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Informed Public Perceptions of Nanotechnology and Trust in Government

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ABOUT THE **AUTHOR**

Jane Macoubrie is a leading social scientist in the discipline of communication studies, studying the principles and variables that affect and construct human communication outcomes.

Dr. Macoubrie is co-author, with North Carolina State University's Michael Cobb , of the 2004 study, "Public Perceptions about Nanotechnology: Risks, Benefits and Trust." This was the first nationally representative survey designed to gauge the American public's perceptions about nanotechnology. It was funded by the U.S. National Science Foundation (NSF).

She has studied face-to-face and Internet mediated communication processes for citizen involvement in policymaking since 1992, focusing on communication variables influencing effective processes. Her research into citizen deliberation of technology policy issues since 2001 has mostly been conducted with support from NSF. She is author of numerous peer-reviewed articles and lectures widely.

Dr. Macoubrie was Assistant Professor of Public and Interpersonal Communication at North Carolina State University from 1998-2005. She received her Ph.D. (1998) and her M.A. (1994) from the University of Washington. Her B.A. degree is from Antioch University Seattle.

INFORMED PUBLIC PERCEPTIONS OF NANOTECHNOLOGY AND TRUST IN GOVERNMENT

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INTRODUCTION

Nanotechnology is science's next big thing. It's the tiny world of controlling matter at the scale of one billionth of a meter, or less than one-100,000th the width of a human hair. Researchers are exploring ways to see and build at this scale, reengineering familiar substances like carbon and gold to create new materials with novel properties and functions.

In just a few short years, nanotechnology has catapulted from being a specialty of a few physicists and chemists to a worldwide scientific and industrial enterprise. The National Science Foundation predicts that the global marketplace for goods and services using nanotechnologies will grow to $1 trillion by 2015, and there are already over 500 products being sold that claim they are made with nanoscale or engineered nanomaterials. These include products like self-cleaning windows, automobile paint, sunscreens, and tennis rackets. In the future, a marriage of nano and biotechnology will likely create a whole new generation of drugs, biomedical devices, and other solutions to some of our most challenging medical problems.

But little is known about the technology's possible health and environmental implications. The federal government is just beginning to develop regulatory approaches specific to nanotechnology applications and production. At this critical juncture, it is important that leaders from industry, government, the science and engineering community, and other sectors develop a better understanding of what the public wants and expects in terms of the oversight of these new and emerging technologies.

This report, "Informed Public Perceptions of Nanotechnology and Trust in Government," could not come at a more propitious time. It provides an in-depth look at what Americans know and do not know about nanotechnology. It offers a view of the nano applications and products people think are most important. It examines who Americans trust most to manage nanotechnology's potential risks. And it highlights what particular concerns citizens may have about nanotechnology's use.

For me, the most important message from this report is that a lack of information—about nanotechnology-based products, about their possible health and environmental implications, and about the oversight processes designed to manage risks—breeds public mistrust and suspicion. This report shows that in the absence of balanced information, people are left to speculate about the possible impacts of nanotechnology. They often draw on analogies to past technologies, many of which may be misleading, such as asbestos, dioxin, Agent Orange, or nuclear power.

Consumers want more information to make informed choices about nanotechnology's use, and they strongly support more research and safety testing before products go to market. When asked whether they felt voluntary standards for industry would be sufficient to manage the potential risks of nanotechnology, 55 percent of study participants said that mandatory government controls are necessary. An additional 33 percent were unsure whether voluntary standards would be sufficient. Government and

industry need to realize that while voluntary measures may be pursued in the short term, they may not assuage public concerns over the long term.

After taking part in the issue groups we conducted, half the participants felt mostly or quite positive about nanotechnology, and 32 percent remained neutral. Traditionally, the public is willing to accept risks associated with new technologies if there is clear evidence of early, significant new benefits like low cost, highly efficient solar energy or a breakthrough treatment for Alzheimer's disease.

For nanotechnology, those significant benefits are still largely a promise. Until they are delivered, expect a certain degree of public skepticism about the next big thing.

David Rejeski
Director, Project on Emerging Nanotechnologies
Washington, DC
September 2005

Executive Summary

This report presents results of a study, conducted May through June of 2005, on the public's perceptions of government, nanotechnology, and regulation. The study was designed in response to a number of questions that emerged from a 2004 study, which found low levels of public trust in government to manage potential risks associated with nanotechnology. In this study, we wanted to learn more about why this low level of trust exists. Is there simply a general public mistrust in government or is it related to individual government agencies or particular applications of nanotechnology? More specifically, we wanted to find out what steps government and industry could undertake to improve trust.

Using a highly structured research approach, we formed groups consisting of private citizens in Cleveland, Dallas, and Spokane, and provided them with balanced, clearly written information on nanotechnology and on U.S. regulatory and policy-making bodies relevant to nanotechnology. The information packets included four sets of briefing materials to explain applications of emerging nanotechnologies, including such areas as consumer and personal product applications and products created by the convergence of biotechnology and nanotechnology.

Our findings suggest the following general public perceptions, which are detailed in the body of the report and presented in table format in the Appendix.

- **Major Benefits Are Anticipated.** The top two anticipated benefits from nanotechnology are major medical advances and improved consumer products, which accounted for 31% and 27% of all the benefits identified, respectively. General technological progress was also seen as a significant benefit, as were advances in environmental protection, lower cost energy, and improved food and nutrition.

  "It sounds like a great idea. It can help everything."

- **Public Wants To be Included.** The need for a voice for the public and the lack of information available to consumers about technology decision-making were strong threads throughout the study. Participants were concerned about the existence of hundreds of nanotechnology-enabled products in the marketplace and the expenditure of billions of dollars of taxpayer money on nanotech R&D without public involvement. Participants presented an overarching desire to both be informed and to have a role in decision-making. "We need to be informed," demanded one participant while another stated that "government should not be making these decisions alone," especially as it relates to medicine and to food.

  "One of the drawbacks of nanotechnology is that there are going to be a lot of people out there who are scared because they don't know what it is, and are going to slow the technology down."

- **Lack of Support for a Ban on Nanotechnology Products.** One non-governmental group has advocated that new nanotechnology products be banned until further study of the potential risks. After learning about

nanotechnology and its applications, 76% of respondents believe "a ban is overreacting."

- **High Demand for Effective Regulation.** The majority of study participants felt that voluntary safety standards applied to industry would not be sufficient to manage the potential risks associated with nanotechnology; 55% said government control beyond voluntary standards is necessary, while 33% were unsure. Only 11% felt voluntary standards would be adequate. Even given their regulatory concerns, 50% felt positive or quite positive after learning about nanotechnology and the differing roles of the regulatory agencies, while 32% remained neutral.

"Nanotechnology can be good, if regulated properly."

- **Low Public Trust in Government.** As in the earlier study, low trust in government to manage technology-related risks was still prevalent. It appears to be related, first, to specific regulatory agencies and other entities of government, and second, to specific applications of nanotechnology. Trust in regulatory agencies seems to reflect past history with certain categories of products, e.g., the Food and Drug Administration's difficulty with the drug Vioxx. Public trust was lowest vis-a-vis the Congress and the White House. Study participants felt political pressure has in the past interfered with protections for public safety. Regulatory agencies were thought to be trying to do their job to ensure public safety, but limited by outside pressure from providing appropriate levels of protection.

"Regulators are affected by politicians… Politicians are influenced by lobbyists."

- **Suspicions of Industry.** Past safety issues with specific products, ranging from drugs to genetically engineered crops, have led to a widespread perception that industry pushes products to market without adequate safety testing, makes too many errors affecting people's health, and puts its own motives ahead of consumer safety. In general the participants felt there are "unscrupulous risks taken by the medical community," and overall there exists "a race with too many mistakes."

"I'm all for it if it makes my life easier, but it is like Vioxx – the world is in a rush, rush, rush, to get it out there."

- **Specific Recommendations on How to Improve Trust.** There was a surprising degree of agreement among participants on how government and industry could improve trust. These were: (1) through more testing before products were introduced and (2) the provision of more information to the public.. One participant observed "[there is] a past history of failed precautions," and most participants supported a more "thorough investigation before [product] release."

- **Media Influence is Presently Low.** Study participants knew little about nanotechnology prior to the study. Of those who had heard of it from one source, 22% said it was from public television or radio, and 20% indicated they had heard about nanotechnology from another person (word-of-mouth). Popular media channels seem to be having little impact on awareness, while for most, commercial news media is not a primary source of information.

Background

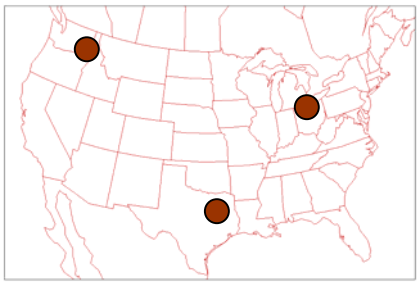
In 2004, the National Science Foundation provided funding for two separate explorations of citizen perceptions of nanotechnology. First, a national survey explored issue framing, trust in government to manage risks, and expectations of benefits versus risks from nanotechnology. Awareness of nanotechnology, attitudes towards it, and the present effect of science fiction films and novels such as Michael Crichton's recent book *Prey* also were investigated (Cobb & Macoubrie, 2004).

Second, a separate study was designed to investigate the reactions of informed citizens. This study used experimental issue groups (EIGs) where citizens in three different cities were provided with background materials on nanotechnology and scenarios depicting possible developments projected for nanotechnology. Several forms of data were collected from the EIGs, including questionnaire data on attitudes towards nanotechnology, levels of concern for risk, trust in government and industry to manage risks, individual level reflections and insights, and demographic data for the participants (Macoubrie, in press). Major findings of the 2004 studies:

- The national survey, which sampled 1,250 people, found high interest in anticipated benefits from nanotechnology. Many people had only heard the word nanotechnology, however, little knowledge has penetrated through the media to the general public.
- The highest interest was in medical applications, particularly to target disease without invasive surgery, collateral damage, or side effects. However, in two regions of the country (West Coast and Midwest), these applications also evoked the lowest trust in government to manage the risks.
- The public was not at all certain benefits would exceed risks. In fact, 22% believed risks would exceed benefits, while 38% expected risks and benefits to be about equal; 40% believed benefits would exceed risks.
- In the experimental groups that were conducted involving 152 people, 95% of the participants expressed little or no trust in government to effectively manage the possible risks associated with nanotechnology. In the national survey, 95% of those surveyed did not trust industry leaders to effectively manage any risks. The similarity of these results was striking.
- In the 2004 experimental study examining concerns about nanotechnology and reasons for them, concerns were dominated by experiential knowledge. Rather than true unknowns, possibilities that neither scientists nor citizens can predict, concerns were based on knowledge of past technological "breakthroughs" from which significant downsides later emerged.
- The public did not seem to be fearful of nanotechnology itself, but is highly aware of past failures to gauge and manage risks found to be associated with other new technologies.
- World military and "evil doer" risks were mentioned the most, followed by concerns about long-term health risks and environmental impacts.
- Finally, higher education (college degree or higher) was related to low trust in government to manage any risks. No other demographic variable showed any significant link.

Overview of this Study

A more detailed description of the study design is provided in the Appendix. This section provides a sketch of the methods in areas that may be of most interest to readers. To study informed citizens' perceptions and attitudes, information was provided to participants about existing and emerging nanotechnology applications in areas such as consumer products, medicine, and agriculture. One group received materials that discussed the anticipated convergence of nanotechnology and biotechnology and its uses to enhance the human body. In all, 12 groups with a total of 177 participants were gathered together in 3 different locations: Spokane, Washington; Dallas, Texas; and Cleveland, Ohio.



Following known best practices of science journalists, the background materials were developed to present a balanced view of known and projected applications of nanotechnology. Brief information also was included on the roles of six regulatory agencies, as well as Congress and the White House, involved (or potentially involved) in nanotechnology oversight. The materials were reviewed by scientists and regulators for accuracy, balance, and clarity and were written to be understandable by a lay audience. Materials focused on conveying known facts and the reasoning about important issues rather than merely stating opposing positions. The data analysis reported here was conducted by Dr. Jane Macoubrie.

Study pre- and post-test questionnaire, informational materials, and additional details of the study methodology are given in the Appendix of this report. Study participants were recruited to be representative of demographics in the 3 locations chosen for the study. The primary characteristics of the study participants relative to the 2000 Census are shown below.

	2005 Study Participants									
	Political Affiliation	Gender %		Race %				Mean Income	Mean Age	EDU %
		M	F	Cauc	Afr.Am.	Hisp./ Latino	Native American & Other			
Study Sample	R=30% D=37% Ind=25% Other=8 %	49.2	49.2	58.8	20.3	14.7	5.1		43	HS=22* SC=26 TRD/CERT=10 CD=23 >CD16
2000 US CENSUS		49	51	77	13	4.2		50K	35.3	HS=27 SC=21 CD=26 >CD=9

EDU: HS = high school diploma, SC = some college, TRD = trade or certificate training beyond HS, CD = college degree, >CD = education beyond 4 year degree. *Less than HS = 2.3%. Missing data = 1.1%.

Results of this study are from an analysis of three forms of data:

1) answers to survey questions in pre- and post-test questionnaires,
2) individual-level data provided in response to opportunities to privately express areas of concerns and benefits, prior to group discussion, and
3) group discussion of concerns, benefits, and perceptions of regulatory agencies.

Pre-test survey questionnaires were administered prior to the study. After reading the informational materials, individuals then gave responses to 'concerns' and 'anticipated benefits' of nanotechnology, discussed specific issues in their group, and finally, completed a post-study questionnaire. Some questionnaire items were included in both pre- and post-test; others were only asked in post-test, as appropriate.

Full Study Results

This section of the report summarizes the findings and uses examples of participants' comments or statements of concerns/benefits to illustrate the results. Data tables of full results are given in the Appendix.

General Attitudes and Knowledge

- **Low Awareness of Nanotechnology:** As in the 2004 studies, most people participating in the study had little initial awareness of nanotechnology. Answering the pre-study questionnaire, 54% professed to know almost nothing, 17% felt they knew something about nanotechnology, and 26% said they knew a little. Asked if nanotechnology is predicted to become another industrial revolution (true), 75% said "don't know" and 24% answered "true." [See Tables 1 and 2, Appendix]

- **Varied Sources of Knowledge:** Study participants were also asked about the sources of their information on nanotechnology, if they had any prior knowledge. When respondents identified only one source of knowledge, 22% said they had heard about nanotechnology from public television or radio, and 20% said they had heard about nanotechnology from another person. 14% had heard of nanotechnology from commercial television or radio news, 10% from science fiction, 8% from magazines and 8% from newspapers. If respondents had heard of nanotechnology from two sources, 28% mentioned magazines, 17% hearing from another person, 14% from science fiction, 11% from trade journals, and another 11% from public television or radio. [See Table 3, Appendix]

- **Generally Positive Attitude towards Nanotechnology:** Initial attitudes towards nanotechnology prior to the study were investigated by asking "are you quite positive, mostly positive, neutral, mostly negative, or don't know concerning your feelings about nanotechnology?" Initially, 38% were neutral, 13% were mostly positive, 41% answered "don't know," and less than 9% were either quite positive or mostly negative. After the study, 50% were mostly or quite positive, 32% remained neutral, 13% were mostly or quite negative, and 3% answered "don't know." [See Table 4, Appendix]

- **Benefits will Exceed Risks:** Perceived risks of nanotechnology versus nanotechnology's benefits were also tested in pre- and post-study questionnaire. After the study, 41% said the benefits should exceed the risks, 30% believed the risks and benefits would be about equal, 15% expected risks to exceed benefits, and 14% answered "don't know." [See Table 5, Appendix]

- **Little Support for a Ban:** After they had learned about nanotechnology, participants were asked: "Should nanotechnology be banned until further study of possible risks?" 76% of the respondents said "a ban is overreacting." An additional 16% said "don't know;" 8% supported a ban of new nanotechnology products. [see Table 6, Appendix]

Respondents' Interests in Nanotechnology Benefits

After reading informational materials on one of the four emergent applications areas of nanotechnology, study participants were asked to identify up to 5 areas of highest interest regarding the potential benefits of nanotechnology. These areas were written individually by study participants on a 5"x7" card, one benefit listed per card. The benefits of interest were clustered together as types of benefits (e.g., "treat cancer," "reduce overuse of antibiotics," "a cure for Alzheimers," "could lead to a cure for HIV/AIDS," are grouped in the benefit category of major medical uses). See the Appendix for more information on the analytic method used to summarize concerns and benefits.

1. **Medical Applications of Greatest Interest:** Study participants named as the top type of benefit major medical advances possible through nanotechnology (31% the of benefits identified). This included a wide range of possible applications from new diagnostic methods to treatments for cancer and diabetes.

2. **Better Consumer Products:** The second most frequently mentioned benefit group (27%), the consumer product category, contains potential benefits like "less toxic paint coatings," "toothpaste to fill cavities," "make life easier," "trash bags that biodegrade" and "stain resistant clothing."

3. **General Progress.** Benefits related to general progress account for 12% of benefits identified (general advancement - 5%, human race progress - 2%, and general knowledge advancement - 5%).

4. **Environmental Protection:** Environmental protection ranked fourth (8%) in benefits mentioned and includes such things as "less contaminated water," "stop damage to the planet," and "reduce waste, use less materials."

5. **Safer and Better Food:** Food and nutrition benefits, the 5th most frequently named benefit (6%) includes "safer food," (from smart packaging), "more nutritious food," and the ability to "feed the world."

6. **Energy, Economy, Electronics**: Energy benefits, the economy, and improved electronics and computing each garnered 4% of benefits envisioned.

7. **Benefits to Soldiers, Security.** Military uses and national security were mentioned in 3% of benefit comments.

N = 349 benefits named by 177 participants	*Percentage*
Major medical uses	31
Consumer products	27
General progress*	12
Environmental protection	8
Food and nutrition	6
Economy, jobs	4

Energy	4
Electronics, computers	4
Military uses and national security	3
Advancing international welfare	1

*Knowledge advancement 5%, Advance society 5%, Human race progress 2%

Specific Concerns About Nanotechnology

Study participants were invited to identify areas of concern separately from benefits. Areas of concern were written individually by study participants on a 5"x7" card, one per card, and later, categorized as they fell cumulatively into particular types of concern.

- **High Level of Concern about Unknowns, Regulation, and Health Risks:** The three top-ranking concerns -- true unknowns, regulation, and human health risks – accounted for almost 40% of the total concerns mentioned. The true unknowns label applies to concerns identified where outcomes and effects cannot be predicted by anyone, including nanoscientists. This category includes concerns such as "unknown risks and consequences," "unintended uses," "how our manipulation will effect natural laws," and "unpredictability if nano follows its own natural laws."

""Keep looking, but be careful what you're looking at. We've got to keep our curiosity up… and be aware of what the consequences can be."

- **Long-term Effects:** Also high on the list of concerns were those relating to the need to better understand and mange potential long-term effects. Concerns identified included "thorough investigation before release," "standards…past history of failed precautions," "you aren't talking about the long-term effects…why not?" and "should have substantial research on long-term effects."

"What effect does it have on the environment? What happens if they don't break down? How do we get rid of them? We don't want to find out in 20 years that it causes cancer."

- **Human Health Risks are Important:** Human health concerns included statements such as "cell effects that lead to cancer, like in the past," "in medical uses it could go where it shouldn't," "immune system responses," "lab-created parts that just fail later," and "medically untested cures."

- **Concerns Affected by Past Problems:** Examples of past regulatory, environmental, and human health errors, given to support concerns in several categories, included Vioxx, Viagra, Phen Fen (dietary pills), DDT, asbestos, nuclear power, lead in gasoline, jet fuel contaminating military bases, and genetically-engineered foods.

"It's like nuclear power. It's a great concept but what do you do with the waste products?"

- **Playing God:** Playing God and messing with nature includes "unnatural products that cause harm," "trying to outthink God…it won't work," "natural is better," "don't mess with nature," "leave DNA alone, don't play God," and "as a consumer, I want purity, not chemicals." While this was a concern mentioned individually by 5% of respondents, this concern was reiterated in group discussion by a small but vocal minority.

- **The Need for Effective Regulations:** The regulatory category includes concerns for both ineffective and potentially over-restrictive regulations. Participants spoke about "politics getting into regulation," "who regulates the regulators, like with biopharming," "lack of regulation during development," "must be regulated sufficiently," "that government can be manipulated to get the effect desired," "if too many regulate, nothing will get done," as well as "whether it will be over-regulated" and "over regulation leaving U.S. in the dust, like with stem cells."

- **Military Uses and Abuses:** Concerns over military uses ranged from "bad guys with progressive tools," to "keep our soldiers safer," "use to fight terrorism," and include concern about "international competition with negative effects," as well as "a new arms race" and "no military applications…I don't' trust this."

"[Nanotechnology] could create weapons worse than nuclear."

- **In My Food?:** Nanotechnology's use in food products, packaging, and agriculture led to food chain concerns, including "long term consumption of nano food," "adulterated field crops," "natural agriculture and animals," "foods that metabolize to worsen health," "biopharming in the wrong hands could be disastrous," and "using live people for experiments with FDA approval."

"I have reservations as far as its use in food, animals, in the chain that we eat."

- **Consumer Information:** Consumer knowledge and information concerns included "what say will the public have?" "government alone should not be making these decisions," "who gets a say in regulation?" "lack of knowledge & disclosure to users," "we should know when food is affected by nano and be told the risks," and "we need to be informed when nanotechnology is in something like cosmetics."

- **People Centered Goals:** People centered goals for progress include concerns like "can we trust government to make decisions for the good of people and not just $$," "moral implications of nano medicine…extent of its use and by whom?" and that we "should study moral and social guidelines more."

"We're gonna be killed or cured."

N = 426 concerns identified by 177 participants	*Percentage*
True unknowns	13
Regulatory concerns	13
Human health risks	13
Testing and research for safety	12
Effect on environment	10
Food & food chain concerns	7
Industry irresponsibility	7
Privacy	6
Military uses, international political instability	6
Playing God, messing with Mother Nature	4.5
Economic access & education	4

Consumer knowledge & information	3
People centered goals for progress	2
Taxpayer cost of development	1
Fearful people stopping good	1
Mistrust of government in general	1
Social upheaval & adjustment	.5

Trust in Regulatory Agencies, Political Entities, and Industry

One purpose of this study was to discover more about the sources of low trust in government in relation to nanotechnology. The 2004 study had found low levels of trust, largely based on experience with earlier technologies, in which situations arose where too little knowledge of products later led to environmental and human health problems. Examples given in 2004 included asbestos, dioxin, lead paint, Prozac accumulating in bodies of water, PCBs, and Agent Orange.

To determine if low trust in government is related to any specific entity, questions in both the entry survey questionnaire and the post-test were asked in relation to different regulatory agencies: "Even if there are risks with nanotechnology, I trust the (.....) to effectively manage these risks." The agencies and political entities tested for association with low trust were the Congress, White House, Food and Drug Administration (FDA), Occupational Safety and Health Administration (OSHA), Centers for Disease Control (CDC), Consumer Product Safety Commission (CPSC), Environmental Protection Agency (EPA), and United States Department of Agriculture (USDA). Congress and The White House were included simply to include a wide variety of political entities that might affect nanotechnology policy and regulation. After participants had read about nanotechnology applications and regulatory responsibilities, as well as completed other parts of the study, the trust questions were asked again in order to measure trust in regulatory entities related to nanotechnology.

Results concerning trust in government indicate that low trust is related specifically to (1) particular federal agencies, and (2) to specific applications of nanotechnology. There also were a number of other interesting findings:

- **Low Initial Awareness of the Role of Government Agencies:** In the pre-test (the questionnaire given prior to reading informational materials on nanotechnology and regulatory agencies), 33% to 46% said they did not know if the FDA, EPA, USDA, White House, or Congress, etc., would effectively manage risks. This uncertainty changed in the post-test, after participants received information on both nanotechnology and regulatory responsibilities.

"I found it interesting so many government agencies are potentially responsible [for nanotechnology]. With so many agencies, bureaucracy hinders the process because everybody is fighting over who is responsible."

- **Low Trust in Congress and the White House:** Congress and the White House received lower initial trust responses compared to regulatory agencies: 40% and 38% 'disagree' or 'strongly disagree' these entities could be trusted to

effectively manage any risks, while 25% and 29%, respectively, agreed or strongly agreed that these entities were trustworthy.

- **Regulatory Agencies Fare Better:** Regulatory agencies received higher levels of agreement that they would effectively manage any risks: 37% initially trusted OSHA, 38% trusted CPSC and 39% of participants initially agreed they would trust CDC to effectively manage risks.

- **More Information Changed Trust Levels:** After learning about nanotechnology and regulatory agency responsibilities, many study participants in the post-test moved away from the "don't know" category. The directions of these changes, however, varied.

- **Worse News for the Congress:** In the post-test answers, Congress fared worst on the question of trust: 63% disagreed or strongly disagreed that Congress would effectively manage any risks (27% agreed or strongly agreed that Congress would not; 10% said "don't know"). In the post-learning answers, the White House fared better than Congress. Still, 43% of participants disagreed or strongly disagreed that the White House would effectively manage any risk (31% trusted the White House, in the post test, while 12% said "don't know").

- **Trust in EPA, OSHA, CPSC, and CDC Increased:** Trust in a number of agencies rose after study respondents knew more about their responsibilities and about nanotechnology. 46% trusted CPSC; 45% trusted EPA; 50% trusted CDC; 46% trusted OSHA. Trust in OSHA is notably ambivalent in comparison to other agencies, however, as 40% also do not trust that agency to effectively manage any risks.

- **Trust in FDA and USDA Not as Certain:** Agencies whose trust figures were lower after citizens learned about nanotechnology and regulatory responsibilities were FDA (43% did not trust and 13% don't know, while 44% do trust) and USDA (45% did not trust, 16% don't know, while 39% do trust). In the discussion part of the study, concerns about FDA regulations were raised in all 12 groups. "FDA should not let companies put all kinds of stuff in food" commented one respondent. Medical products were frequently given as examples where important risks emerged years after product release. In addition, participants spoke about their low trust in FDA as related to perceived influence from Congress and industry, which they believed could undermine regulatory protections. Taken together, the evidence points to FDA, and to a lesser extent, USDA, as significant nanotechnology regulatory concerns for citizens.

Explaining more about public trust are the comments participants made about this issue in the group discussions. The group moderator synthesized these comments about the regulatory agencies in this conclusion: "Many participants trust the average agency employee to be honest and hardworking, but see the upper levels of agency management to be susceptible to political pressure and political control." Despite mixed-to-negative views of some regulatory agencies, a

substantial proportion of participants also expressed that they "are glad the agencies exist, acknowledge their past contributions to society, and felt that the agencies at the very least are doing the best they can."

In the individual-level concerns expressed, participants further illuminated their feeling that politics negatively affects public safety. That "legislators try to undo environmental protections," is one example.

Strategies to Increase Public Trust in Nanotechnologies

We also asked survey questions concerning ways government could work to increase public trust and whether people believed industry self-regulation would be sufficient (see Appendix, Tables 9, 10, and 11, respectively).

- **Voluntary Standards Insufficient:** The majority of study participants felt that voluntary standards applied by industry would not be sufficient. 55% said government control beyond voluntary standards is necessary, while 33% were unsure; 11% felt voluntary standards would be adequate.

"Voluntary standards, possible risks, and bureaucrats: That's a red flaa for me."

- **More Safety Testing and Information Needed:** There was strong agreement among participants concerning the most important ways government and industry could work to increase public trust. 71% of top choices were for increased safety tests before products go to market, supplying more information to support informed consumer choices, and demonstrating how current regulation is sufficient to protect the environment and workers.

- **Tracking Risks of Products on the Market:** "Better tracking risks related to products already on the market" was the 4th-highest ranking choice for ways both government and industry could work to increase public trust.

Interest in Public Information and Education

A strong thread of concern about public information is woven throughout the survey and group discussion data.

- **Consumers Want More Information:** Increasing consumers' ability to make informed choices was the 2nd most preferred way our respondents said either government or industry could help to enhance the public' trust. In other words, public information is a highly preferred mechanism either industry or government should employ to increase public trust.
- **Lack of Information Breeds Suspicions:** Group discussion stressed the lack of public information over and over again. The group facilitator noted that, "The lack of public notification and information about the market status of nanotechnology products was also a major concern of these participants...The public not getting enough information is viewed as an integrity issue since it creates a suspicion of government lying and cover-ups. A strong minority opinion held that it is the public's

responsibility to get involved and educate themselves…The key element to building trust between regulatory agencies and the public is open access to information, as well to separate the regulatory process from political control."

- **No Information on Long-term Effects:** The moderator observed that "Participants were disturbed that so little information about long-term health effects of nanotechnological products, particularly consumables, is available even though products are coming out on the market. This was true of environmental effects as well." One respondent keyed in on this as a concern: "You aren't talking about the long terms effects and what is known. Why?"

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APPENDICIES

1. DATA TABLES, NANOTECHNOLOGY AND PUBLIC TRUST 2005

Table 1. Initial Knowledge of Nanotechnnology

How much would you say you know about nanotechnology?	Pre-Test
a lot	2.8
some	16.9
a little	26.0
nothing	54.2
Total	100.0

Table 2. Knowledge Re “Next Industrial Revolution”

“Nanotechnology is predicted to be the next industrial revolution”	Pre-test
true	24.3
don't know	75.1
Not true	.6
Total	100.0

Table 3. Sources of Knowledge on Nanotechnology

	All Sources	If Information From 1 Source	If Information From 2 Sources	If Information From 3 Sources
ads	2.9	4.1		3.6
children's TV	2.9	2.0	5.6	2.4
specials public TV or radio	17.6	22.4	11.1	17.9
commercial TV or radio news	11.2	14.3	5.6	11.9
magazines	17.1	8.2	27.8	17.9
newspaper articles	10.0	8.2	8.3	11.9
trade or professional journals	8.2	6.1	11.1	8.3
science fiction books or stories	12.4	10.2	13.9	13.1
talk with another person	16.5	20.4	16.7	13.1
Internet	.6	2.0		

school	.6	2.0		
Total	100.0	100.0	100.0	100.0

Note. Respondents were allowed to identify all relevant sources of learning about nanotechnology. The frequency with which each source type was mentioned is classifed above in relation to three classes of informed respondents.

Table 4. Attitudes in Pre- and Post-Test

	Pre-Study	Post-Test
quite positive	7.9	9.6
mostly positive	13.0	40.1
neutral	37.9	32.2
mostly negative	.6	9.6
don't know	40.7	2.8
Missing data		.6
Total	100.0	2.8

Significant change: Pearson Chi-Square=84.092, df = 24, p = .000

Table 5. Expectations: Will Benefits Exceed Risks?

	Pre-Study	Post-Test
benefits will exceed risks	15.8	40.7
risks will exceed benefits	5.1	15.3
risks & benefits equal	13.6	29.9
don't know	65.0	14.1
	.6	
Total	100.0	100.0

Table 6. Should Nanotechnology Products be Banned Until Further Study?

Should new nanotechnology products be banned for the time being?	Pre-Study	Post-Study
agree to total ban	6.2	8.5
Ban is overreacting	35.6	**75.7**
Don't know	57.1	15.8
Missing data	.1	
Total	100.0	100.0

Table 7. Trust in Regulatory Agencies and Political Entities, Pre- and Post-Test

%	CDC	EPA	CPSC	OSHA	FDA	USDA	WHITE HOUSE	CONGRESS
strongly agree	9.6 (9.6)	7.9 (6.2)	6.8 (6.2)	6.2 (9.0)	6.8 (6.2)	6.8 (6.2)	5.6 (4.5)	7.3 (2.8)
agree	29.4 (40.1)	23.2 (39.0)	29.4 (40.1)	30.5 (36.7)	24.3 (36.7)	23.7 (32.8)	23.2 (26.6)	18.1 (23.7)
don't know	42.4 (14.1)	41.8 (14.1)	43.5 (15.3)	40.1 (14.0)	42.4 (13.0)	45.8 (16.4)	32.8 (12.4)	35.0 (10.2)
disagree	14.7 (27.1)	19.8 (29.4)	15.3 (27.7)	19.2 (29.9)	19.8 (32.8)	18.1 (33.3)	26.0 (34.5)	27.1 (41.2)
strongly disagree	3.4 (9.0)	6.8 (10.2)	4.5 (9.6)	3.4 (10.2)	6.2 (11.3)	5.1 (11.3)	11.9 (21.5)	12.4 (21.5)
Missing data	0.6 (0)	(0.6) (1.2)	(0.6) (1.2)	0.6 (0)	0.6 (0)	0.6 (0)	(0.6) (0.6)	(0.6) (0.6)
*Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note. Pre-test percentages are given first in each column; directly below are percentages of the post-test answers, in brackets (FDA 6.8% strongly agree in pre-test, 6.2%, etc.).

Table 8. Post-Test Summary Percentages, Trust in Regulatory Agencies and Political Entities

%	CDC	EPA	CPSC	OSHA	FDA	USDA	WHITE HOUSE	CONGRESS
Strongly agree or agree	**50**	**46**	**46**	**46**	**43**	**39**	**31**	**27**
Don't know	14	14	15	14	13	16	12	10
Disagree or strongly disagree	36	39	38	40	44	45	56	63
Total	100	99*	99*	100	100	100	99*	100

All percentages are rounded. *The designated percentages do not round to 100 due to a higher percentage of missing data for that entity.

Table 9. Can Industry Self-Regulation Be Sufficient?

Answer choices	% agreement
I feel government control beyond voluntary standards is necessary	55.4
I am not sure how I think about this	32.8
I feel voluntary standards would be adequate	10.7
Missing data	1.1
Total	100.0

Note. This was a post-test question only, assuming that only an informed public could give a useful answer to the question.

Table 10. Preferred Ways Government Could Increase Public Trust

Preferred Ways Government Could Increase Public Trust	Percent
increase safety tests before market	34.5
supply more product information so people can choose	24.9
show how regulatory practices are sufficient	11.9
track better the product risks in market	9.6
allow industry to be more self regulating	8.5
no top choice (multiple answers)	3.4
other (write in answers)	3.4
nothing needs to be done	2.3
be more hands off in regulating industry	1.7
Total	100.0

Note. The same answer choices were available for both industry and government, with the exception of the “hands off” answer; the opportunity to write in any other answers was also available in both cases.

Table 11. Preferred Ways Industry Could Increase Public Trust

Preferred Ways Industry Could Increase Public Trust	Percent
increase safety test before going to market	28.2
supply more information so people can choose	28.2
voluntarily use higher safety standards	19.2
track risks in market better	13.0
show how current reg practices are sufficient	6.8

nothing needs to be done	1.7
Missing data	1.7
Other (write in answers)	1.1
Total	100.0

Note. The same answer choices were available for both industry and government, with the exception of the “hands off” answer shown in Table 10; the opportunity to write in any other answers was also available in both cases.

2. Study Design

Study Method

To investigate concerns of an informed public and the effect of nanotechnology development scenarios, the study used a 3 by 4 quasi-experimental design. Quasi-experiments are field experiments in which one variable is controlled, while all others are left to vary as they naturally occur (Cook & Campbell, 1979; Shadish, Cook, & Campbell, 2002).

In each of 3 regional sites, participants were presented with one of 4 scenarios. Each scenario depicted a particular pathway for nanotechnology development, or 4 different scenarios, represented in written briefing materials. There was no expectation that stimuli such as the briefing materials might inherently cause a particular type of public response. Rather, the assumption was that participants would draw on existing values and knowledge in combination with the new information, and the conclusions reached thus could be usefully contrasted with those of the uninformed public.

A pre- and post-test survey questionnaire was used to gathered data on attitudes towards nanotechnology, trust in government to manage risks, and participant demographics. Data also was collected on individual concerns, expressed privately, as well as on anticipated benefits, in two separate steps, after participants read the briefing information. After providing information on concerns and benefits, each group also talked with each other about nanotechnology; the discussion thus forms a third source of information on participants' perceptions of nanotechnology and government.

Procedures

Study participants were brought together in quasi-experimental groups (4 experimental conditions) at each of 3 study locations. Although groups were used in the study, they were experimental groups rather than focus groups. Focus groups are essentially group interviews (e.g., Krueger, 1994), whereas individual-level data was sought for this study. Experimental groups were used for efficiency and control: individuals could read the experimental materials in their group settings to control for knowledge that might otherwise be gained between recruitment and exposure to experimental materials. Fifteen individuals representative of local demographics were recruited for each group.

Each group of participants first completed an entry or pre-test questionnaire. Individuals then read their experimental materials, and next, were asked to silently consider and record three or four concerns they might have about nanotechnology. Each concern was recorded by participants on a 5"x7" card, along with their personal reason or reasons for that concern. After time allowed to express concerns, individuals were then asked to silently consider and record the benefits of nanotechnology they most anticipated. After providing individual concerns and reasons, each group then spent about 40 minutes discussing concerns and expected benefits, and the roles of regulatory agencies. A standardized 1.5 hours was allotted to each group.

Participants

For this study, data was collected from individuals in experimental groups, where briefing materials were also distributed and read. Three different sized cities in the midwest, western, and southwestern regions of the U.S were chosen as sampling sites, both to discover attitudes that might be affected by regional economic and cultural variables, as well as to allow the sampling of a range of U.S. ethnicities, incomes, education levels, etc. Participants (N = 177) self assigned themselves randomly to the experimental conditions, without knowledge of doing so, by choosing group meeting times that fit their schedule. A professional firm conducted recruitment in the selected sites of Spokane, Washington; Dallas, Texas; and Cleveland, Ohio. (The 2004 study sites were in Raleigh-Durham, North Carolina; San Diego, California; and St. Paul-Minneapolis, Minnesota.) Recruitment lists were randomly generated telephone number lists in selected zip codes and study participants were recruited to be fairly representative of local demographics (see Table 1 for a comparison of the participant sample to U.S. Census Bureau 2000 statistics).

2005 Study Participants N = 177										
	Political Affiliation	Gender %		Race %				Mean Income	Mean Age	EDU %
		M	F	Cauc	Afr. Am.	Hisp. / Latino	Native Am. & Other			
Study Sample	R=30% D=37% Ind=25% Other=8%	49.2	49.2	58.8	20.3	14.7	5.1		43	HS=22* SC=26 TRD/CERT=10 CD=23 >CD=16
2000 US CENSUS		49	51	77	13	4.2		50K	35.3	HS=27 SC=21 CD=26 >CD=9

Abbreviations. Political affiliation: R=Republican, D=Democrat, Ind=Independent. EDU: HS = high school diploma, SC = some college, TRD = trade or certificate training beyond HS, CD = college degree, >CD = education beyond 4 year degree. *Less than HS = 2.3%. Missing data = 1.1%.

Experimental conditions: briefing materials

The briefing materials for each of the 4 experimental conditions were one-and-one-half to four pages in length and designed to be read in less than 20 minutes. The materials were written for the study by the author and reviewed, for clarity and accuracy, by several nanoscientists with a broad understanding of the subject, as well as by naïve readers. Two critical choices were made in development of the briefing material. The

first was a decision to develop the materials as a lay-written review of knowledge, to focus on facts and evidence relevant to nanotechnology and its development. This choice was based on results of a recent British study of media coverage of science (Hargreaves, Lewis, & Speers, 2003). That study's authors concluded that journalists had contributed to public misunderstanding of science by reporting scientific controversy on childhood vaccinations, but not consistently reporting the evidence underlying the debate. This appears to have led to inaccurate British public perceptions about measles vaccinations and a purported link to autism. This link had been suggested by one study, but its results had not been replicable in subsequent studies. In this situation, the British public's understanding accurately captured the controversy as portrayed by journalists, but that understanding was ill founded.

A second important choice in developing the nanotechnology briefing materials was to explain nanoscience concepts by using metaphors that would be familiar to most people, in addition to using accurate scientific language. Using familiar metaphors is a teaching strategy that helps to make complex ideas accessible, and here, was intended to give adults with different education levels the greatest chance of absorbing the ideas. The status of nanotechnology was also represented by using many examples of current discoveries or existing applications, cited to the source in footnotes, for credibility.[i] The examples were gathered from nanoscience news sources and nanotechnology industry publications, and since nanotechnology is an international phenomenon, U.S. and international examples were used.

Condition 1 materials presented basic information and an overview of nanotechnology applications in general. Condition 1 groups thus represent the least informed individuals in this study. Individuals in Condition 2 received basic information plus specific information on medical and industrial nanoresearch, and anticipated and actual current uses such as in cancer treatment or disease diagnosis, electronics, energy production, and environmental cleanup. Condition 2 materials also noted the potential convergence of medical biotechnology and nanotechnology. Condition 1 and 2 materials were replications of the 2004 Condition 1 and 2 materials, but had updated examples of nanotechnology products and supplied information on the regulatory and political bodies' potential role in managing risks and benefits.

Condition 3 materials focused on nanotechnology in consumable products such as cosmetics, food products, agriculture, personal care products, clothing, and so forth. Condition 4 materials discussed the anticipated convergence of nanotechnology, biotechnology, and uses to enhance the human body. Those applications include biopharming (use of genetically altered field crops to produce human insulin, etc.), regeneration of spinal cord and brain cells or limbs, and to enhance human mental functioning. Condition 4 materials were similar to those used in 2004 but presented updated information.

Analyzing concerns

Concerns were expressed privately by participants after they had read the briefing materials for their experimental condition. Multiple concerns about nanotechnology were allowed per person, up to a limit of four; the total number of concerns expressed was N

= 394, or about 2 per person. Practices of rigorous qualitative analysis (Eisenhardt, 1989; Miles & Huberman, 1984; Yin, 1989) were followed to analyze concerns, which were classified by topical concern and then summarized quantitatively. Following Miles & Huberman's recommended practices for cross-case analysis, first individual-level concerns were noted sequentially in a data log, for each group; no concerns were excluded. Each log entry retained as much as possible the citizens' own words and focused on "the point" that was stressed. Concerns had been expressed on 5x7 cards. If a card held only the words "health effects," that is, the log entry was simply those words. If a card held the question "How will this affect sensitive individuals?" concern for "effect on sensitive individuals" was recorded in the data log. Based on the log of concerns for each group, analysis focused on summarizing the local (statement level) subjects or issues.

To rigorously summarize the concerns expressed, the author utilized knowledge about understanding others' points and dialogue topics. That body of knowledge asserts that people understand others' points by tracking the more general issue, called the "global" topic or subject (Cegala, Dewhurst, Galanes, Burggraf, Thorpe, Keyton, & Makay, 1989; Tracy, 1982, 1983; Reinhart, 1981). "Local" or statement level topics are made coherent, in a complex conversation, by their organization within global issues or topics, that is. Here, the strategy used was to group local concerns in more general, logical global concern groupings, to render the concerns intelligible as a whole, but retaining as well the individual voice that give the global topic labels greater meaning. For the same reason, the labels given to the subject or issue clusters are expressions used by individuals in the study.

Example of Local Issues and Summary Global Issue

General (global) versus Local (statement-level) expression of concern	
Long term health effects	Long term risks of ultrafine pigments, nano cosmetics, wearing nanopants Breakthroughs that turn into disasters Biodegradable nanostructures' effect on food chain

Summaries were first produced for each group. The group summaries were then merged to produce a cross-case summary for each region, in order to locate shared concerns across all the groups. The most frequently mentioned concerns were not reduced further (military concerns and long term health concerns are two examples). Lower frequency concerns were reexamined and if possible, grouped under a slightly more general issue label, in order to retain the most concerns possible while reducing complexity to a manageable level. The focus of analysis at this level, thus, was on aggregating concerns as topical issues rather than on tracing arguments.[ii] Tracing arguments could be a valid way to understand premises and choices, but for this study, concerns or issues were investigated as global issues. The summarization process was intended to discover shared concerns across all participants.

[i] Sources for examining developing applications and research discoveries include industry magazines such as *SmallTimes*, on line at http://smalltimesmedia.com and *Nanotechnology Now.* Other sources regularly reporting nanoscience developments include *Science Daily* (www.sciencedaily.com)*, Nature, PR Newswire*, *The Age*, and *The Scientist*. A historical narrative of nanotecology's development is in Regis, E. (1995). Nano. The emerging science of nanotechnology: remaking the world-molecule by molecule. Boston: Little, Brown.

[ii] Whereas a topic is the substantive subject of a sentence, paragraph, or discussion, an "argument" is a more complex feature of communication, as well as a term with multiple uses and meanings (O'Keefe, 1977). In O'Keefe's formulation, "argument$_1$" is defined as a statement-level argument; "Jenny's hair is red" is an example of argument$_1$, a statement that makes an argument for or against something. "Argument$_2$" locates a different sense of the term argument, where 'argument' is a type of interaction between several parties, an interactive exchange including claims, counterclaims, rebuttals, etc. In yet another common meaning of the term argument, the "argumentative case" is a complex line of argument (Rieke & Sillars, 1997). A line of argument is a collection of premises put forward by one author, making a case for a particular conclusion.

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