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Affect, Values, and Nanotechnology Risk Perceptions: An Experimental Investigation

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Despite knowing little about nanotechnology (so to speak), members of the public readily form opinions on whether its potential risks outweigh its potential benefits. On what basis are they forming their judgments? How are their views likely to evolve as they become exposed to more information about this novel science? We conducted a survey experiment (N = 1,850) to answer these questions. We found that public perceptions of nanotechnology risks, like public perceptions of societal risks generally, are largely affect driven: individuals' visceral reactions to nanotechnology (ones likely based on attitudes toward environmental risks generally) explain more of the variance in individuals' perceptions of nanotechnology's risks and benefits than does any other influence. These views are not static: even a small amount of information can generate changes in perceptions. But how those perceptions change depends heavily on individuals' values. Using a between-subjects design, we found that individuals exposed to balanced information polarize along cultural and political lines relative to individuals not exposed to information. We discuss what these findings imply for understanding of risk perceptions generally and for the future of nanotechnology as a subject of political conflict and regulation.

1. Introduction: As Goes Berkeley, . . .?

In December 2006, Berkeley, California, became the first governmental entity in the United States to regulate nanotechnology. Facilities that manufacture or use nanoparticles must now file reports with city officials disclosing

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"how [they] will safely handle, monitor, contain, dispose, track inventory, [and] prevent releases" of these materials.[1]

Far more remarkable, however, than the content of this (very modest) regulation are how little time and information municipal officials needed to decide it was necessary. Having never heard of nanotechnology before the University of California proposed construction of a research laboratory, the city's hazardous waste director immediately commenced an inquiry to determine whether it posed a threat to public safety. "We sent them a bunch of questions starting with: 'What the heck is a nanoparticle?' "[2] Regulators were quickly able to learn that, but not much more: "The human health impacts of nanoparticles," the city's Environmental Advisory Commission reported, "are very complex and are only beginning to be understood." Nevertheless, citing concerns that nanoparticles might "penetrate skin and lung tissue" and possibly "block or interfere with essential reactions" inside human cells, officials concluded that a precautionary stance was in order.[3]

What should those who are interested in public attitudes toward nanotechnology make of Berkeley's response? Why did regulators react with nearly instantaneous concern toward this novel form of science? Why did their anxieties seem to grow in the face of admittedly indefinite information? How are they, and publicly accountable officials elsewhere, likely to react as they learn even more about this nascent technology?

We conducted a study to help answer these questions. It involved a sample of approximately 1,800 Americans, whose knowledge of and attitudes toward nanotechnology were assessed, both in the presence and in the absence of information about nanotechnology's potential risks and benefits.

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[1] Berkeley Municipal Code § 15.12.040.

[2] Barnaby J. Feder, *Teeny-Weeny Rules for Itty-Bitty Atom Clusters*, N.Y. Times, § 4, Jan. 14, 2007 (quoting Nabil Al-Hadithy).

[3] Memorandum from Community Environmental Advisory Commission to Mayor and City Council, at 2 (Dec. 5, 2006).

The results were instructive. Before being furnished with information, the vast majority of our subjects knew little if anything about nanotechnology, yet the vast majority of them formed an immediate opinion, one way or the other, about whether its benefits outweighed its risks. The driving force behind these snap judgments, we found, was affect: the visceral, emotional responses of our subjects, pro or con, determined how beneficial or dangerous they thought nanotechnology was likely to be—a result in keeping with the force that affect is known to exert over perceptions of personal and societal risks generally.[4]

These instantaneous judgments were not static, however. Individuals exposed to information on the risks and benefits of nanotechnology formed views different from individuals not so informed. But the *ways* in which information influenced our subjects—whether it inclined them to see nanotechnology as more risky or more beneficial—was highly conditional on the values they held. This finding, too, is consistent with previous work documenting the role that different worldviews—hierarchical and egalitarian, individualistic and communitarian—play in orienting persons' assessments of the dangers different forms of commerce and technology pose to public safety.[5]

These results paint a picture, then, of at least one possible future for nanotechnology. It is one in which citizens rapidly take affect-driven positions, which harden as they conform what they learn thereafter to their more basic cultural attitudes toward technology and risk. The result is likely to be a state of political polarization over the desirability of nanotechnology that very much resembles the one that now exists other controversial environmental issues, including nuclear power and global warming. Or at least that is how things are likely to play out absent the development of strategies that neutralize the ten-

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[4] *See* Paul Slovic, The Perception of Risk 403-06 (2000).

[5] *See generally* Dan M. Kahan, Paul Slovic, Donald Braman & John Gastil, *Fear of Democracy: A Cultural Critique of Sunstein on Risk*, 119 Harv. L. Rev. 1071, 1083-88 (2006). Much of this work is based on the ongoing research of the Cultural Cognition Project. Background on the Project and access to related data and papers can be found at http://research.yale.edu/culturalcognition/.

dency of persons to assimilate information in a manner that confirms their emotional and cultural predispositions.

The rest of this paper elaborates on these claims. We start, in part 2, with an account of the background of our investigation of nanotechnology risk perceptions. In part 3, we describe the hypotheses and design of our study, and in part 4 the results. We then turn in part 5 to a discussion of the implications of our findings for the likely career of nanotechnology risk perceptions in the United States. And finally, in part 6, we conclude.

2. Background: What We Know, What We Don't, and Some Conjectures

Not much more is known about public perceptions of the risks of nanotechnology than is known about nanotechnology risks themselves. A lot is known, however, about the nature of public risk perceptions generally. When the insights of the science of risk perception are combined with the work that has been done on attitudes toward nanotechnology, it is possible to form some fairly plausible conjectures about why people react the way they do to this nascent technology and how their positions are likely to evolve as more information becomes publicly available.

The most basic insight generated by risk-perception research is that attitudes toward putatively dangerous activities—from nuclear power generation to firearms possession to smoking—are *affect driven*. The visceral reactions images and emotions such activities arouse are the strongest predictor of whether individuals view them as socially deleterious or benign.[6] Affect has been found to operate as a heuristic substitute for more systematic forms of reasoning when individuals have access to relatively little information or little time to assess it.[7] Affect also interacts with various other processes of cognition: emo-

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[6] *See, e.g.*, P. Slovic, E. Peters, M. L. Finucane & D. G. MacGregor, *Affect, Risk, and Decision Making*, 24 Health Psychol. S35 (2005); George F. Loewenstein, Elke U. Weber, Christopher K. Hsee & Ned Welch, *Risk as Feelings*, 127 Psych. Bull. 267 (2001).

[7] *See*, *e.g.*, Paul Slovic, Melissa L. Finucane, Ellen Peters & Donald G. MacGregor, *Risk as Analysis and Risk as Feelings: Some Thoughts About Affect, Reason, Risk, and Rationality*, 24 Risk Anal. 311-322 (2004).

tionally charged events, for example, are more likely to be noticed and recalled, thereby biasing estimations of their likelihood;[8] feelings such as fear and hope skew individual estimations toward the probability of adverse and favorable outcomes;[9] the desire to avoid dissonance disposes individuals to conform their processing of information about risks and benefits toward their feelings about a putatively dangerous activity.[10] It has also plausibly been argued that evolutionary processes have endowed human beings with a disposition to rely on certain emotions, such as disgust, to help them discern sources of potential harm.[11]

It stands to reason, then, that affect will influence perceptions of nanotechnology risks. The immediacy of the apprehension experienced by Berkeley regulators and their decision to regulate on the basis of exceedingly little information about its dangers, for example, comport with an affective style of reasoning.

The findings of previous studies of nanotechnology attitudes also hint at the role affect plays. A national survey conducted by Peter Hart Research Associates found that although a large majority of respondents reported having heard "little" or "nothing at all" about nanotechnology before being polled, a majority still had a position on whether its risks would outweigh its benefits.[12] Again, affect would explain why so many persons without significant knowledge about nanotechnology would nevertheless have an opinion about how dangerous it is. An informative study by Steven Currall and fellow researchers found that public perceptions of the risks and benefits of nanotechnology are inversely correlated—that is, that people who believe nanotechnology is beneficial

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[8] *See* Cass R. Sunstein, Laws of Fear: Beyond the Precautionary Principle, 64 (2005).

[9] *See* Yuval Rottenstreich & Christopher K. Hsee, *Money, Kisses, and Electric Shocks: On the Affective Psychology of Risk*, 12 Psych. Sci. 185 (2001).

[10] *See* Slovic, *supra* note 4, at 404-05.

[11] *See* Valerie Curtis & Adam Biran, *Dirt, Disgust, and Disease: Is Hygiene in Our Genes?* 44 Perspectives in Biology & Med. 17 (2001).

[12] *See* Peter D. Hart Research Associates, Inc., Report Findings, at 6-7 (Sept. 19, 2006), available at http://www.nanotechproject.org/file_download/98.

also tend to believe it is risky, and vice versa.[13] Currall and his associates characterized this result as suggesting that for ordinary people nanotechnology "risks and benefits are both enmeshed in a complex decision-making calculus."[14] But an alternative interpretation is that individuals' perceptions are simple and affective: to avoid dissonance, individuals conform their assessments of *both* the risks and benefits of nanotechnology to their feelings about it. Indeed, numerous studies have shown that exactly this dynamic generates inversely correlated judgments of risk and benefit for all manner of affect-driven risk perceptions.[15]

Another important insight in the study of risk perceptions generally is the impact of cultural outlooks. Shared systems of value invest putatively dangerous activities with social meanings (human mastery or hubris; self-reliance or selfishness; virility or contemptible self-indulgence), which in turn determine whether those activities generate positive affective responses (hope, pride, admiration) or negative ones (dread, fear, disgust).[16] Shared group commitments also affect the processing of information about risk. Individuals are more likely to seek out and to credit information about societal dangers from those who share their basic understanding of the good life. They are also loath to form factual beliefs that differ from those same persons, lest they be deprived of important forms of social and emotional support.[17] As a result, perceptions of what sorts of activities are dangerous, and what sorts of policies are likely to abate those risks, tend to be uniform among persons who subscribe to a shared cultural ethic and polarized across persons who subscribe to compet-

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[13] *See* Steven C. Currall, Eden B. King, Neal Lane, Juan Madera & Stacey Turner, *What Drives Public Acceptance of Nanotechnology?* Nature Nanotechnology, Dec. 2006, at 154-55.

[14] *Id.* at 155.

[15] *See generally* Melissa L. Finucane, Ali Alhakami, Paul Slovic & Stephen M. Johnson, *The Affect Heuristic in Judgments of Risks and Benefits*, 13 J. Behav. Decisionmaking 1 (2000).

[16] *See, e.g.*, Ellen M. Peters, *An Emotion-Based Model of Risk Perception and Stigma Susceptibility: Cognitive Appraisals of Emotion, Affective Reactivity, Worldviews, and Risk Perceptions in the Generation of Technological Stigma*, 24 Risk Analysis 1347 (2004).

[17] *See, e.g.,* Geoffrey L. Cohen, Party over Policy: The Dominating Impact of Group Influence on Political Beliefs, 85 J. Personality & Social Psych. 808 (2003); Serena Chen, Kimberly Duckworth & Shelly Chaiken, *Motivated Heuristic and Systematic Processing*, 10 Psych. Inq. 44 (1999).

ing ones.[18] The sum total of these and like social influences on risk perception generate a phenomenon that can be called the "cultural cognition of risk."[19]

Drawing heavily on the work of anthropologist Mary Douglas,[20] one conception of the cultural cognition of risk divides cultural outlooks along two cross-cutting dimensions.[21] The first, "hierarchy-egalitarianism," characterizes the relative preference of persons for a society in which resources, opportunities, privileges and duties are distributed along fixed and differentiated lines (of gender, race, religion, and class, for example) versus one in which those goods are distributed without regard to such differences. The other, "individualism-communitarianism," characterizes the relative preferences of persons for a society in which individuals secure the conditions for their own flourishing without collective interference versus one in which the collective is charged with securing its members' basic needs and in which individual interests are subordinated to collective ones.

Individual risk perceptions, this position asserts, reflect and reinforce their cultural outlooks so defined. Accordingly, egalitarians and communitarians are relatively sensitive to environmental and technological risks, abatement of which justifies regulating activities that generate inequalities and symbolize unconstrained pursuit of individual self-interest. Because they prize the autonomy of markets and other private orderings, individualists tend to be dismissive of claims that commerce and industry are dangerous and worthy of regulation. So do hierarchists, who see assertions of environmental risk as im-

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[18] *See* Cass R. Sunstein, *Deliberative Trouble: Why Groups Go to Extremes*, 110 Yale L.J. 71, 92-94 (2001); Donald Braman, Dan M. Kahan & James Grimmelmann, *Modeling Facts, Culture, and Cognition in the Gun Debate*, 18 Soc. J. Res. 283 (2005).

[19] *See generally* Paul DiMaggio, *Culture and Cognition*, 23 Ann. Rev. Sociology 263 (1997) (developing theory that mechanisms of cognition mediate role between cultural commitments and various types of perceptions); Dan M. Kahan, Paul Slovic, Donald Braman & John Gastil, *Fear of Democracy: A Cultural Critique of Sunstein on Risk*, 119 Harv. L. Rev. 1071, 1083-88 (2006) (applying this approach to risk perception).

[20] Mary Douglas, Natural Symbols, viii (1970).

[21] *See generally* Dan M. Kahan, Donald Braman, John Gastil, Paul Slovic, & C.K. Mertz, Gender, *Race and Risk Perceptions: The Influence of Cultural Status Anxiety*, 4 J. Empirical Legal Stud. 465 (2007).

plicitly challenging the authority of societal and governmental elites.[22] Hierarchists and individualists have their own risk anxieties—of market disruption and unduly invasive restrictions of hand guns—which egalitarians and communitarians likewise dismiss. There are also issues, such as the dangers of social deviancy, on which hierarchs and communitarians square off against egalitarians and individualists. Work by us and by other researchers have strongly documented these patterns of risk perception.[23]

There is reason to think that cultural worldviews do—or over time will—influence nanotechnology risks, too. In the Hart poll, for example, whites and men were significantly less disposed to see nanotechnology as risky than African-Americans and women.[24] These demographic characteristics tend to correlate with, and thus can be seen as rough proxies for, the worldviews characterized by hierarchy-egalitarianism and individualism-communitarianism.[25] In addition, after respondents were furnished information about the risks and benefits of nanotechnology, significant differences also emerged between Republicans and Democrats, affiliations that also correlate (although imperfectly[26]) with these outlooks.[27] That the effect of information varies along demo-

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[22] *See generally* Mary Douglas & Aaron B. Wildavsky, Risk and Culture: An Essay on the Selection of Technical and Environmental Dangers (1982).

[23] *See e.g.,* Karl Dake, *Orienting Dispositions in the Perception of Risk: An Analysis of Contemporary Worldviews and Cultural Biases*, 22 J. Cross-Cultural Psych. 61 (1991); Ellen Peters & Paul Slovic, *The Role of Affect and Worldviews as Orienting Dispositions in the Perception and Acceptance of Nuclear Power*, 26 Journal of Applied Social Psychology 1427-1453 (1996); Hank C. Jenkins-Smith, *Modeling Stigma: An Empirical Analysis of Nuclear Waste Images of Nevada,* in Risk, Media, and Stigma: Understanding Public Challenges to Modern Science and Technology 107 (P. S. James Flynn, and Howard Kunreuther ed., 2001); Poortinga, Steg & Vlek, Environmental Risk Concern and Preferences for Energy-Saving Measures, 34 Environment & Behavior 455 (2002). *See generally* Kahan, *supra* note 5, at 1085-87 (describing our findings and citing additional studies).

[24] The Hart poll report notes the difference between men and women. *See* Hart & Assoc., *supra* note 12, at 7. Our independent evaluation of the data, which we obtained from the Project on Emerging Nanotechnologies, showed the race effect.

[25] *See generally* Kahan *et al.*, *supra* note 21.

[26] *See generally* John Gastil, Dan M. Kahan, Donald Braman & Paul Slovic, *The "Wildavsky Heuristic": The Cultural Orientation of Mass Political Opinion* (unpublished manuscript, Oct. 15, 2005), available at http://research.yale.edu/culturalcognition/content/view/92/90/.

[27] We observed this effect in our own multivariate regression analysis of the Hart data.

graphic and ideological lines can thus be seen as evidence of a cultural bias in the processing of information.

Putting all this together, one can at least imagine a richer, and more detailed, picture of the formation and evolution of nanotechnology risk perceptions. On this view, individuals, particularly poorly informed ones, are likely to form reactions that are largely affective in nature. More informed persons might be less likely to rely on affect. But their views are even more likely to have a recognizable cultural complexion. Indeed, one might surmise that the effect of learning more about the risks and benefits of nanotechnology will not be to generate consensus but rather to provoke dissensus along ideological or cultural lines.

These are, of course, conjectures. So we devised a more rigorous empirical study to test them.

3. An Experimental Study of Nanotechnology Risk Perceptions

3.1. Hypotheses

Our study focused on two major hypotheses and a number of related subhypotheses. The first major hypothesis was that individuals' perceptions of nanotechnology risks and benefits would be affect driven.

A subhypothesis was that affect toward nanotechnology would itself be explained by individuals' dispositions toward environmental risks generally. Confronted with a novel form of technology, individuals, we surmised, would likely form their affective appraisals based on whether they generally see technology as societally dangerous or beneficial.[28]

In the same vein, we also predicted that affect toward nanotechnology would reflect subjects' cultural dispositions. Because cultural outlooks tend to

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[28] *See generally* Anthony Leiserowitz, *Communicating the Risks of Global Warming: American Risk Perceptions, Affective Images and Interpretive Communities*," in *Communication and Social Change: Strategies for Dealing with the Climate Crisis* (forthcoming 2007) (finding that members of the public can be classified according to shared categories of risk perception that themselves reflect broader values).

influence whether an individual's affect is negative or positive, we conjectured that outlooks could be expected to have at least some impact on nanotechnology affect. We predicted, in particular, that hierarchical and individualist subjects would have a relatively positive affective response to nanotechnology, and egalitarian and communitarian subjects a relatively negative one, in accord with the dispositions of such persons toward environmental risks generally.

Our second major hypothesis was that individuals would react to information about nanotechnology risks and benefits in a manner that reflected their cultural outlooks. The phenomenon of "biased assimilation and polarization" refers to the tendency of people who disagree on a disputed issue to construe information in a way that supports their existing views and thus to form views that are even more divergent.[29] We predicted that subjects' cultural predispositions toward environmental risks would bias their assimilation of information about nanotechnology risks and thus polarize subjects along cultural lines. Specifically, we predicted that the more hierarchical and individualistic subjects were, the more favorable their views would become as they were exposed to information, whereas the more egalitarian and communitarian subjects were, the more negative their views would become. A subhypothesis was that individuals would become polarized along other lines characteristic of disagreements about environmental risks, including gender, race, and ideology.

3.2. Study Design

3.2.1. Sample

The sample consisted of approximately 1,850 individuals demographically weighted to reflect national representativeness.[30] They were drawn from a

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[29] *See* Charles G. Lord, Lee Ross & Mark R. Leper, *Biased Assimilation and Attitude Polarization: The Effects of Prior Theories on Subsequently Considered Evidence*, 11 J. Personality & Soc. Psych. 2098-2109 (1979).

[30] Numerous studies have shown that the on-line samples and testing methods of Knowledge Networks yield results equivalent in reliability to conventional random-digit-dial surveys. Studies based on those samples and methods are routinely published in academic journals. *See* http://www.knowledgenetworks.com/ganp/2005aapor.html; http://www.knowledgenetworks.com/ganp/docs/List%20of%20Journals%208-28-2006.pdf A more complete description of the composition of Knowledge Networks and of the demographic characteristics of the sample used in this study appears in Appendix A.

panel of on-line survey respondents assembled by Knowledge Networks for participation in scholarly public opinion analysis. The subjects were administered an on-line survey-experiment that consisted of approximately 50 questions and that took an average of approximately 10 minutes to complete.[31] Survey responses were collected between December 14, 2006, and December 28, 2006.

3.2.2. Measures

3.2.2.1. Cultural Worldviews

The subjects' cultural worldviews were measured with two scales developed for use in a previous national study of cultural orientations and risk perceptions.[32] "Hierarchy-Egalitarianism" ("Hierarchy") consisted of 12 items, and "Individualism-Communitarianism" ("Individualism") 18 items, designed to assess subjects' worldviews along those two dimensions. Both were highly reliable (Hierarchy, $\alpha = .81$; Individualism $\alpha = .83$).

We also divided our subjects into "types" reflecting their cultural worldviews. Based on their scores relative to the median ones for Hierarchy and Individualism, individuals were designated as either "Hierarchs" or "Egalitarians," and as either "Individualists" or "Communitarians." They were further divided into four distinct types— "Hierarchical Individualists," "Hierarchical Communitarians," "Egalitarian Individualists, and "Egalitarian Communitarians"—based on the combinations of these designations.

3.2.2.2. Other Individual Characteristics

Various demographic characteristics of interest were collected. These included the subjects' races, their genders, their ages, their education levels, their household incomes, their parental status, their political party affiliations and their political ideologies (measured with a liberal-conservative scale). Subjects were also asked to indicate whether they "strongly disagreed," "disagreed," "agreed," [or] "strongly agreed" with the statement, "The federal government can

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[31] Pertinent elements of the survey instrument appear in Appendix B.

[32] *See generally* Kahan *et al.*, *supra* note 21.

be trusted to protect the public from environmental and technological risks" (Govtrust).

3.2.2.3. Nanotechnology

The experiment-survey instrument contained a number of items relating to nanotechnology. One ("Nanoknow") asked "[h]ow much have you heard about nanotechnology before today?," and permitted responses of "nothing at all," "just a little," "some," and "a lot."[33] Subjects who indicated they had heard "nothing at all" or "just a little" were classified as having "low knowledge," those who had heard "some" as "moderate knowledge," and those who had heard "a lot" as "high knowledge" with respect to nanotechnology.

Another item ("Nanoaffc") measured respondents' affect toward nanotechnology. Using a "bipolar" scale previously found to be a reliable and robust measure of affective attitudes,[34] this item asked "[h]ow would you say nanotechnology makes you feel?," and permitted responses of "very bad," "bad," "neither good nor bad," "good," and "very good."

Finally, respondents' perceptions of nanotechnology risks was measured with an item ("Nanorisk") that asked them "[d]o you think the risks of nanotechnology will greatly outweigh its benefits, the risks of nanotechnology will slightly outweigh its benefits, the benefits of nanotechnology will slightly outweigh its risks[,] [or] the benefits of nanotechnology will greatly outweigh its risks[?]"

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[33] Subjects were instructed that they should refuse to answer this or any other question on which they were "unsure." This instruction has been found to generate the same rate of "don't know/unsure" responses among on-line survey respondents as permitting only a volunteered "don't know/unsure" response in telephone surveys. *See* J. Michael Dennis, Rick Li, & Cindy Chatt, *Benchmarking Knowledge Networks' Web-Enabled Panel Survey of Selected GSS Questions Against GSS In-Person Interviews* (Unpublished manuscript, Feb. 2004), available at http://www.knowledgenetworks.com/ganp/docs/GSS%202002%20DK%20Rates%20on%20KN%20Panel%20v3.pdf.

[34] Ellen Peters & Paul Slovic, *Affective Asynchrony and the Measurement of the Affective Attitude Component*, Cognition & Emotion (forthcoming 2007).

Nanoknow and Nanorisk were adapted from the Hart survey. In contrast to that survey, however, the nanotechnology items in our experiment-survey instrument were introduced (as a group) with this statement:

> Now we would like to know what you think about nanotechnology. Nanotechnology is the ability to measure, see, predict and make things on the extremely small scale of atoms and molecules. Materials created with nanotechnology can often be made to exhibit very different physical, chemical, and biological properties than their normal size counterparts.

This brief and nonjudgmental language was included with the expectation that without at least a minimal description of nanotechnology those who responded "nothing at all" to the prior knowledge item ("Nanoknow") would feel it was inappropriate to offer a response to Nanorisk even if they had an opinion on nanotechnology's relative risks and benefits.

3.2.2.4. Other Risk Perceptions

Subjects were asked to specify whether they regarded a set of additional activities as presenting "almost no risk," "slight risk," "moderate risk" or "high risk." These included "global warming" and "nuclear power," which were combined into a single measure of environmental risk ("Envrisk," $\alpha = .57$).

3.2.3. Information Experiment

The subjects were divided into two groups. The "no information treatment" group was exposed to no information about nanotechnology aside from the minimal introductory statement. The "information treatment" group received two paragraphs of additional information (the order of which was randomly varied) relating, respectively, to the benefits and risks of nanotechnology:

> The potential benefits of nanotechnology include the use of nanomaterials in products to make them stronger, lighter and more effective. Some examples are food containers that kill bacteria, stain-resistant clothing, high performance sporting goods, faster, smaller computers, and more effective skincare products and sunscreens. Nanotechnology also has the potential to provide new and better ways to treat disease, clean up the environment, enhance national security, and provide cheaper energy.
>
> While there has not been conclusive research on the potential risks of nanotechnology, there are concerns that some of the same properties that make nanomaterials useful might make them harmful. It is thought that some nanomaterials may be harmful to humans if they are breathed in and might cause harm to the environment. There are also concerns that invisible, nanotechnology-based monitoring devices could pose a threat to national security and personal privacy.

These statements preceded the nanotechnology risk and affect items for the information-treatment group subjects.

The rationale for dividing the subjects into two groups was to facilitate a valid evaluation of the effect of information. The Hart survey had assessed the evaluation of the impact of information with a within-subjects design—that is, by re-measuring nanotechnology risk perceptions of the same subjects before and after they received information. In such a design, changes in responses could be thought to reflect a contrived disposition on the part of subjects to appear open-minded and receptive to information. To avoid a confounding interpretation of this sort, we decided to use a between-subjects design—one in which the responses of subjects who received no information would be compared to those of informed subjects who offered their responses only after receiving information.

The sizes of the two groups differed: approximately 1,500 for the no-information treatment group and approximately 350 for the information-treatment group. The larger sample size for the no-information group was selected in order to assure adequate power to facilitate the detection of relatively small effect sizes in the anticipated multivariate regression analysis of nanotechnology risk perceptions among those subjects. The smaller sample used for the information-treatment group was anticipated to be large enough to permit detection of the hypothesized biased-assimilation/polarization effects across subjects of diverse cultural orientations and other characteristics.

4. Results

4.1. No-Information Treatment: An Analysis of Nanotechnology Risk Perceptions

4.1.1. What Americans Know About Nanotechnology, and What They Think About It

The size of the no-information treatment group (n = 1,500) made it possible to form an assessment of how much the general public in the United States knows about nanotechnology and what they think about it. We found, consistent with the Hart survey, that the American public is largely uninformed about this novel technology. A full 81% of our subjects reported having heard either

"nothing at all" (53%) or "just a little" (28%) about nanotechnology prior to being surveyed. Only 5% reported having heard "a lot."

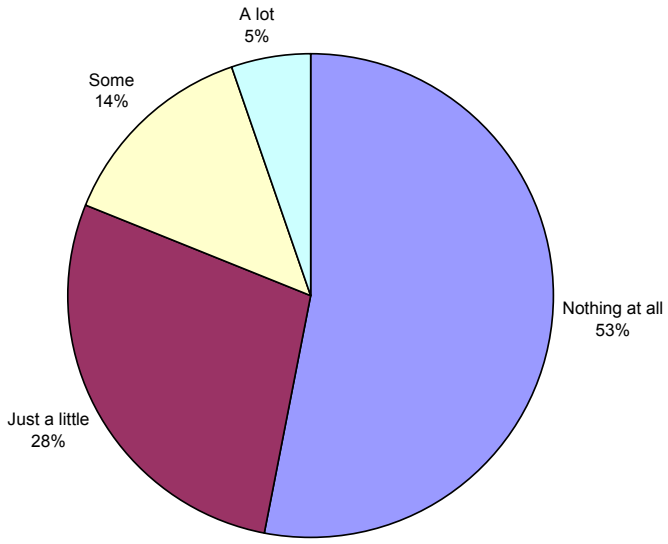

Figure 1. Prior Knowledge of Nanotechnology

Nevertheless, we also found that after being supplied with a minimal and nonjudgmental description of what nanotechnology is, the vast majority of Americans are willing to offer an opinion about its relative risks and benefits. Eighty-nine percent had a position one way or the other.[35] Interestingly, although divided, Americans, on the whole, seem relatively pro-nanotechnology. A majority, 53%, indicated that they believed nanotechnology's benefits would either "slightly" or "strongly" outweigh its risks. Thirty-six percent indicated that they believed that nanotechnology's risks would either "slightly" or "strongly" outweigh its benefits. Treating these four responses to the Nanorisk

[35] This general finding—that the proportion of persons holding an opinion on nanotechnology risks substantially exceeds the proportion who report having heard more than "a little" about it—is also consistent with the Hart survey. In the Hart survey, however, some 47% of the respondents were "unsure" whether risks outweigh benefits. Only 11% of our respondents refused to take a position one way or the other. We attribute the difference primarily to our decision to use a brief introductory statement describing what nanotechnology is before soliciting opinions.

item as a four-point scale, with "1" being "risks strongly outweigh benefits" and "4" being "benefits strongly outweigh risks," the mean score for the sample was 2.66.

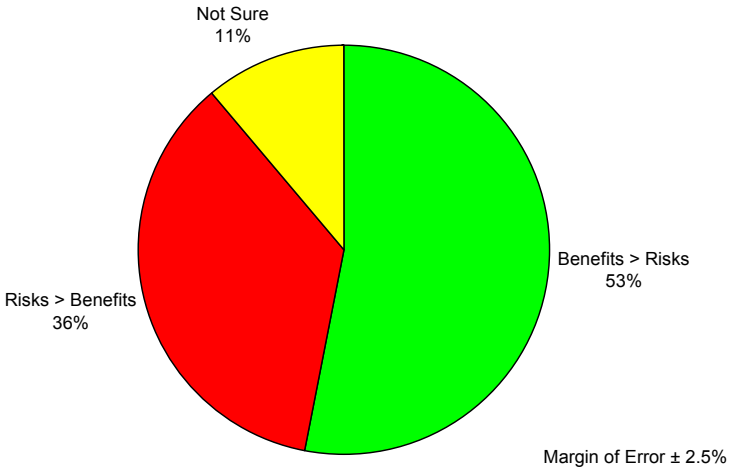

Figure 2. Risks vs. Benefits, No-Information Condition

An examination of opinions among subgroups of the population (Table 1), however, revealed somewhat more ambivalence and division. The "white male effect" in risk perception refers to the tendency of white men to be less concerned with all manner of risk than women and minorities.[36] There is clearly a white male effect in assessment of nanotechnology risks. Men (mean = 2.81) and whites (mean = 2.67) were significantly more disposed to see benefits as outweighing risks than were women (mean = 2.50) and African-Americans (mean = 2.32), respectively. White males (mean = 2.85) were the most disposed to see benefits as outweighing risks.

Differences among political groups appeared minimal. There was no significant difference in the evaluations of Republicans (mean = 2.66) and Democrats (mean = 2.66), for example. Surprisingly, liberals (mean = 2.78) held a slightly more positive view about the benefits and risks of nanotechnology than

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[36] *See* Melissa Finucane, Paul Slovic, C.K. Mertz, James Flynn & Theresa A. Satterfield, *Gender, Race, and Perceived Risk: The "White Male" Effect,* 3 Health, Risk, & Soc'y 159 (2000); Kahan *et al.*, *supra* note 21.

conservatives (mean = 2.66), although the difference was borderline significant (p = .10). Both conservatives and liberals had more positive views than moderates (mean = 2.57), a result that also seemed a bit surprising but not particularly meaningful.

	Benefit > Risk	Risk > Benefit	mean	significance
Overall	53%	36%	2.66	–
Men	59%	31%	2.81	a***
Women	47%	40%	2.50	a***
Whites	54%	34%	2.67	b***
Blacks	36%	49%	2.32	b***
White Males	61%	30%	2.85	c***
White Females	46%	39%	2.46	c***
Republicans	55%	35%	2.66	
Democrats	54%	37%	2.66	
Liberals	58%	33%	2.78	d*, e***
Conservatives	55%	35%	2.66	d*, f***
Moderates	48%	39%	2.57	e***, f**
Hierarchs	53%	36%	2.64	
Egalitarians	52%	35%	2.67	
Individualists	51%	36%	2.62	
Communitarians	54%	35%	2.70	
Hierarch Individualists	54%	34%	2.65	
Hierarch Communitarians	53%	39%	2.63	
Egalitarian Individualists	47%	38%	2.56	g**
Egalitarian Communitarians	54%	33%	2.73	g**
Low Knowledge	47%	40%	2.51	h***, i***
Moderate Knowledge	80%	19%	3.18	h***
High Knowledge	83%	14%	3.33	i***

$n \approx$ 1,500. Shared alphabetic notation denotes significant differences in group means: * $p \leq .10$, ** $p \leq .05$, ***$p \leq .001$, 2-tail.

Table 1. Risk/Benefit Perceptions by Group, No-Information Condition

Differences among culturally defined groups was also insubstantial. There were no statistically significant differences among Hierarchs (mean = 2.64) and Egalitarians (mean = 2.67) or among Individualists (mean = 2.62) and Communitarians (mean = 2.70). There was a statistically significant difference among Egalitarian Individualists (mean = 2.56) and Egalitarian Communitarians (mean = 2.73), suggesting a weak disposition on the part of individualists to perceive nanotechnology positively, but the difference again seemed largely to defy meaningful interpretation.

The most striking differences were based on subjects' levels of (reported) knowledge. "Low knowledge" subjects—those who indicated they had heard either "nothing at all" or "just a little"—were considerably more disposed to see risks as outweighing benefits (mean = 2.51) than were either "moderate knowledge" (mean = 3.18) or "high knowledge" (mean = 3.33) subjects, whose respective positive views of nanotechnology benefits did not differ significantly.

This particular finding is ambiguous. It could be interpreted to mean that exposure to information about nanotechnology tends to make persons more disposed to see its benefits as outweighing its risks. But another possibility is that some other influence that disposes individuals to see nanotechnology as beneficial *also* disposes them to learn more about it. As we will discuss presently, results from the information-condition permit additional assessment of this issue.

4.1.2. Why Americans Think What They Do About Nanotechnology: The Role of Affect

To attempt to explain variation in perceptions of the risks and benefits of nanotechnology, we conducted a multivariate regression analysis (Table 2).[37] The dependent variable was Nanorisk, reverse coded so that it measured the degree to which subjects perceived risks as outweighing benefits. The independent variables included a range of individual characteristics that we believed might likely explain differences in nanotechnology risk perceptions, including affective responses to nanotechnology (Nanoaffc).

We entered the variables in steps to make more transparent the relative impact of affect and other influences. In step 1, we assessed the impact of all the independent variables other than affect. Consistent with the simple mean scores by group, this analysis revealed that by far the biggest impact on nanotechnology risk perceptions is how much subjects know (or report knowing) about it (Nanoknow): the more they know, the less risky they perceive nanotechnology to be relative to its benefits. The subjects' perceptions of other

[37] Subjects who did not take a position on whether nanotechnology risks outweigh nanotechnology benefits or vice versa are of course omitted from the regression. Missing data, in this and other regression analyses, are handled generally through pairwise deletion.

environmental risks (Envrisk) had the next largest effect: the more concerned subjects were with nuclear power and global warming, the more concerned they were with the risks of nanotechnology. Not surprisingly,[38] the more subjects trusted government to regulate risks effectively (Govtrust), the less concerned they were about nanotechnology risks.

The regression analysis slightly complicated the finding of a "white male effect" for nanotechnology risks. It confirmed that being female and being black rather than white disposed subjects to see nanotechnology as risky, even controlling for other influences. However, relative to whites, being a minority other than an African-American actually predicted less concern for nanotechnology risks.

Semi-Partial Coefficients		
	Step 1	Step 2
female	.062 **	.036 *
other_minority	-.063 ***	-.047 **
black	.058 **	.040 *
age	.021	.012
hh_income	-.044 *	-.035 *
education	-.046 *	-.047 **
parent	.013	-.01
republican	.023	.020
third_party	.016	.020
conservative	.038 *	.015
govtrust	-.086 ***	-.061 ***
individ	-.005	.015
hierarch	.038 *	.019
envrisk	.115 ***	.084 ***
nanoknow	-.276 ***	-.164 ***
nanoaffc		-.334 ***
R^2	.18	.29

$n \approx$ 1,240. DV=Nano risk > benefit. * $p \leq .10$, ** $p \leq .05$, ***$p \leq .01$, 2-tail.

Table 2. Regression Analysis of Nanotechnology Risk Perceptions

Both a hierarchal cultural orientation and a conservative political ideology had small and borderline-significant effects. However, the direction of the effects—toward *more* concern with nanotechnology risks—was unanticipated.

[38] *See* Slovic, *supra* note 4, at 316.

In step 2, we added the affect variable (coded toward positive feelings) to the model. It was significant and had the predicted effect on nanotechnology risk perceptions: the more positive subjects' affect toward nanotechnology was, the less risky they perceived it to be relative to its benefits. Indeed, affect proved to be the largest predictor, with an effect size double that of prior knowledge. Adding affect to the model increased the model's explanatory power by approximately 60%, and subsumed the (odd) effects of both cultural orientation and political ideology. Overall, then, the results strongly confirm the first main hypothesis, namely, that perceptions toward nanotechnology risks would be affect driven.

Race and gender effects persisted, as did the effect of government trust, after the inclusion of affect. So did the effect of education: the more educated the subjects were, the less concerned they were about nanotechnology risks holding all other influences constant.

4.1.3. Explaining Affect

We performed additional regression analyses to attempt to determine the source of the variation in our subjects' affective appraisals of nanotechnology (Table 3).[39] Environmental risk perception had the predicted effect on affect: holding all other influences constant, the more concern our subjects had about global warming and nuclear power, the more negative their affect was toward nanotechnology. The first subhypothesis was thus confirmed.

[39] Subjects who did not take a position on whether nanotechnology risks outweigh nanotechnology benefits or vice versa are omitted from the regression. Some of these subjects, however, did respond to the nanotechnology affect item. Including them in the regression does not produce any materially different results, with the exception that the coefficient for parent becomes borderline significant.

Semi-Partial Coefficients	
female	-.083***
other_minority	.040*
black	-.062**
age	-.018
hh_income	.036
education	-.005
parent	-.030
republican	-.005
third_party	.011
conservative	-.061**
govtrust	.063**
individ	.056**
hierarch	-.059**
envrisk	-.082***
nanoknow	.288***
R^2	.17

n ≈ 1,240. DV=Nano risk > benefit. * $p \leq .10$, ** $p \leq .05$, ***$p \leq .01$, 2-tail.

Table 3. Regression Analysis of Nanotechnology Affect

The second subhypothesis was that cultural worldviews would influence affect toward nanotechnology. Both Hierarchy and Individualism did have a significant effect. However, the sign of Hierarchy was negative, indicating that the more hierarchical our subjects were the more negative their affect and the more egalitarian the more positive. This particular result was contrary to our hypothesis.

Certain other demographic characteristics also had an effect. Thus being female and black both predicted negative affect. So (unexpectedly) did conservative political ideology.

By far the largest influence on affect was prior knowledge. The more subjects reported having heard about nanotechnology before being surveyed, the more positive their affective appraisal of it.

4.2. Information Treatment: The Impact of Information

By comparing nanotechnology risk assessments across the information-treatment and no-information treatment groups, we were able to assess the impact of information exposure on attitudes toward nanotechnology risk perceptions. The results showed that information has a profoundly ambiguous effect.

4.2.1. Main Effects: Information Doesn't Matter

The main effect of information exposure—that is, the overall effect of information exposure across the treatment groups—is essentially nil. The respective mean evaluations of nanotechnology risks of the information-treatment group (2.65) and the no-information group (2.66) are statistically insignificant. Because the sample sizes of the two groups generated a likelihood of over 90% for detecting even a small effect size at an alpha of .10,[40] it can be fairly concluded that balanced information of the sort reflected in our experimental manipulation does *not* affect opinions toward nanotechnology in the general population.

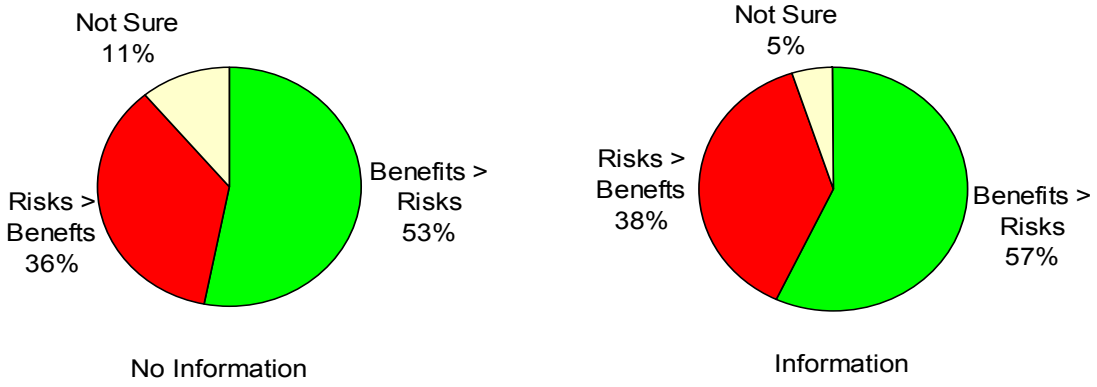

Figure 3. Views of Subjects Across Conditions

Consistent with this finding, the overall percentages of subjects in the information group who took the position either that benefits would outweigh risks (57%) or that risks would outweigh benefits (38%) were quite comparable to those in the no-information condition (53% and 36%, respectively). Not surprisingly, the percentage of subjects in the information condition who did not have a view on the relative preponderance of risks and benefits (5%) was less than half that in the no-information (11%), a difference that was significant at $p \leq .01$.

[40] *See* Jacob Cohen, Statistical Power Analysis for the Behavioral Sciences 33, tbl 2.3.3 (1988).

The absence of a main effect casts at least modest doubt on the proposition—suggested by the high correlation between prior knowledge and the view that benefits predominate over risks in the no-information condition—that exposure to information makes individuals less concerned about nanotechnology risks. As in the no-information condition, the vast majority of subjects in the information condition, 78%, reported having heard either "nothing at all" (52%) or "just a little" (26%) before the study. Accordingly, if learning about nanotechnology does dispose persons to a more positive view, one might well have expected a sample so dominated by persons without substantial prior knowledge to shift toward a more positive view upon exposure to information.

4.2.2. Individual Differences: Biased Assimilation and Polarization

When one examines the impact of information on subgroups, however, a very different story emerges. Examining differences between relevant groups of interest (Table 4),[41] it is clear that exposure to balanced information did have a very profound impact on attitudes toward nanotechnology. However, what that impact is—whether information inclined subjects to see risks predominating over benefits or vice versa—depended on the group to which they belonged.

[41] For comparing groups, we evaluated the relative differences in the means of groups of interest across conditions. For example, whereas the difference between Hierarchs and Egalitarians was -.03 in the no-information condition, it was .14 in the information condition, generating a .17 change in the difference of the two groups' scores. The differences between the two means in the two conditions were converted into *z* scores, the differences between which were tested for statistical significance. *See generally* Cohen, *supra* note 40, at 110-11, 139-40. Because the sign of the differences in means were hypothesized in advance for the groups of interest, we used one-tailed *p* value to measure significance.

	Mean Benefit/Risk Perception		
	No Info Group	With Info Group	Significance
Overall	2.66	2.65	–
Men	2.81	2.91	
Women	2.50	2.45	
Whites	2.67	2.76	a**
Blacks	2.32	2.02	a**, b**, c**
White Males	2.85	2.93	b**
White Females	2.46	2.60	c**
Republicans	2.66	2.74	
Democrats	2.66	2.62	
Liberals	2.78	2.62	d**
Conservatives	2.66	2.71	d**
Moderates	2.57	2.55	
Hierarchs	2.64	2.72	e*
Egalitarians	2.67	2.58	e*
Individualists	2.62	2.73	f**
Communitarians	2.70	2.54	f**
Hierarchal Individualists	2.65	2.81	g**, h**
Hierarchical Communitarians	2.63	2.47	g**
Egalitarian Individualists	2.56	2.60	
Egalitarian Communitarians	2.73	2.57	h**
Low Knowledge	2.51	2.50	
Moderate Knowledge	3.18	3.10	
High Knowledge	3.33	3.14	

Shared alphabetic notation indicates significant difference in differences between mean scores of groups across conditions: * $p \leq .10$, ** $p \leq .05$, ***$p \leq .01$, 1-tail.

Table 4. Differences in Benefit/Risk Perceptions Across Treatment Groups

4.2.2.1. Impact on Culturally Defined Groups

We hypothesized that information exposure would generate a "biased assimilation and polarization effect" along cultural lines. That is, we predicted that individuals would assimilate balanced information in a way biased by their cultural predispositions toward environmental risks generally. This hypothesis was strongly confirmed by the data. Thus, whereas hierarchs (2.64), egalitarians (2.67), individualists (2.62) and communitarians (2.70) all had comparable mean evaluations in the no-information condition, these types diverged relative to one another in expected directions—Hierarchs (2.72) and individualists (2.73) toward benefit, and egalitarians (2.58) and communitarians (2.54) toward risk—in the information condition (Figure 4).

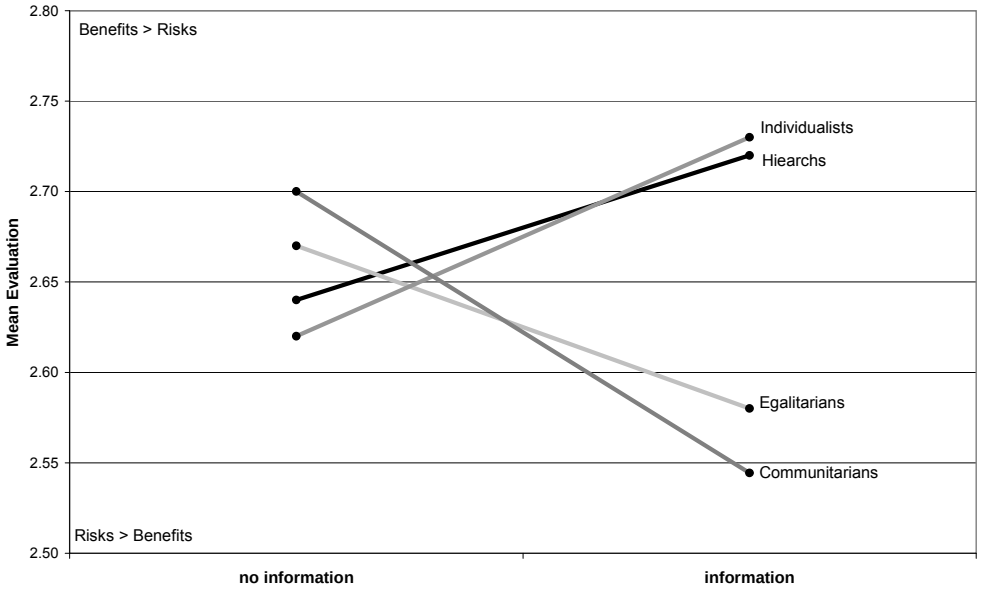

Figure 4. Impact of Information Across Condition by Dimension of Cultural Worldview

We saw a similar effect across subjects divided into the four cultural types formed by the overlap of the Hierarchy-Egalitarian and Individualism-Communitarian worldview dimensions. Although not significantly different from each other in the no-information condition (Table 1), Egalitarian Communitarians and Hierarchical Individualists assumed their characteristically risk-sensitive and risk-skeptical positions, respectively, in the information condition (Table 4, Figure 5). Hierarchical Communitarians and Hierarchical Individualists also displayed a biased-assimilation/polarization effect, suggesting that a combination of hierarchical and individualistic views most powerfully disposed subjects to be receptive to the benefits of nanotechnology.

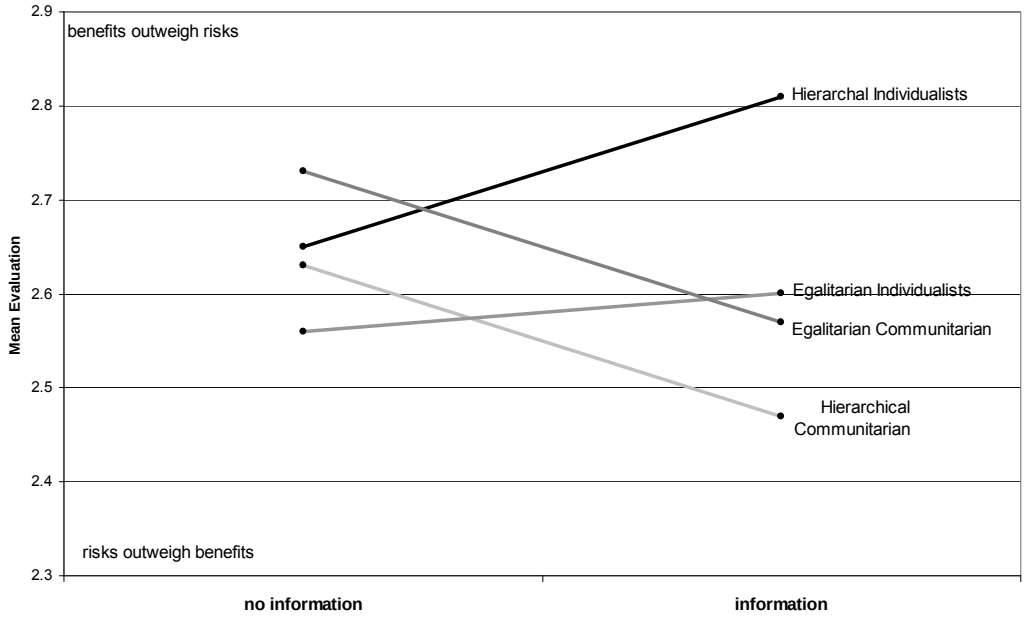

Figure 5. Impact of Information Across Condition by Culture Type

4.2.2.2. Impact on Politically Defined Groups

We observed a similar biased-assimilation/polarization effect among subjects divided into ideological subgroups. Whereas liberals had proven (somewhat surprisingly) more disposed to see benefits than risks relative to conservatives in the no-information condition (Table 1)—an effect that weakly persisted in a multivariate regression analysis before the addition of affect as an independent variable (Table 2)—the two groups traded places in the information condition (Table 4, Figure 6). This result confirmed our subhypothesis that biased assimilation and polarization would be observed along other relevant lines in addition to cultural ones.

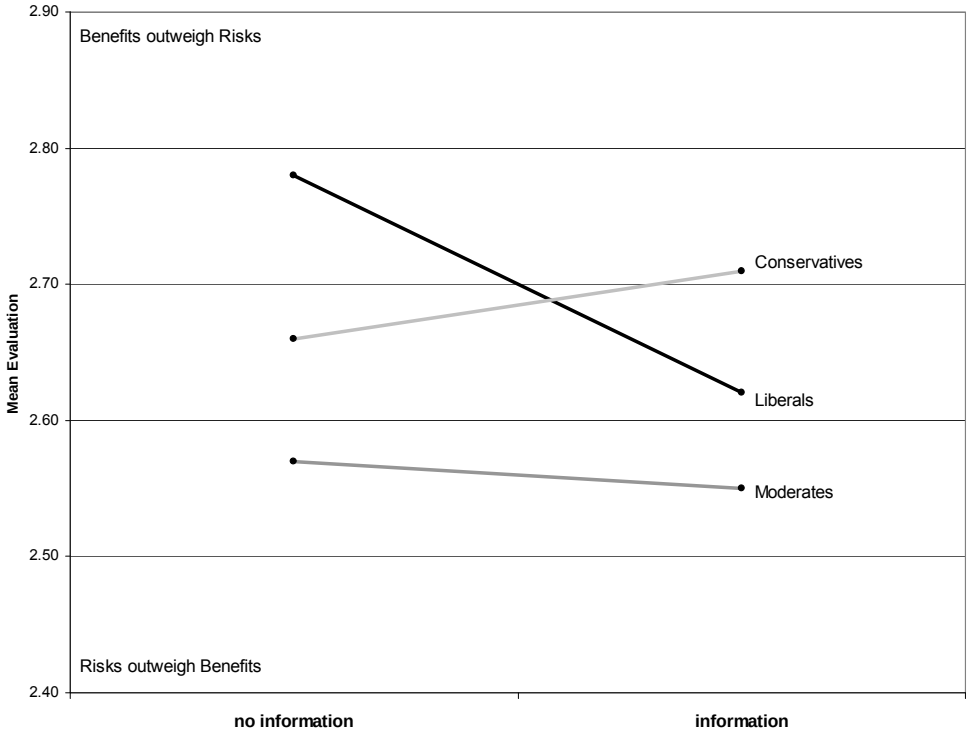

Figure 6. Impact of Information Across Condition by Ideology

Individuals who identified as Democrats and Republicans in the information condition also polarized relative to their counterparts in the no-information condition (Table 4), but the difference was not statistically significant (p = .11). This finding, of course, is *not* tantamount to saying that our experiment found that information does not generate divisions among individuals based on party affiliation. On the contrary, there is an 89% likelihood that the effect observed in the data is a real one. Moreover, although the power of our sample makes it very unlikely that we would have failed to observe a statistically significant effect in our experiment were cable of producing one, we would by no means be surprised if a stronger manipulation—e.g., information framed in a more opinionated and argumentative form—generated a statistically significant finding of polarization among Democrats and Republicans.

4.2.2.3. Impact on Race and Gender Groups

We also found biased assimilation and polarization along race and gender lines. Whites and African-Americans in the no-information condition held significantly different perceptions of the relative predominance of nanotechnology risks and benefits (Table 1). That division grew in intensity (Table 4, Figure 7) in the information condition. This result also confirmed our subhypothesis that there would be a biased-assimilation/polarization effect along lines in addition to culture.

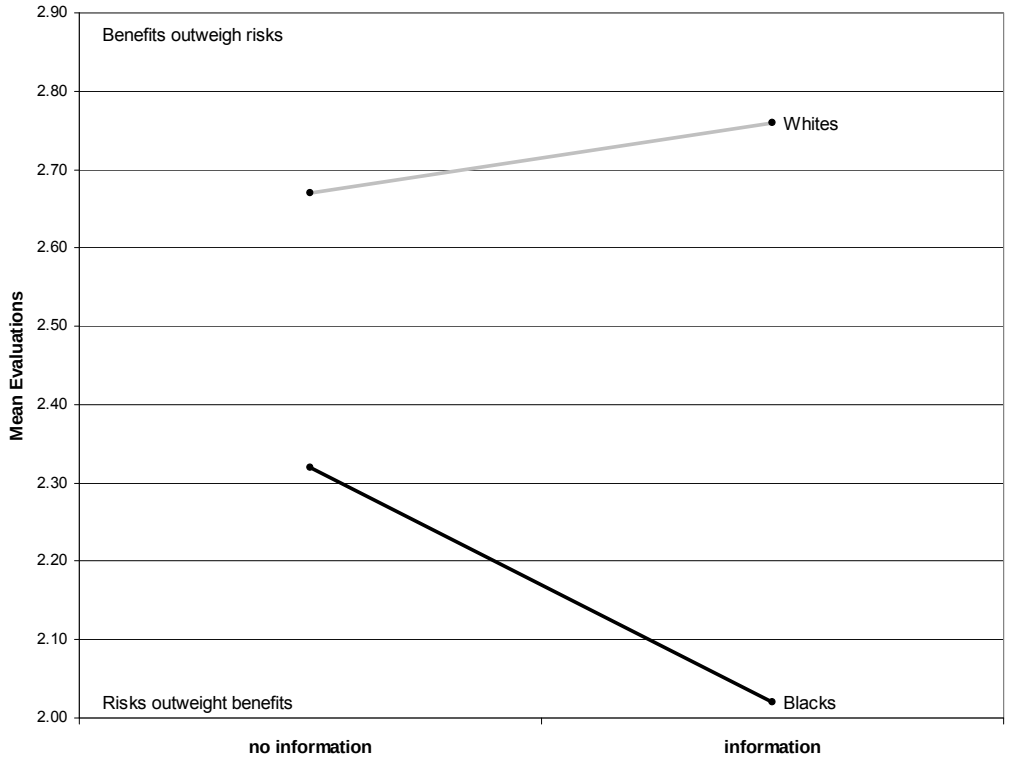

Figure 7. Impact of Information Across Condition by Race

Men and women also displayed a biased-assimilation/polarization effect (Table 4), but as in the case of Democrats and Republicans, the difference was significant at only $p = .11$. We again note that this finding should not be interpreted to mean that we found that men and women do not polarize, much less that they reacted similarly, to information about nanotechnology's risks and benefits.

Among whites, however, it seems fair to conclude that there is *not* a biased-assimilation/polarization effect across genders. As in the information-

condition, white males (mean = 2.93) and white females (mean = 2.60) held significantly different views (p = .01) of the risks and benefits of nanotechnology in the information condition (Table 4). However, the difference between the two, rather than increasing across the conditions, actually grew *smaller* (Table 4), although by an amount that itself did not even approach statistical significance (p = .34). We were surprised by this result, which defied one of our sub-hypotheses about the effect of information.

4.2.2.4. Impact on Groups Defined by Prior Knowledge of Nanotechnology

It is also fair to say that information exposure does not close the gap between persons with little prior knowledge and those with more. Differences among persons with low knowledge, on the one hand, and those with moderate and high knowledge, on the other, remained significant in the information condition (Table 4, Figure 8). More interestingly, the *difference* in the mean evaluations of low-knowledge and moderate- and high-knowledge groups also did not even approach statistical significance.[42] The only reason the difference between these groups narrowed, moreover, was that subjects with moderate or high knowledge in the information condition were more concerned about risks than were their counterparts in the no-information condition, although the difference was not significant.

As noted, the strong correlation in the no-information condition between prior knowledge and a positive attitude toward nanotechnology risks and benefits was subject to two interpretations: that knowledge disposes persons to a favorable view; or that persons disposed to a favorable view by some other influence are disposed to learn more (or at least report knowing more) about nanotechnology. The observed failure of information exposure to narrow the gap between low-knowledge subjects, on the one hand, and moderate- and high-knowledge subjects, on the other, in the information condition strongly supports the latter view.

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[42] Comparing those who reported knowing "just a little" or "nothing" with those who reported knowing "a little" or "nothing," on the one hand, with those who knew "some" or "a lot," on the other, the value of p, 1-tailed, was .32.

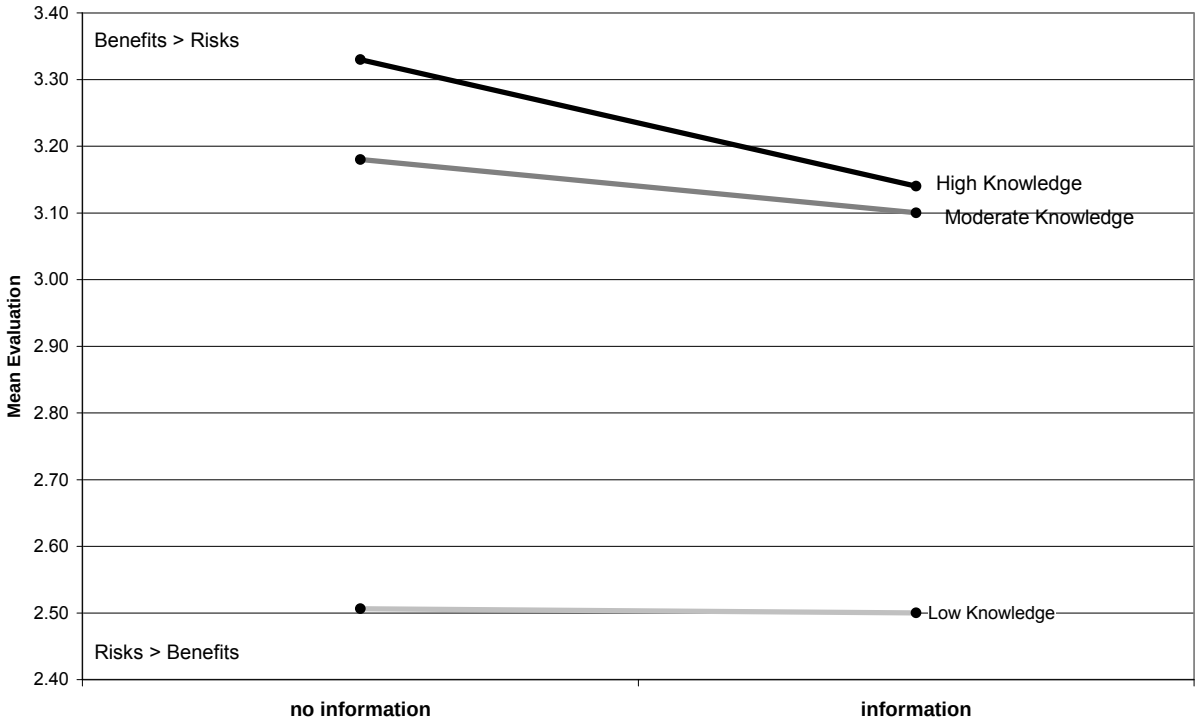

Figure 8. Impact of Information Across Condition by Prior Knowledge Level

5. What We Now Know, What We Still Don't, Plus Some More Conjectures About Nanotechnology Risk Perceptions

We began with some questions about the formation and evolution of nanotechnology risk perceptions. Based on our study results, we now venture some answers.

5.1. What Explains Existing Public Reactions to Nanotechnology Risks?

Individuals, even ones who admittedly know little about nanotechnology, have views about the risks and benefits of this emerging science. How do they form them?

The answer, our study demonstrates, is *affectively*. As they do for myriad other putatively dangerous activities, individuals form an instantaneous reaction to nanotechnology that then guides their appraisal of its risks and benefits. Indeed, we found that this emotional response to nanotechnology better explains differences in individuals' opinions than does any other factor, includ-

ing their race or gender, their level of education, their income, their political and cultural commitments, their trust in government, and their level of knowledge about nanotechnology.

This finding, of course, raises the question, what accounts for individuals affective reactions to nanotechnology? Why are some people positively disposed, and others negatively disposed, toward it?

Our study suggests supplies at least some partial answers. One important influence, we found, was how individuals perceive other types of environmental risks, including nuclear power and global warming. It seems quite plausible, in particular, that most people, lacking much information about this novel form of technology, form an instantaneous reaction to it based on their views about technology and environmental risk more generally. It's only a guess, but we suspect individuals' reactions to the word *technology* itself might well determine their affective response toward nano*technology*, at least before they have had a chance to learn much about it.

5.2. How Is the Public Likely to React to Additional Information About Nanotechnology Risks?

One might suppose that as members of the public learn more about nanotechnology their assessments of its risk and benefits should converge. Our results suggest that exactly the opposite is likely to happen.

Specifically, we found that *how* people react to information depends largely on their values. Individuals who hold values that predispose them to credit claims of environmental risk generally tend to become alarmed, whereas those who hold values that predispose them to dismiss claims of environmental risk generally tend to be become reassured, as they are exposed to balanced information about nanotechnology's risks and benefits. Thus, individuals who are relatively hierarchical and individualistic, on the one hand, and those who are relatively egalitarian and communitarian, on the other, are likely to process information in a biased way that polarizes them. By the same token, people who describe themselves as liberals are likely to diverge from people who describe themselves as conservatives.

This finding is of general importance, we believe, in the study of public risk perceptions. Scholarship in this field is dominated by two competing theories.[43] The "rational weigher" theory holds that people, in aggregate and over time, generally process information about risk in a manner that promotes their expected utility.[44] The "irrational weigher" theory, in contrast, holds that individuals lack the capacity to process information about risk in this way because of cognitive biases and other forms of bounded rationality.[45]

Neither of these theories can explain our findings. The rational-weigher theory assumes that people value protection from risk at different levels, but nothing in it suggests that people with different cultural values will draw different inferences from information about *whether* a technology is risky. And unless we make the implausible assumption that persons of different cultural outlooks differ in the extent of their ability to surmount limits on human cognition, there is likewise nothing in the irrational-weigher theory that would predict that persons of differing cultural outlooks will construe information about risks and benefits differently.

This phenomenon is more readily explained by a third model, which we have called the "cultural evaluator" theory of risk perception.[46] This theory says that individuals don't simply weigh risks, whether rationally or irrationally, but rather evaluate what one position or another on those risks will signify about how society should be organized. What individuals *learn*, then, when they are exposed to information is not so much how a putatively dangerous activity will advance their utility understood in narrow instrumental terms, but rather what position with respect to that activity will best express their cultural identities.[47] In connection with nanotechnology, our findings suggest that even minimal exposure to information (information that on its face has nothing to do

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[43] *See* Kahan *et al.*, *supra* note 5, at 1074-76.

[44] *See, e.g.*, W. Kip Viscusi, Risk by Choice: Regulating Health and Safety in the Workplace (1983).

[45] *See, e.g.*, Sunstein, *supra* note 8.

[46] *See* Kahan *et al.*, *supra* note 5, at 1087-88.

[47] *Cf.* Cohen, *supra* note 17 (developing this point in connection with political opinions generally).

with culture!) is sufficient to enable people of shared cultural orientations to figure out what that position is.

Nevertheless, our findings do reveal at least one interesting puzzle. There is clearly a positive correlation in general between how much people know—or at least report knowing—and the view that nanotechnology's benefits outweigh its risks. At first glance, this appears to imply that people become more favorably disposed to nanotechnology the more they know about it. But this interpretation is almost certainly incorrect, or at least unduly simplistic. As our own results demonstrate, people with different values react in divergent ways—some negatively, some positively—to the same information. In addition, considering only how much people knew prior to the study, exposing ill-informed people to information did nothing to narrow the gap between their relatively negative view of nanotechnology and the relatively positive view of persons who describe themselves as well-informed.

Under these circumstances, the most convincing conclusion is that the relationship between prior knowledge and a positive view of nanotechnology is spurious. Some other influence is moving individuals who are otherwise positively disposed to nanotechnology to learn more about it. The mystery, of course, is what that influence is.

Discovering how predispositions toward putatively dangerous activities motivate people's own efforts to learn about that activity would be a major advance in the science of public risk perception. Precisely because it is novel, nanotechnology furnishes an excellent focus for research on this question.

6. As Goes Berkeley, So Goes the Nation? Not Necessarily

Reacting quickly and on the basis of very little information, government officials in Berkeley decided that regulation of nanotechnology was appropriate to safeguard the public. Should we expect democratically accountable officials elsewhere to follow suit? The answer is, it depends.

It depends, for one thing, on the cultural and political makeup of those communities. We suspect that Berkeley reacted the way it did because a disproportionately large portion of its population subscribes to egalitarian and communitarian worldviews. Indeed, it was probably his experience at the Uni-

versity of California, Berkeley, that moved political scientist Aaron Wildavsky, one of the founders of the cultural theory of risk, to draw a connection between an egalitarian, collectivist orientation and sensitivity to environmental risk.[48] The American population as a whole, however, is culturally diverse. In other localities, ones that are more inclined toward hierarchy and individualism, the impulse to regulate nanotechnology will surely be much less intense.

What does this mean, though, about regulation of nanotechnology at the national level, where most significant environmental law is formed? A distinct possibility is that nanotechnology, as it assumes a bigger profile (!) in the public imagination, will become a subject of increasing division. After all, we were able to generate cultural and ideological polarization among our subjects using *balanced* information. Because individuals in the real world are much more likely to select information in a biased fashion that matches their cultural and political dispositions,[49] one might anticipate even more extreme polarization outside the lab. Nanotechnology, on this view, could go the route of nuclear power and other controversial technologies, becoming a focal point of culturally infused political conflict.

But that admittedly bleak outcome isn't a certainty, either, in our view. The cultural cognition of risk suggests that individuals are likely to respond to risks in a way that expresses their values. But nothing in the theory implies that those responses are somehow fixed in some way that defies the power of society itself to manage.

Indeed, there *have* been instances in which democratically accountable officials have forged conditions enabling citizens of opposing cultural views to converge on appropriate risk-abatement policies.[50] These success stories,

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[48] *See* Douglas & Wildavsky, *supra* note 22.

[49] *See* Braman *et al.*, *supra* note 18.

[50] *See* Kahan *et al.*, *supra* note 5, at 1097-98; *see also* Donald Braman & Dan M. Kahan, *Overcoming the Fear of Guns, the Fear of Gun Control, and the Fear of Cultural Politics: Constructing a Better Gun Debate*, 55 Emory L.J. 569, 588-98 (2006); *cf.* Geoffrey Cohen, David Sherman, Anthony Bastardi, Michelle McGoey, Lillian Hsu, & Lee Ross, *Bridging the Partisan Divide: Self-Affirmation Reduces Ideological Closed-Mindedness and Inflexibility*, J. Personality & Social Psych. (forthcoming 2007); Geoffrey L. Cohen, J. Aronson & C. M. Steele, *When Beliefs Yield to Evidence: Reducing Biased Evaluation by Affirming the Self*, 26 Personality and Social Psych.

however, reinforce the major conclusion of our study: that mere dissemination of scientifically sound information is not by itself sufficient to overcome the divisive tendencies of cultural cognition. Those in a position to educate the public—from government officials to scientists to members of industry—must also intelligently frame that information in ways that make it possible for persons of diverse cultural orientations to reconcile it with their values.

It's not clear whether the nation will go the way of Berkeley—or for that matter, even where Berkeley itself will go—on nanotechnology. What is clear, however, is society's desperate need for a new science of "democratic risk deliberation" that makes it possible to identify regulatory policies that simultaneously promote the welfare and affirm the values of a culturally diverse citizenry.

Bull. 1151 (2000) (finding that self-affirmation promotes willingness to consider information that challenges beliefs held by one's ideological reference group).

Appendix A

Knowledge Networks Panels and Sample for this Study

1. *Knowledge Networks*

Knowledge Networks (http://www.knowledgenetworks.com/) is a public opinion research firm with offices located throughout the United States. It maintains an active respondent pool of some 40,000 persons who are recruited to participate in on-line surveys and experiments administered on behalf of academic and governmental researchers and private businesses. Knowledge Network respondents agree to participate in three to four surveys per month in exchange for Internet access and other forms of compensation. It uses recruitment and sampling methods that assure a diverse sample that is demographically representative of the U.S. population. Numerous studies have concluded that on-line testing of Knowledge Network samples generates results equivalent in their reliability to conventional random-digit-dial surveys (http://www.knowledgenetworks.com/ganp/2005aapor.html, and studies using Knowledge Networks facilities are routinely published in peer-reviewed academic journals (http://www.knowledgenetworks.com/ganp/docs/List%20of%20Journals%208-28-2006.pdf).

2. *Demographic composition of sample for this study*

a. Total number of subjects: 1,862.

b. Gender: 51% female, 49% male.

c. Race: 72% white, 10.1% African-American.

d. Average age: 46.4 years.

e. Median household income: $35,000 to $40,000.

f. Median education level: Some college.

Appendix B

Select Experiment Survey Instrument Items

1. Cultural Orientation Scales

Four-point response scale for all items: Strongly Disagree, Disagree, Agree and Strongly Agree.

Individualism-Solidarism Scale

1. IINTRSTS. The government interferes far too much in our everyday lives.

2. SHARM. Sometimes government needs to make laws that keep people from hurting themselves.

3. IPROTECT. It's not the government's business to try to protect people from themselves.

4. IPRIVACY. The government should stop telling people how to live their lives.

5. SPROTECT. The government should do more to advance society's goals, even if that means limiting the freedom and choices of individuals.

6. SLIMCHOI. Government should put limits on the choices individuals can make so they don't get in the way of what's good for society.

7. SNEEDS. It's society's responsibility to make sure everyone's basic needs are met.

8. INEEDY. It's a mistake to ask society to help every person in need.

9. SRELY. People should be able to rely on the government for help when they need it.

10. IRESPON. Society works best when it lets individuals take responsibility for their own lives without telling them what to do.

11. ITRIES. Our government tries to do too many things for too many people. We should just let people take care of themselves.

12. IFIX. If the government spent less time trying to fix everyone's problems, we'd all be a lot better off.

13. IENJOY. People who are successful in business have a right to enjoy their wealth as they see fit.

14. IMKT. Free markets—not government programs—are the best way to supply people with the things they need.

15. IPROFIT. Private profit is the main motive for hard work.

16. IGOVWAST. Government regulations are almost always a waste of everyone's time and money.

Hierarchy-Egalitarianism Scale

1. HEQUAL. We have gone too far in pushing equal rights in this country.

2. HREVDIS1. Nowadays it seems like there is just as much discrimination against whites as there is against blacks.

3. EWEALTH. Our society would be better off if the distribution of wealth was more equal.

4. ERADEQ. We need to dramatically reduce inequalities between the rich and the poor, whites and people of color, and men and women.

5. EDISCRIM. Discrimination against minorities is still a very serious problem in our society.

6. HREVDIS2. It seems like blacks, women, homosexuals and other groups don't want equal rights, they want special rights just for them.

7. HCHEATS. It seems like the criminals and welfare cheats get all the breaks, while the average citizen picks up the tab.

8. EDIVERS. It's old-fashioned and wrong to think that one culture's set of values is better than any other culture's way of seeing the world.

9. HWMNRTS. The women's rights movement has gone too far.

10. ESEXIST. We live in a sexist society that that is fundamentally set up to discriminate against women.

11. HTRADFAM. A lot of problems in our society today come from the decline in the traditional family, where the man works and the woman stays home.

12. HFEMININ. Society as a whole has become too soft and feminine.

13. EROUGH. Parents should encourage young boys to be more sensitive and less rough and tough.

2. Government Trust Item

GOVTRUST. The federal government can be trusted to protect the public from environmental and technological risks. [Strongly Disagree, Disagree, Agree, Strongly Agree]

3. Environmental Risk Perception Items

How much risk do you believe each of the following poses to the safety or health of people in our society? [Almost No Risk, Slight Risk, Moderate Risk, High Risk]

GLOBWARM. Global Warming
. . .
NUKEPOW. Nuclear Power

4. Nanotechnology Items

General Introduction and knowledge item

INTRO9. Now we would like to know what you think about nanotechnology. Nanotechnology is the ability to measure, see, predict and make things on the extremely small scale of atoms and molecules. Materials created with nanotechnology can often be made to exhibit very different physical, chemical, and biological properties than their normal size counterparts.

NANOKNOW. How much have you heard about nanotechnology before today? [Nothing at All, Just a Little, Some, A Lot]

Information Manipulation

> The potential benefits of nanotechnology include the use of nanomaterials in products to make them stronger, lighter and more effective. Some examples are food containers that kill bacteria, stain-resistant clothing, high performance sporting goods, faster, smaller computers, and more effective skincare products and sunscreens. Nanotechnology also has the potential to provide new and better ways to treat disease, clean up the environment, enhance national security, and provide cheaper energy.
>
> While there has not been conclusive research on the potential risks of nanotechnology, there are concerns that some of the same properties that make nanomaterials useful might make them harmful. It is thought that some nanomaterials may be harmful to humans if they are breathed in and might cause harm to the environment. There are also concerns that invisible, nanotechnology-based monitoring devices could pose a threat to national security and personal privacy.

Affect Item

NANOAFFECT. How would you say nanotechnology makes you feel? [very bad, bad, neither good nor bad, good, very good]

Risk/Benefit Item

NANORISK. Do you think
(1) the **risks** of nanotechnology will **greatly outweigh** its **benefits**
(2) the **risks** of nanotechnology will **slightly outweigh** its **benefits**
(3) the **benefits** of nanotechnology will **slightly outweigh** its **risks**
(4) the **benefits** of nanotechnology will **greatly outweigh** its **risks**