutrients in different forms, such as tablets, jellies, and even liquids; these forms make it difficult to imagine what is being ingested. This is good news for people whose digestive function has been weakened by health problems; on the other hand, the possibility that we will end up consuming monotonous meals that have neither an interesting appearance nor texture three times a day must be taken into consideration. Eating is proof that we are alive. We want to enjoy delicious meals everyday; therefore, the panel wishes to ensure that this joy can be experienced when consuming nanofoods.

We want people to use raw ingredients in their cooking, take the time to prepare their meals carefully, and eat them with their families. This wish is driven by two motivations: our belief in dietary education and our belief in local production for local consumption. However, today parents and children are busy and, thus, tend to opt for quick meals by using precooked food products, etc. We would like to see the development of products that simultaneously contribute toward delicious and safe meals and reduce the work involved in cooking. We would like to add that nanofood research and development will not only have an impact on and change our approach to cooking and consuming meals; it is also predicted to have an impact on the overall process surrounding food, namely, the distribution and preservation of the food until it makes its way to the dinner table. For example, by dramatically improving our ability to maintain the freshness of food, nanofood has the potential to enable people to eat food that tastes as though it had just been picked even if they are outside the area in which it was grown. However, the close relationship between regional climate and ingredients will probably be weakened. Thinking about nanotechnology in food processing has the potential to be a catalyst for the review of all aspects of our food culture.

Chapter 2: Toward the Establishment of Safety

1. A Definition of Nanofood and the Development of Standards for Nanofoods Are Necessary

We would like the relevant specialized institutions to create a precise definition of nanofood. We expect practical difficulties with respect to measurement technologies, etc., but we would still like to see the creation of international standards such those provided by the International Organization for Standardization.

2. Measures for the Labeling of Nanofoods and the Authorization of Nanofoods by a Certification Body to Ensure that Consumers Can Select and Purchase Nanofoods with Peace of Mind

The following three types of labels must be improved: ingredients, manufacturing processes, and purpose (i.e., for the promotion of digestion and absorption, etc.). We want a mandatory nanomark to be created and we want a graded label to be affixed to the packaging of all nanofood products; these will enable consumers to purchase nanofoods with peace of mind.

3. Systems That Reflect the Opinions of Consumers

We would like companies, universities, and research institutions to create systems under which consumers do not consume "passively," as they used to, but instead think actively, along with the developers of nanofoods, about what these products should be like, thereby formulating the future vision of nanofoods.

4. Ensuring a Safe Working Environment

Rules should be created for the establishment of the safety of the workers involved in the manufacturing of nanofoods, albeit using a different approach than that for ensuring the safety of consumers buying these foods.

Chapter 3: Publication of Information

1. Proposals to Companies

We want companies to publish specific details about how they use nanotechnology. [. . .] If they wish to obtain a social consensus, we want them to disseminate product information and increase transparency. We hope that they will offer consumers explanations and information that will enable them to make judgments about whether or not to use foods that are produced using nanotechnology. We believe that the extent to which companies can actively disclose both the risks and the benefits of nanofoods will determine whether they can come out on top in the marketplace. [. . .] If the companies do this, their image will improve and, as a result, they will win the trust of consumers, which will result in profits.

2. Proposals to Public Institutions

We want public institutions, nonprofit organizations, etc., to collate large amounts of information and transmit this information to the public. We recommend the development of an environment that provides consumers easy access to information about nanofoods whenever they have a question.

Chapter 4: Our Wishes and Our Requirements

We want food that will contribute to a richer life and that fully exploits the benefits of nanotechnology. [. . .]

1. Enhancement of Taste, Flavor, Texture, Etc.

   a. Food that enables the consumer to appreciate our innate joy of eating

b. Food that retains its flavor and freshness for a long time, preserving the texture of freshly prepared food
c. Food that has a new texture that is doughy and moist

2. Improvement of the Absorption Ratio

a. Food that improves the absorption ratio through added nutrients modified through nanotechnology
b. Food that fulfils its nutritional function, even when only a small amount is ingested, by improving the ingredient absorption ratio, such as functional food and nutritional supplements
c. Food that aims for a synergistic effect by creating hybrids of multiple nutrients rather than relying on single nutrients
d. Food that blends carbohydrates and the nanotech version of the local specialties of Hokkaido so that a variety of nutrients can be ingested

3. Technologies to Protect Food from Outside Air, Bacteria, Etc.

Food with a nanosized coating that is produced using natural ingredients, delaying the breeding of bacteria and extending its use-by date

4. Technologies That Apply Nanotechnology to Take Advantage of Ingredients Previously Thrown Away

In the interest of averting a worldwide food crisis, nanotechnology can be used on substances that would have been thrown away in the past because they had no nutritional value.

Chapter 5: Getting Familiar with the Food of the Future: Nanoart Education

As we briefly mentioned in Chapter 1 of these recommendations, eating is among the primordial functions of human beings. Moreover, we realize that there is a possibility that dietary habits will change rapidly due to the evolution of scientific technology. Everyone has a right to know about the technologies that surround them, particularly how they apply to food; we feel, therefore, that further education must be provided. We offer the following examples of science education and art education in the broad senses of the terms [. . .].

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