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Potential Solutions to Public Deliberation Problems: Structured Deliberations and Polarization Cascades

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Some deliberative theorists advocate for increased public participation to improve the health and vitality of democracy, but skeptics warn that public deliberation may fall prey to multiple decision-making pathologies. We describe a research program based on structured public deliberations about science and technology policies that was designed to explore the validity of critics' worst fears. In this research, we specifically test the complaint that group deliberations often bias toward the original majority preferences because of cognitive and affective errors in decision making, such as deference to the numerical majority opinion held within a group. Our results, based on data collected from a set of small-group public deliberations about nanotechnology, offer weak support to the polarization hypothesis. We explain this finding as the likely consequence of manipulating two key variables of deliberations: task facilitation and the quality of the argument pool. As a result, we argue that it is possible to structure public deliberations about policy to mitigate known decision-making problems. We conclude by also warning scholars of the dangers in assuming that opinion change consistent with polarization effects is inherently the result of undesirable decision-making qualities.

Introduction

It has become common place in modern life for people to worry about the potential risks and perils of new technologies. In numerous ways, popular worries express themselves and provide policy makers, technology developers, and government regulators with difficult challenges in shaping public policies aimed at developing and deploying those technologies (Bauer, 1995; Piller, 1991; Shrader-Frechette, 1991; Slovic, 1999). Public backlash against genetically modified foods (GMF), for example, largely occurred because citizens became increasingly uncertain whether GMF posed uncontrollable risks (Gaskell, Bauer, Durant, & Allum, 1999). Presently, the rise of nanotechnology is also poised to present difficult challenges for those tasked with conveying its costs and benefits to the public (Cobb, 2005).

Solving these concerns has, in recent years, emphasized the potential value of greater public involvement in shaping the public policies that encourage the development of new technologies, or regulate their deployment.[1] The literature addressing group decision making and deliberation, however, identifies a number

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of decision making pathologies that might distort the outcomes of enhanced public involvement. If deliberative outcomes are expected to produce inferior decisions, then perhaps another model of participatory democracy is needed to resolve kinds of policy issues. In this article, we describe a research program that harnesses the power of the Internet and creates structured citizen deliberations (about science and technology issues) intended to mitigate deliberative problems identified in the literature. We report data obtained from two small group deliberations about nanotechnology that challenge critics' belief that public participation is undesirable because group deliberations are inevitably biased by polarization cascades.

Public Deliberations: The Benefits

Drawing on philosophical developments in deliberative democracy (Bohman, 1996; Dryzek, 2000; Elster, 1998; Fishkin, 1991; Gutmann & Thompson, 2004) and participatory public policy analysis (deLeon, 1990, 1997; Fischer, 2003), many theorists call for more robust forms of public involvement that focus on active deliberative practices by ordinary citizens. Standard public opinion polling, it is argued, cannot plumb the public's thoughtful and informed opinion. On the other hand, reliance upon organized advocacy groups to express public opinion falls prey to the politically strategic maneuverings of interest-group bargaining. Missing from the political mix is the voice of informed, deliberative citizens who are not already committed to a specific policy outcome.

Deliberation theorists claim that deliberative practices can have a number of salutary benefits. In general, these benefits are best described as producing better decisions or better citizens. As for better decisions, Fishkin and his colleagues, for example, argue that deliberative polling produces superior individual-level preferences because informed opinions are more consistent with one's true interests (Ackerman & Fishkin, 2003; Fishkin, 1991, 1997; Luskin, Fishkin, & Jowell, 2002). Alternatively, effective public deliberations, as an integral part of the agenda setting, aggregation, and policy formulation stages of the policy process, will generate public decisions with significantly greater legitimacy than decisions reached without such public involvement (Arvai, 2003). In addition, decisions that clearly embody informed public input of this kind should reduce the levels of public opposition to those decisions, which may allow for significantly improved implementation.

In terms of better citizens, effective public deliberations are thought to create civic learning opportunities for participants and observers that presumably add to the health of a democratic polity (Putnam, 2000; Talisse, 2001). A crucial part of deliberations includes factual learning by the participants, who must be brought "up to speed" on the technical, economic, and political aspects of the issue that they are examining. In this process, the citizen participants also learn first hand the difficulties of balancing costs and benefits, making fair trade-offs, accommodating the demands of diverse affected parties, and so on. In addition, deliberation is predicted to orient citizens away from individual and personal goals and toward common issues. Through the exchange of different views, they hope, more strident

and radical views of some participants will gradually soften, and the group as a whole will shift its concluding opinions more toward a middle ground between the original positions of the participants. According to Mendelberg (2002, p. 3), "The promise of deliberation is its ability to foster the egalitarian, reciprocal, reasonable and open-minded exchange of language."

Public Deliberation: The Costs

Not all scholars are partisans for public deliberations. Fishkin and Luskin (2004, p. 11), both avid supporters of deliberative polling, summarize the criticisms of deliberation found in the literature as *defeatist* (deliberation is impossible), e*xtenuationist* (deliberation is unnecessary), and *alarmist* (deliberation is harmful). After examining the actual participatory preferences of average citizens, Hibbing and Theiss-Morse (2002) conclude even more bluntly that deliberation in the real world can be dangerous. They write:

> [R]eal-life deliberation can fan emotions unproductively, can exacerbate rather than diminish power differentials among those deliberating, can make people feel frustrated with the system that made them deliberate, is ill-suited to many issues, and can lead to worse decisions than would have occurred if no deliberation had taken place. (pp. 190–1)

A central element of many critiques of deliberation involves a number of specific affective and cognitive decision pathologies that often appear when citizens deliberate (Kuran & Sunstein, 1999; Mendelberg, 2002; Sunstein, 2002, 2005). These scholars claim that ordinary people are subject to emotional, social, and intellectual errors in their thinking, and thus the public cannot ordinarily serve as the fundamental guide for policy making. Crucial here is the assertion that the errors afflict not only solitary individuals but also groups of people. Indeed, group interactions accelerate the problems.

One particularly troublesome decision-making pathology is that deliberation promotes *polarization cascades* within groups. Polarization cascades occur when individuals holding the minority opinion in a group adopt the majority opinion for normatively undesirable reasons after deliberating. In some cases, the minority adopts the majority position simply because of the numerical disadvantage of their ideas within the group, as opposed to changing their minds based on the merits of the majority's ideas. In other cases, members of the original minority position move toward the majority position because of cosmetically persuasive arguments, social comparisons, confidence that breed extremism and emotional contagion (Sunstein, 2005). Regardless, each of these sources involves a noncognitive, even nonrational, source of attitude shifts, certainly not what deliberation theorists hoped would result from encouraging ordinary citizens to deliberate together.

Recall that many theorists expected deliberations would moderate extreme views initially held by participants at the beginning of the process. Actual deliberations, however, often fail to follow this pattern of shifting toward a middle position. Rather, groups tend to shift even further in the direction of which ever

position held the majority at the beginning of the deliberations. Instead of fostering an exchange of information that is weighed carefully, discussion serves merely to benefit the already advantaged by amplifying their opinions (Abrams et al., 1990; Brown, 1986; Myers, 1975; Sunstein, 2003; Zuber, 1992). As Sunstein (2003, p. 15) warns, "groups consisting of individuals with extreme tendencies are more likely to shift, and likely to shift more . . . When like-minded people meet regularly, without sustained exposure to competing views, extreme movements are all the more likely." As a result, we too propose that small group deliberations normally descend into polarization cascades when a predeliberation majority preference exists.

Avoiding Polarization Cascades

Is it possible to structure deliberative environments that meet deliberative democracy proponents' expectations while simultaneously avoiding polarization cascades? Several scholars (Delli Carpini, Cook, & Jacobs, 2004; Mendelberg, 2002; Sunstein, 2002) admit that polarization and other deliberative pathologies might be held at bay by manipulating key facets of the deliberative environment. According to the literature, some of the most important factors appear to be the nature of the argument pool (i.e., the diversity of perspectives presented to the deliberators), the social composition of the group, and the operational structure of the deliberations. Sunstein, (2003) concludes:

> Group polarization can be heightened, diminished, and possibly even eliminated with seemingly small alterations in institutional arrangements. To the extent that limited argument pools and social influences are likely to have unfortunate effects, correctives can be introduced, perhaps above all by exposing group members, at one point or another, to arguments to which they are not antecedently inclined. . . . The value of deliberation, as a social phenomenon, depends very much on social context—on the nature of the process and the nature of the participants. (p. 98)

These elements of structure and operations of the deliberations are hypothesized to ameliorate, blunt, or prevent the sorts of cognitive and affective pathologies noted in the literature. Thus, we propose that the use of a professional facilitator and the dissemination of balanced informational materials to create a heterogeneous argument pool significantly reduces the probability of polarization cascades arising.

Data and Methods

Citizen Technology Forums (CTF)

There are a variety of existing techniques for conducting public deliberation, but the Danish Consensus Conference is one of the most intensive.[2] Consensus conferences involve assembling a group of average, nonexpert citizens for the

purpose of advising the parliament about how to manage a specific technology (Andersen & Jæger, 1999; Joss & Durant, 1995a, 1995b; Mayer, 1997; Mayer & Geurts, 1996). The citizens are provided with background materials and access to experts and, with the assistance of a professional facilitator, are asked to devise a set of policy recommendations that everyone in the group can endorse. The end result, a consensus conference final report, is delivered to the press, the public, and the parliament, and typically involves three weekends of work, about one month apart.

With funding from the National Science Foundation and the National Nanotechnology Initiative, a team[3] at North Carolina State University have completed 10 Danish-style consensus conferences (called a "Citizens' Technology Forum"—CTF) including a two-site CTF dealing with nanotechnology.[4] In the two nanotechnology CTFs that we report in this article,[5] one set of citizens was recruited in Raleigh, NC (N = 13), and the other in Boston, MA (N = 7).[6] In each location, we strove to balance CTF participants by gender and family income but, with small samples, this is impossible. As a result, most participants at both sites were White and more highly educated than normal, and in the Raleigh sample, they were heavily Democratic although they were not especially liberal ideologically. While it is not clear that skewed demographics like these affect basic opinions about nanotechnology (Cobb & Macoubrie, 2004), they more importantly might influence deliberation. Some scholars, for example, suggest that characteristics associated with disadvantaged socioeconomic status lead to further inequalities during deliberation (Bohman, 2004; Young, 2000, 2003). Unfortunately, our cases of disadvantaged status are too few that we can not adequately test these kinds of predictions.

Each panel met separately, in face-to-face (F2F) settings, for the initial and the final weekend. In-between, they completed the traditional conference tasks in a series of two-hour online synchronous sessions via the Internet ("keyboard-to-keyboard": K2K), participating at the same time and interacting with each other. During the traditional Danish process, the panelists interact with the content experts during the final weekend. In the nanotechnology CTF, the panelists in both cities interacted with content experts earlier and simultaneously via the Internet. The panelists were allowed to ask additional questions of each expert, to fill in gaps in their knowledge base. As the panelists developed their understanding of the technical, cultural, economic, and political aspects of nanotechnology, they became aware of additional information needs and were encouraged to develop specific questions they would like to put to content experts.[7] Such experts were recruited with the idea of giving voice to as wide an array of opinions within the expert community as possible. Each panel then deliberated separately to produce its own final report; there was no effort made to arrive at a single, combined consensual report.

For both groups, steps were taken to address the issues of the argument pool, the social composition of the deliberators, and the operational structure of the deliberations. Efforts to ensure a wide and diverse argument pool included disseminating carefully prepared background materials on nanotechnology to

each panelist. These materials were vetted by an oversight committee (comprised of technical experts, industry representatives, and spokespeople for involved nongovernment organizations) that reflected as wide a spectrum of opinion as possible concerning nanotechnology. The oversight committee was given the task of assuring that the initial information provided to the panelists was complete, accurate, balanced, and comprehensible to average citizens. Moreover, careful efforts were made to ensure that the deliberators interacted with a diversity of content experts during the question-and-answer components of the CTF.

Furthermore, efforts were made to recruit a diverse volunteer pool, from which representative panels could be drawn. To ensure a wide exposure to diverse perspectives, both panels were able to exchange views, concerns, and opinions via the Internet. The Internet is widely celebrated for its potential to reduce information transaction costs and promote citizens' participatory activities (Coleman & Gøtze, 2001), thereby facilitating the depolarizing effects associated with a wider pool of arguments.

One critical operational element affecting the deliberative environment is the presence of a trained facilitator (Gastil & Levine, 2005). In our research, we used a professional facilitator who worked to (i) minimize personal and social distortions; (ii) give everyone who wanted to be heard multiple chances to speak (or write); (iii) keep the groups focused on specific tasks; and (iv) encourage panelists to deal with everyone's various positions honestly and fairly.[8]

It should be apparent that our design does not include a control group, a CTF without a trained facilitator, or an attempt to vary the quality of the argument pool. The reasons for these omissions are both practical (limited funding reduced the number of CTF) and deliberate (modest objectives). Thus, one of our principal goals was to evaluate whether attitudinal changes after citizens deliberated were independent of polarization cascades. We are unable and unwilling to make more authoritative or comparative claims about the specific effects of manipulating key variables.

Subjective Nanotechnology Preferences

Participants' preferences about nanotechnology policy were measured before and after taking part in the CTF activities.[9] In all, we obtained participants' answers to seven different questions inquiring whether they perceived nanotechnology as too risky in general and too risky for physical or social systems specifically, how important of an issue nanotechnology is for government, whether government could adequately manage these risks, whether the economic costs of not proceeding outweighed potential development risks and whether a worldwide ban on technology was needed (precise question wording for these items are located in the Appendix). All but one question was asked using a five-point Likert response scale ranging from "strongly oppose" or "strongly disagree" to "strongly favor" or "strongly agree" (the question asking

about general risk uses a three-point answer scale ranging from "the risks will be greater than benefits" to "risks will be equal to benefits" to "the benefits will be greater than risks").

Ranking the Risks and Benefits of Nanotechnology

A second set of dependent variables measures participants' priority rankings of the risks of nanotechnology that most need to be avoided and the benefits of nanotechnology that they most preferred to achieve. The lists contained five risks and five benefits of nanotechnology that are commonly cited by scientific experts and are identical to those asked about in nationally representative surveys (Cobb & Macoubrie, 2004; Scheufele & Lewenstein, 2005). The five risks were (i) "economic disruption caused by the loss of traditional jobs," (ii) "losing your personal privacy to tiny new surveillance devices," (iii) "a nanotechnology inspired arms race between the U.S. and other countries," (iv) "breathing tiny nano-sized particles that accumulate in your body," and (v) "the uncontrollable spread of self-replicating nano-sized robots." The five benefits were (i) "cheaper, longer lasting consumer products," (ii) "new and better ways to treat and detect human diseases," (iii) "increased national security and defense capabilities," (iv) "new and better ways to clean up the environment" and (v) "the ability to improve human physical and mental abilities."

Results

We begin by examining the most basic formulation of polarization effects, whether after deliberating the mean opinion within a group moves in the direction initially favored by a majority. Thus, we compare each of our CTF groups' initial mean opinions across the seven measures of nanotechnology preferences in the pretest survey to the mean opinions in the posttest. The results of these comparisons are presented in Tables 1 and 2, by CTF location. Included in the tables are

Table 1. Group Means Test for Polarization Effects, Raleigh CTF

Measure	Scale Midpoint	Predeliberation Means	Postdeliberation Means	Supports Polarization Hypothesis?
Risks versus benefits	**2.0**	**2.38**	**2.77****	**Yes**
Importance of nano	3.0	3.23	3.46	No
Physical risks too high	3.0	3.0	3.7**	Yes
Social risks too high	**3.0**	**3.54**	**3.69**	**No**
Government will manage risks	3.0	2.77	3.08	No
Need to develop nano	**3.0**	**2.85**	**2.77**	**No**
Need a worldwide ban	**3.0**	**4.15**	**4.0**	**No**

Notes: The scale midpoint is the neutral position on the opinion measure; means below the midpoint indicate originally unfavorable opinions and means above the midpoint indicate originally favorable opinions; ***$p < 0.05$; **$p < 0.10$; *$p < 0.15$, two-tailed paired-sample T-tests. Highlighted rows indicate cases when the pre-CTF majority opinion was substantial (at least a two-person majority).

Table 2. Group Means Test for Polarization Effects, Boston CTF

Measure	Scale Mid-Point	Predeliberation Means	Postdeliberation Means	Supports Polarization Hypothesis?
Risks versus benefits	**2.0**	**2.29**	**2.29**	**No**
Importance of Nano	3.0	2.86	2.86	No
Physical risks too high	3.0	3.14	2.71	No
Social risks too high	**3.0**	**3.57**	**2.86*** **	**No**
Government will manage risks	3.0	**2.71**	**2.43**	**Yes**
Need to develop nano	**3.0**	2.86	2.14	NA
Need a worldwide ban	**3.0**	**3.57**	**3.29**	**No**

Notes: The scale midpoint is the neutral position on the opinion measure; means below the midpoint indicate originally unfavorable opinions and means above the midpoint indicate originally favorable opinions; ***$p < 0.05$; **$p < 0.10$; *$p < 0.15$, two-tailed paired-sample T-tests. Highlighted rows indicate cases when the pre-CTF majority opinion was substantial (at least a two-person majority).
NA, not applicable.

data on the scale midpoints for each question, the pre- and posttest means, and an indication of whether the patterns in the data support the polarization hypothesis. Highlighted rows indicate cases when the pre-CTF majority opinion was substantial (at least a two-person majority) because these are the occasions when polarization effects are hypothesized to be the strongest.

According to these data, there are only a few instances of opinion change that are consistent with the polarization hypothesis. Furthermore, the limited evidence in support of polarization cascades is not replicated for any particular measure of participants' opinions across both CTF. In the Raleigh group, opinion changes are consistent with the polarization hypothesis on just two of the seven measures; in the Boston group, only one measure is consistent with the polarization hypothesis. Most striking is the fact that data consistent with polarization cascades emerged only two of the eight times a significant pre-CTF majority was present. Also of note, in data unreported in these tables, we observed modest correlations between pre- and post opinions, suggesting that significant individual level opinion change occurred even when opinion remained the same and changing opinions were thus largely independent of initial preferences. In other words, weak correlations and similar mean opinions indicate that supporters of nanotechnology became more skeptical after deliberation and initial skeptics became more supportive, contrary to expectations derived from the polarization hypothesis.

It is possible that comparing pre- and posttest group means, although the most obvious and direct test for polarization, hides some of the evidence in favor of the polarization hypothesis because just one or two extreme responses could skew the means. Therefore, we undertook a less conventional second look at the data by investigating individual level opinion change. We start by characterizing the original group disposition on each measure as favorable or unfavorable (or neutral in one case). Next, we identified the direction of each participant's pretest opinions to examine which ones changed their minds in the direction favored by the original numerical majority. We present these results in Tables 3 and 4, by CTF location.

Table 3. Individual Level Opinion Change Over Time, Raleigh CTF

Measures	Original Group Disposition	Participants Who Moved Toward Unfavorable	Participants Who Remained the Same	Participants Who Moved Toward Favorable	Polarization Hypothesis Supported?
Risks versus benefits	Favorable	0	10	3	Yes
Importance of nano	Slightly favorable	3	4	6	Yes
Physical risks too high	Slightly favorable	1	6	6	Yes
Social risks too high	Favorable	2	8	3	Yes
Government will manage risks	Slightly unfavorable	3	5	5	Reversed
Need to develop nano	Unfavorable	6	3	4	Yes
Need a worldwide ban	Favorable	4	5	4	No

Notes: Entries are counts of individuals; Reversed = exact opposite of polarization.

Table 4. Individual Level Opinion Change Over Time, Boston CTF

Measures	Original Group Disposition	Participants Who Moved Toward Unfavorable	Participants Who Remained the Same	Participants Who Moved Toward Favorable	Polarization Hypothesis Supported?
Risks versus benefits	Favorable	1	5	1	No
Importance of nano	Slightly unfavorable	2	2	3	No
Physical risks too high	Slightly favorable	4	1	2	Reversed
Social risks too high	Favorable	4	3	0	Reversed
Government will manage risks	Unfavorable	2	5	0	No
Need to develop nano	Neutral	4	2	1	NA
Need a worldwide ban	Favorable	3	3	1	Reversed

Note: Entries are counts of individuals; Reversed = exact opposite of polarization.
NA, not applicable.

Comparatively, these data offer stronger support for the polarization hypothesis. The supporting evidence is equivocal, however, because it is entirely based on what transpired in the Raleigh CTF and opinions often shifted in the exact opposite direction predicted by polarization. Nevertheless, movement on five of the seven opinion measures in the Raleigh CTF was consistent with polarization effects. In some cases, the change of opinions was substantial, but a majority of participants never changed their minds at all. At other times, opinions actually move in the direction originally favored by the minority. This happens once in the Raleigh sample, on answers to whether government will effectively manage the risks of nanotechnology, and it occurs about half the time in the Boston sample. These results, where participants are more likely to join the position originally held by the numerical minority rather than the majority, are simply incompatible with the polarization hypothesis.

Although past studies have not empirically isolated the opinion changes among deliberators who originally expressed neutral attitudes, we undertake this analysis in our third look at the data. It is possible that polarization occurs by prompting those who initially reported a neutral position to consistently side with the pre-CTF majority. In fact, the literature on polarization clearly implies that some kinds of people should be more susceptible to nonrational opinion change than others, and citizens who have weakly held beliefs (i.e., "neutral") would seem to be more susceptible to deliberative errors. We examine this possibility and report the results of this test in Tables 5 and 6 by CTF location.

Although a test like this cannot be definitive because it is based on few participants originally answering "neutral," we find a limited amount of evidence consistent with polarization. As before, however, the results are ambiguous and supporting data are concentrated within the Raleigh sample. Raleigh CTF participants originally claiming to be neutral on questions about nanotechnology moved in the direction predicted by polarization four of seven times while Boston participants exhibited the same movement just once. Yet, only two of the four times in the Raleigh sample was shift of opinions based on more than one net participant. Overall, then, evidence for polarization effects is based on the opinion change of just one net individual in three of the five cases across the two CTF.

Our final set of results examines categorical data on participants' prioritization of the risks and benefits of nanotechnology. We present the risk and benefit rankings over time by CTF location in Tables 7 and 8. Table 7 includes the benefits in order of how many participants cited it as the most important one to achieve, and Table 8 does the same except that it is based on their choice of the most important risk to avoid.

Interestingly, both CTF groups identified the ability to treat human diseases as the most important potential benefit of nanotechnology before and after deliberating. For the Raleigh group, an initially sizeable majority felt this way, and it increased by three people saying this after deliberation. In Boston, both the order and size of the initial majority remained constant, although the initial majority was a slim one, making it a very conservative test. Thus, our data on preferences for

Table 5. Opinion Change among Participants Originally Feeling Neutral, Raleigh CTF

Measures	Original Group Disposition	Participants Who Moved Toward Unfavorable	Participants Who Remained the Same	Participants Who Moved Toward Favorable	Polarization Hypothesis Supported?
Risks versus benefits	Favorable	0	3	1	Yes
Importance of nano	Slightly favorable	1	0	3	Yes
Physical risks too high	Slightly favorable	0	1	1	Yes
Social risks too high	Favorable	1	3	1	No
Government will manage risks	Slightly unfavorable	1	2	1	No
Need to develop nano	Unfavorable	1	0	2	No
Need a worldwide ban	Favorable	0	0	3	Yes

Note: Entries are counts of individuals.

Table 6. Opinion Change among Participants Originally Feeling Neutral, Boston CTF

Measures	Original Group Disposition	Participants Who Moved Toward Unfavorable	Participants Who Remained the Same	Participants Who Moved Toward Favorable	Polarization Hypothesis Supported?
Risks versus benefits	Favorable	0	0	0	NA
Importance of nano	Slightly unfavorable	2	1	3	No
Physical risks too high	Slightly favorable	1	1	0	No
Social risks too high	Favorable	1	2	0	No
Government will manage risks	Unfavorable	1	2	0	Yes
Need to develop nano	Neutral	1	0	0	NA
Need a worldwide ban	Favorable	3	0	1	No

Note: Entries are counts of individuals.
NA, not applicable.

Table 7. Pre- and Posttest Ranking of Participants' Most Preferred Benefit of Nanotechnology, by CTF Site

Raleigh CTF		Boston CTF	
Pretest ranking	Posttest ranking	Pretest ranking	Post-test ranking
Treat diseases N = 7	Treat diseases N = 10	Treat diseases N = 4	Treat diseases N = 4
Environmental N = 3	Environmental N = 2	Environmental N = 3	Environmental N = 3
Improve humans N = 2	Consumer goods N = 1		
Consumer goods N = 1			

Table 8. Pre- and Posttest Ranking of Participants' Most Important Risk of Nanotechnology to Avoid by CTF Site

Raleigh CTF		Boston CTF	
Pretest ranking	Posttest ranking	Pretest ranking	Posttest ranking
Economic disruption N = 4	Arms race N = 6	Grey-goo N = 3	Arms race N = 3
Losing privacy N = 4	Economic disruption N = 2	Losing privacy N = 2	Breathing nanoparticles N = 2
Arms race N = 3	Losing privacy N = 2	Economic disruption N = 1	Losing privacy N = 1
Breathing nanoparticles N = 1	Breathing nanoparticles N = 2	Breathing nanoparticles N = 1	Economic disruption N = 1
Grey-goo N = 1	Grey-goo N = 1	Grey-goo N = 3	Arms race N = 3

potential benefits is somewhat consistent with polarization effects in the Raleigh CTF but polarization is unsupported in the Boston CTF.

The data on risks, however, are clearly inconsistent with polarization cascades. Instead, these results suggest that learning about nanotechnology played an important role in opinion change. In both CTF, the initial plurality choice fell out of favor after deliberations. An arms race, for example, became the most feared risk after deliberations across both CTF, increasing it from being cited three to six times in the Raleigh sample and from not being mentioned at all to being cited three times in the Boston group. Also, the risk of economic disruption lost ground in the Raleigh group, dropping two votes and from being ranked first into a tie for second. Meanwhile, the infamous "grey-goo" scenario declined as the original plurality choice in the Boston sample to not being cited by anyone in the end.

Discussion

It is worth observing that we undertook multiple tests looking for evidence of polarization cascades while most empirical studies only examine aggregate level shifts in opinions. We too investigated the nature of aggregate level shifts in

opinion, but we carried the analysis a step further by also studying individual level changes in opinions. In our view, aggregate level analyses might overlook the fact that some people are more likely to change their minds for reasons that have to do with conformity, for example, and aggregate level analyses might miss these effects in smaller deliberative groups. In one of these additional tests, we isolated participants who were originally neutral on an issue position and compared their post-CTF opinions to the original majority position within their group, something that prior studies typically neglect to do. Regardless of the method we used, evidence for polarization cascades was minimal.

In the broad sense, our conclusion from this particular episode—that deliberations can be structured to mitigate or possibly avoid polarization cascades—can be only tentative and suggestive, for reasons already noted about our design and sample. Nevertheless, these findings are consistent with results obtained from six earlier CTF that were conducted about global warming (Cobb, 2004). This study also identifies important issues in the assessment of public deliberation practices. Although polarization cascades are a legitimate concern for anyone considering public deliberations, several features of the nanotechnology CTF were designed specifically to strengthen the probability that the panelists will engage in fair and productive discussion. Some of the more important features were:

- The selection process for the panelists, with the intention of ensuring that panels were comprised of a broadly representative sample of the community's population.
- The background materials presented to the panelists, which were written to carefully include diverse perspectives on nanotechnology and to reflect the spectrum of opinions found in both general and specialist literatures.
- Panelists interacting with content experts who voice a diversity of opinions.
- The professional facilitator, assisted by a staff, to lead all of the panel sessions.

These steps, aimed at ensuring that the deliberations are conducted in a fair, balanced, and well-informed way, accord well with Sunstein's (2003) call for efforts to ameliorate polarization effects. He notes the importance of a diverse population of deliberators, of having an expansive argument pool to which the deliberators are exposed, and of having effective facilitation during the actual deliberations. Given the structural and process protections included in the CTF process, it would be worrisome if we had not found a diminution of polarization effects.

Another concern worth highlighting is that deliberative practices can pursue different goals, and the aims pursued may be implicated in triggering polarization cascades. For instance, Fishkin and Luskin (2004) also find that polarization effects are diminished or eliminated in their deliberative polling experiences. However, their structural and procedural protections differ from ours in, sometimes, substantive ways. While we sought group consensus from our deliberations, deliberative polls do not require that a collective outcome be reached. In deliberative polling, there is "no requirement of consensus, not to mention unanimity. The

'voting,' moreover, occurs only in the 'secret ballot' of the final confidential questionnaire, which may limit social comparison effects" (Fishkin & Luskin, 2004, p. 17).

To repeat, CTF do seek a "verdict," a collective, consensual statement of policy preferences that all in the group can endorse. The open-ended discussion of a CTF more or less precludes secret balloting because the goal is a consensus rather than a majority voting victory. There is some evidence that seeking a unitary, consensual decision from a deliberating panel can induce some of the polarization cascade processes (Mendelberg, 2002; Sunstein, 2003), although others do not see strong associations between such cascades and the pursuit of consensus (Delli Carpini et al., 2004). That we had trouble finding even marginal evidence of cascades in our CTF suggests that carefully structured deliberative processes can be effective even when consensus is the goal of the deliberations. The processes that generate polarization cascades are complex; not all groups polarize in every deliberative setting, and, clearly, more research is needed here.

A final important issue that we address, one that is often overlooked in discussions of group polarization problems, is the notion that all opinion shifts consistent with polarization processes are necessarily "bad," i.e., suggestive of emotional or social pathologies in group decision making. Missing from the discussion is the recognition that evidence of polarization might actually reflect opinion changes derived from appropriately cognitive sources, such as learning and responding to the power of better and not just structurally persuasive argument (see Cobb & Kuklinski, 1997). If a hypothetical panel were to deliberate on, for instance, the acceptability of slavery, and if the original distribution of attitudes opposed slavery and the final distribution opposed slavery even more extensively and intensively, is it clear that this results from noncognitive or nonrational sources? Might this result just as easily reflect the impact of stronger (and normatively desirable) arguments? It is certainly a central claim of deliberative democrats that public deliberations should produce better-informed and more cognitively robust decisions. Our results do not address this specific issue, but we believe that more extensive research into the prospect of cognitive polarization processes deserves the attention of the deliberation research community.

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Notes

1. Enlarged public engagement has worked its way into recent legislation. Concerns that potential public opposition to emerging nanotechnology applications might replicate the turmoil surrounding genetically modified foods led policymakers to include specific language about public deliberations

in the 21st *Century Nanotechnology Research and Development Act*. Public Law 108–153, 108th Congress. Page 117 STAT. 1923. The statute includes, under "Program Activities," a provision assuring that "ethical, legal, environmental, and other appropriate societal concerns, including the potential use of nanotechnology in enhancing human intelligence and in developing artificial intelligence which exceeds human capacity, are considered during the development of nanotechnology by . . . providing . . . for public input and outreach to be integrated into the Program by the convening of regular and ongoing public discussions, through mechanisms such as citizens' panels, consensus conferences, and educational events, as appropriate," (*21st Century Nanotechnology Research and Development Act*).

2. For nearly 20 years, the Danish Board of Technology, at the behest of the Parliament, has conducted a series of public deliberative practices called "consensus conferences." Consensus conferences have occurred in several other countries, including Britain, France, Canada, and, a few times, in the U.S. (Guston, 1999; Hamlett, 2002a, 2002b). Other deliberative practices have also appeared, such as citizens juries (Armour, 1995) and deliberative polls (Fishkin, 1991; Fishkin & Luskin, 2004).
3. The team includes we two authors and Dr. Jane Macoubrie, senior advisor, Project on Emerging Nanotechnologies, Woodrow Wilson International Center for Scholars. The team wishes to thank the Social Dimensions on Science, Engineering and Technology Program (SDEST) and The National Science Foundation and The National Nanotechnology Initiative for supporting this research.
4. Over the past five years, the team has conducted a total of 10 CTFs, including eight dealing with climate change and two addressing genetically modified foods.
5. We limit our analysis in this research to the two nanotechnology CTF because we have either already reported on the prior CTF results or are in the process of doing so in additional manuscripts.
6. Recruitment for the Boston site was particularly difficult, and several more participants dropped out before the completion of the CTF. Needless to say, it is impossible to achieve a random distribution of important demographic characteristics with such small sample sizes and the results of this study should be interpreted cautiously. A full explanation of recruitment methods is available upon request.
7. Participants asked many questions whenever permitted, and their knowledge scores significantly increased by the end of the CTF.
8. We recognize that facilitator guided deliberations are atypical of some of the kinds of group deliberations that critics of increased citizen participation have in mind, and using a facilitator raises some valid questions about the external validity of our study. Thus, we avoid generalizing from our study to other forms of deliberation, such as autonomous deliberative networks found in online communities.
9. In addition to participants' demographics, we also measured their factual knowledge about nanotechnology, their self-efficacy, and their trust in decision makers. We also measured their opinions about the merits of deliberation with others but, in this research, we limit our analysis to measures of participants' subjective opinions about nanotechnology because these are the types of measures identified in the literature as being affected by polarization cascades.

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Appendix

Question Wording and Answer Key

Question Label	Question Wording
"Risks versus benefits"	Which of the statements below best expresses your present belief about nanotechnology? The risks will probably exceed the benefits, the risks and benefits will probably be about equal, or the benefits will probably exceed the risks?
"Importance of nano"	Do you agree or disagree that nanotechnology is one of the more important issues confronting government.
"Physical risks too high"	Do you agree or disagree that the risk of nanotechnology directly affecting physical things like human health, wildlife, or the environment in general is currently too high?
"Social risks too high"	Do you agree or disagree that the risk of nanotechnology affecting social systems like the economy, trade, and sustainable food supply is currently too high?
"Government will manage risks"	Do you agree or disagree that even if there are risks with nanotechnology, government will effectively manage these risks?
"Need to develop nano"	Do you agree or disagree that if the U.S. economy would suffer because other countries develop nanotechnology faster, we should develop nanotechnology at full speed despite its possible risks?
"Need a worldwide ban"	At the present, some express strong concern about nanotechnology risks and have called for a world ban on new nanotechnology products. Do you support or oppose such a ban?