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PROJECT ON EMERGING NANOTECHNOLOGIES

RESEARCH BRIEF

Toward a Comprehensive Strategy for Nanotechnology Risk Communication

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PREFACE

Scientists have only begun to investigate whether nanotechnology poses any threats to the environment and public health and, if so, what steps should be taken to mitigate them. But as formative as our understanding of nanotechnology's risks might be, our understanding of how to *communicate* scientific evidence of those potential risks to the public is even more primitive.

The study of risk perception teaches that the transmission of risk information is fraught with potential for misadventure. On matters as diverse as climate change and gun control, domestic terrorism and silicone breast implants, ordinary people form strong, and instantaneous, emotional reactions that thereafter color how they interpret hard empirical evidence. Social psychologists have made substantial advances in documenting the operation of these forces, but to date, there have been only a handful of studies exploring systematically how they might shape public responses to nanotechnology. Even more important, the studies have not offered recommendations on how these forces might be constructively guided to ensure informed public perceptions and discourse.

If permitted to widen, the disparity between our scientific knowledge of the risks of nanotechnology and our scientific knowledge of how to communicate what we know could itself threaten advancement of this important new technology. One of the central teachings of risk- communication scholarship is that members of the public tend to form opposing beliefs about technological and environmental risks on the basis of diverse cultural dispositions. The inability to communicate effectively the potential risks associated with nanotechnology could create an environment where appropriate regulation and confident private sector investment are threatened. Nanotechnology, in that case, could suffer the same fate as other technologies, including nuclear power and genetically modified organisms, whose development was stifled by political contention.

Avoiding this fate has been the goal of a series of studies conducted jointly by the Cultural Cognition Project (CCP) at Yale Law School and the Projection on Emerging Nanotechnologies (PEN) at the Woodrow Wilson International Center for Scholars. Prepared as an introductory overview, this Preface briefly summarizes the theory behind and results of three sets of research studies, and then proposes a series of recommendations based on them.

THE CCP/PEN STUDIES

The Basic Theory: Cultural Cognition of Risk

Cultural cognition refers to the tendency of people to form beliefs about the risks and benefits of an activity that fit their cultural evaluations of it. The phenomenon comprises a variety of discrete psychological mechanisms, but in sum, it is much easier to believe that behavior one finds noble is also beneficial for society than to believe that conduct one regards as repugnant is beneficial for society. For example, people who hold relatively *individualistic* values tend to be skeptical of asserted environmental and technological risks because they perceive (subconsciously) that accepting such assertions would justify governmental restrictions on commerce and industry, activities that such persons admire. People with *egalitarian* values, in contrast, tend to blame commerce and industry for social inequities and thus find it congenial to believe that such activities also endanger the environment and public health.

Cultural cognition is a major source of the intense political controversy that surrounds matters like climate change, nuclear power, gun control and the universal vaccination of schoolgirls for human papillomavirus. In a climate of cultural conflict, moreover, members of the public are much less likely to converge on scientifically sound information that benefits society as a whole. Indeed, in such a tendentious climate, those who have a stake in *misleading* the public (whether to market technologies that in fact harm people or to rally support in favor of blocking technologies that do not) can much more readily do so. Accordingly, the phenomenon of cultural cognition can pose a major challenge both to support for new and beneficial technology and to enactment of sound regulatory policy that assures such technologies are compatible with public health and safety (Kahan & Braman 2006; Kahan, Slovic, Braman & Gastil 2006).

The Studies: Cultural Cognition of Nanotechnology Risks

The CCP/PEN collaboration examined the cultural cognition of nanotechnology risks. The goals were to understand whether and how cultural cognition might be expected to affect public opinion toward nanotechnology and, just as important, to generate insights that might be used to form strategies for communicating scientifically sound information about nanotechnology in forms that make it accessible to citizens of diverse cultural outlooks. These aims were explored over the course of three distinct studies.

1. Affect and culturally biased assimilation. The first study—a survey experiment of a diverse sample of some 1,800 Americans—confirmed that cultural cognition plays a significant role in the formation of nanotechnology risk perceptions. As they do for most other risk issues (Slovic, Finucane, Peters, & MacGregor 2004), members of the public, the study found, form a rapid, visceral, emotional response when evaluating nanotechnology risks: although some 80% had heard little or nothing about nanotechnology before the study, 90% had an opinion from the very outset about whether its risks outweighed its benefits or vice versa. In addition, when asked to consider balanced information about nanotechnology risks and benefits, the inferences study subjects drew were conditional on their cultural values. Relative to those not exposed to information, subjects who held relatively individualistic and nonegalitarian (or hierarchical) values saw likely benefits as predominating over likely risks; those who held egalitarian and nonindividualistic (or communitarian) values, in contrast, saw likely risks as predominating over likely benefits. Consistent with previous opinion polls, the study also found that subjects who reported being relatively familiar with nanotechnology tend to have a more favorable view of it. But as reported in Kahan, Braman, Slovic, Cohen & Gastil (Kahan et al., 2008), nanotechnology-familiarity was highly associated with holding individualistic and hierarchical values. In sum, after forming an initial, affect-driven reaction toward nanotechnology, individuals both seek out and assess information in a biased manner that reflects their cultural predispositions—tendencies that naturally polarize them on nanotechnology's risks and benefits.

2. Cultural credibility. Scientific experts are certain to play a key role in shaping perceptions of nanotechnology risks. But the second CCP/PEN study found that *how* members of the public are likely to react to what such experts tell them will turn less on what the experts actually know than on what *values* the experts are perceived to have. In an experiment involving a diverse national sample, the study team again found that subjects processed arguments about the risks and benefits of nanotechnology in a manner that reflected their cultural predispositions toward environmental and technological risks in general. Yet when those same arguments were attributed to fictional policy experts, another group of subjects tended to adopt the views of the expert whose perceived values were similar to their own, and to reject the views of experts whose perceived values were different from their own, no matter what position those experts took on nanotechnology. Cultural cognition, in other words, can also generate polarization by influencing how credible people find risk communicators to be. Nevertheless, the study found, the same dynamic can be used to mitigate cultural polarization: exposed to experts whose perceived values were like their own on *both* sides of the debate, subjects of diverse values tended to converge in their views.

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3. Cultural message framing. The third CCP/PEN study looked at message framings. It found that how individuals interpret information on nanotechnology risks varies depending on whether the emphasized application of nanotechnology *affirms* or *threatens* their cultural values. If the use of nanotechnology in consumer goods is made salient, for example, persons with pro-commerce individualistic values see greater benefits, but persons with anti-commerce egalitarian and communitarian values see greater risks, as they consider the same balanced information. In contrast, if the use of nanotechnology to monitor pollution emissions is emphasized, the opposite pattern occurs. This finding suggests that were it possible to design message framings that simultaneously affirmed all groups’ values and threatened no one’s, individuals of diverse cultural outlooks would uniformly attend to information in an open-minded way. Nevertheless, a message framing emphasizing the commercial use of nanotechnology to clean up the environment failed to produce that effect in the experiment. Indeed, risk-mitigating framings had the perverse effect of increasing nanotechnology risk perceptions overall.

TAKING STOCK

Taken as a whole, what do the CCP/PEN studies teach us? We believe the results suggest four critical lessons and three specific recommendations.

Lessons Learned

1. The spontaneous-enlightenment fallacy. It seems reasonable to expect that scientific understanding of nanotechnology risks and how to abate them will grow apace with knowledge of the myriad beneficial uses to which nanotechnology can be put. But it would be a mistake simply to assume that the best scientific evidence will naturally permeate public opinion and policymaking. People’s values supply the cognitive and social pathways through which they form and revise their perceptions of risk in general, and nanotechnology risk perceptions, the CCP/PEN studies show, are no exception. Accordingly, making popular deliberations over the regulation of nanotechnology responsive to the best scientific information will necessarily depend on securing conditions in which that information is accessible to persons of diverse cultural outlooks.

2. The risk of cultural polarization. Those conditions cannot be taken for granted. On the contrary, the CCP/PEN studies suggest that, left to its own devices, the natural tendency of the deliberative environment is toward cultural polarization over nanotechnology risks. Persons of diverse values, the studies show, are inclined to construe whatever information they are furnished in opposing ways that reflect their cultural predispositions toward environmental risk generally. The resulting division

of opinion is likely to feed on itself, moreover, because of the disposition of individuals to defer to the views of those who share their values and who, for that same reason, tend to have a unitary view. These are dynamics that historically have generated intense conflict over other emerging technologies, including nuclear power and genetically modified organisms. The CCP/PEN studies suggest that nanotechnology is poised to go down the same path.

3. The tractability of cultural polarization. At the same time, nothing in the studies suggests that such controversy is inevitable. The mechanisms of cultural cognition that create the danger of polarization, the CCP/PEN studies imply, can be used to design techniques of risk communication that ameliorate that danger. For example, the study of culture and credibility suggests that it is critical to pay attention to the identity of risk communicators: the appearance that particular positions on nanotechnology risks are held only by experts who subscribe to a particular set of values can accentuate polarization, yet the cultivation of a pluralistic information environment—one in which members of the public can see that experts of diverse values are as likely to be found on one side of the question as on the other—dissipates cultural divisions. In the latter circumstance, individuals cannot employ the mental shortcut of imputing greater expertise to experts who happen to share their values, and thus are more likely to attend to the content of the experts' arguments in a deliberate and open-minded fashion. The cultural-message framing study also suggests that the context in which persons are made to consider nanotechnology can affect how open-mindedly they attend to information.

4. The imperfect state of knowledge. The CCP/PEN studies also show that we have a long way to go before risk communicators will be in a position reliably to steer nanotechnology away from the hazard of cultural polarization. The translation of even promising laboratory results into concrete strategies for risk communication will require concerted and sustained field experiments involving genuine nanotechnology applications, actual scientific data and real, rather than fictional, expert communicators. In addition, as the unexpected results of the message-framing study dramatize, considerably more work needs to be done even to fill in gaps in basic understanding of how symbolic and affective resonances of particular nanotechnology applications are likely to influence the way in which persons of diverse values respond to risk information.

Recommendations

1. More research. While the CCP/PEN studies have by no means established precisely what types of risk-communication strategies are necessary to avoid cultural polarization over nanotechnology, they have demonstrated that such strategies are necessary. Because perfecting the science of nanotechnology risk communication is essential to society's realization of the full benefits of nanotechnology itself, we urge that every major government and university funding initiative directed at the development of nanotechnology and the study of nanotechnology risks include a risk-communication component.

2. Focus on framing. The most urgent focus of any nanotechnology risk-communication strategy should be on message framing. The CCP/PEN message-framing study shows that the salience of particular nanotechnology applications has a large, and at this point largely unpredictable, impact on information processing. Additional research on framing is particularly urgent because of the potential that unanticipated affective and symbolic resonances of particular applications (including those that involve using nanotechnology to *mitigate* environmental risk) could in fact exacerbate the danger of polarization.

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Message framing, we believe, presents the most promising strategy for promoting public receptivity to sound scientific information and avoiding a fractious climate of reflexive closed-mindedness.

3. Contextualization. In addition, such research should be more finely tailored to real-world nanotechnology research. The experimental designs used in the CCP/PEN studies were well suited for showing that public perceptions of nanotechnology can be expected to be influenced by cultural cognition. But because they involved specialized laboratory conditions, remote from genuine nanotechnology research, the studies do not directly lend themselves to concrete communication strategies. To bridge this gap between theory and practice, we believe future research on nanotechnology risk communication should be integrated into research projects of nanotechnology scientists whose interest in effective communication of their own research can supply the setting for field experimentation. In this way, scientists involved in the study of nanotechnology and scientists involved in the study of nanotechnology-risk communication can make reciprocal use of their proximity to one another to advance their common ends.

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CULTURAL MESSAGE FRAMING

Cultural Cognition and Nanotechnology Risk Perceptions: An Experimental Investigation of Message Framing

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INTRODUCTION AND SUMMARY OF CONCLUSIONS

What will science reveal about the risks and benefits of nanotechnology? What conclusions will members of the public form? The study of *cultural cognition*—the tendency of individuals to interpret information about risk in a manner congenial to their self-defining values—suggests it would be a mistake to assume the answers to these questions will be the same. Indeed, previous experimental studies, conducted by the Cultural Cognition Project (CCP) in conjunction with the Project on Emerging Nanotechnologies (PEN), have identified various dynamics that impel persons of opposing values to polarize when exposed to balanced and accurate information on nanotechnology risks.

The most recent study in this series investigated the power of *information framing* to accentuate or mitigate such cultural polarization. Major findings include:

1. Framing matters. The beliefs individuals form when exposed to balanced information on the risks and benefits of nanotechnology are significantly affected by the salience of different nanotechnology applications, including its use in the manufacturing of consumer goods, its use in facilitating environmental protection and its use to enhance national security.

2. Risk-mitigation framing can backfire. Paradoxically, framings of nanotechnology that emphasize its potential to mitigate especially alarming risks *unrelated* to nanotechnology—such as arsenic in groundwater or biological weapon attacks—can enhance the perception that *nanotechnology itself* is risky. The aroused anxiety that such framings produce apparently spills over to nanotechnology and crowds out the message that nanotechnology can make society safer.

3. Framing effects are culture-specific. The impact particular framings have on nanotechnology risk perceptions depends on individuals' cultural identities. If a particular nanotechnology application *threatens* a group's cultural values, its members will form a higher estimation of the risks and a lower estimation of the benefits of nanotechnology generally than if the application *affirms* that group's values.

4. Framing can aggravate cultural polarization. If *one and the same* application threatens one group's values and affirm another's, making that application salient will accentuate culturally polarized interpretations of balanced information. For example, commercial production of consumer goods has positive connotations for persons who admire competitive market behavior and negative ones for those who are ambivalent about such behavior. As a result, the latter will see nanotechnology as more risky, and the former as less risky, when they are made conscious of the use of nanotechnology to produce consumer goods. Making salient the government's use of nanotechnology to *regulate* commerce and industry has exactly the opposite effect on these groups.

5. "Green-to-gold" is not a silver bullet. In theory, it should be possible to construct an information frame that affirms diverse cultural values simultaneously, thereby mitigating cultural polarization and promoting open-minded deliberation. We considered whether emphasizing the use of nanotechnology to create market opportunities for firms that produce devices to clean the environment would have this effect. It did not.

"Information communicators should be sensitive to the emotional and symbolic associations that different applications of nanotechnology can trigger in the minds of culturally diverse members of the public."

THE CULTURAL COGNITION OF NANOTECHNOLOGY RISKS

Cultural cognition refers to the tendency of persons to conform their factual beliefs about the risks and benefits of a putatively dangerous activity to their cultural appraisals of these activities (DiMaggio 1997; Kahan, Slovic, Braman & Gastil 2006). Simply stated, it is much easier, from a psychological point of view, to believe that behavior one finds noble is also socially beneficial, and behavior one finds debased is dangerous, than vice versa (Douglas 1966; Gutierez & Giner-Sorrola 2007). Public opinion researchers have identified competing cultural values as the source of disagreement about numerous contested risks—from nuclear power (Peters & Slovic 1996; Jenkins-Smith 2001) to global warming (Leiserowitz 2005) to gun possession (Kahan, Braman, Gastil , Slovic & Mertz 2007).

The impact of cultural outlooks on risk perceptions tends to interact with other individual characteristics such as race and gender. White males have been shown to be less concerned with technological and environmental risks than are women and minorities (Flynn, Slovic & Mertz 1994). Research has found that this so-called white male effect is driven by a relatively discrete subset of white men who hold distinctively hierarchical and individualistic worldviews (Finucane, Slovic, Mertz, Flynn & Satterfield 2000), outlooks associated in general with skepticism toward environmental risks (Dake 1991). People who hold more egalitarian and communitarian values tend to be uniformly sensitive toward environmental risks, irrespective of race and gender (Kahan, Slovic, Braman, Gastil & Mertz 2007).

Although by no means the only psychological dynamic that is likely to shape nanotechnology risk perceptions, cultural cognition could prove an especially consequential one. Knowing little about this novel science, individuals are likely to rely on cultural predispositions toward environmental risks to make sense of what they are learning. Groups with risk-sensitive dispositions and those with risk-skeptical dispositions are thus naturally poised to form opposing views. The gulf between them, moreover, could well grow as individuals confer with culturally like-minded peers, who as a result of the same predispositions are likely to hold opinions that are relatively uniform—and uniformly opposed to those held by persons of competing cultural outlooks. If these self-reinforcing dynamics take hold, nanotechnology, like nuclear power and genetically modified foods, could become a focal point for intense, culturally rooted political conflict. Such conflict would be a barrier to considered public deliberation, not to mention a potential threat to the development of nanotechnology.

Two previous experimental studies conducted by the Cultural Cognition Project, in collaboration with the Project on Emerging Nanotechnologies, lend credence to this scenario. The first study found that individuals who are relatively unfamiliar with nanotechnology nevertheless form rapid, affective assessments of its risks and benefits and, when exposed to balanced information about it, tend to polarize along cultural lines (Kahan, Slovic, Braman, Gastil & Cohen 2007; Kahan, Braman, Slovic, Cohen & Gastil in press). The second study found that the reaction of individuals to information about nanotechnology is highly conditional on the relationship between individuals' cultural outlooks and the perceived outlooks of individuals attributed as the source of the information. Accordingly, when individuals observe a policy expert whose values they share advancing the position they are culturally predisposed to accept, and another policy expert whose values they find alien advancing the position they are culturally predisposed to reject, cultural polarization on nanotechnology risks grows even larger (Kahan, Slovic, Braman, Gastil, Cohen & Kysar 2008).

At the same time, the CCP/PEN studies suggested the threat that cultural cognition could pose

to enlightened deliberation, they also suggested how an understanding of the mechanisms of cultural cognition might be used to counteract that very threat. The relationship between culture and credibility, for example, implies that individuals can be made more receptive to evidence they might be predisposed to reject when it is supplied to them by an expert whose values they share. Indeed, in a "pluralistic information environment"—one in which individuals can perceive no pattern between positions on nanotechnology risks and the perceived values of information sources—cultural polarization is significantly reduced (Kahan, Slovic, Braman, Gastil, Cohen & Kysar 2008). Those interested in promoting open-minded public discussion of the best evidence that science reveals, then, should commit themselves to assuring that members of the public are furnished with conspicuous examples of experts of diverse cultural outlooks on *both sides* of any debated issue.

The previous CCP/PEN studies also suggested a profitable course of action for public-opinion researchers. It is that such researchers continue to focus on identifying how the perception of nanotechnology risk perceptions are likely to be influenced by the mechanisms of cultural cognition, for such study is likely to yield realistic insights into how public deliberation might go wrong *and* into what might be done to prevent that.

THE CURRENT STUDY

The current study examines a mechanism of exactly that character: *information framing*. A "framing effect" occurs when some element of presentation that is logically unrelated to the content of information nevertheless affects the impact of that information on beliefs or behavior. We investigated how framings that either *threaten* or *affirm* a recipient's cultural worldview can influence that individual's assessment of information on nanotechnology risks and benefits.[1]

Identity-Threat and -Affirmation

Individuals conform their factual beliefs to their group commitments as a means of psychic self-defense. We all depend critically on our connection to others for material, emotional and other forms of support. The prospect of disagreeing with our peers on the risks and benefits of some activity (for example, owning a gun) that our group intensely values (or despises) threatens to drive a wedge between us and persons whose good opinion is essential to our well-being. To resist that threat, we naturally resist information that challenges beliefs that are dominant within our cultural groups (Cohen 2003; Kahan, Braman, Gastil, Slovic & Mertz 2007).

This self-defensive resistance to information can be counteracted, however, by identity *affirmation*. Boosting a person's sense of self promotes open-mindedness because it creates a buffer that offsets the threat a person experiences when he or she contemplates information that challenges beliefs dominant among her peers (Cohen, Aronson & Steele 2000; Cohen, Bastardi, Sherman, Hsu, McGoey & Ross 2007).

These dynamics can affect risk perceptions through framing effects. Individuals are more likely to resist information when it is framed in a way that threatens their cultural commitments, and more likely to give it considered attention when it is framed in a way that affirms their commitments (Kahan, Slovic, Braman & Gastil 2006).

An example involves the impact of identity-affirming and identity-threatening information on perceptions of the risk of global warming. Persons who hold individualistic worldviews tend to be skeptical about global warming because they perceive (subconsciously) that broad acceptance of climate change as a serious environmental risk could lead to restrictions on commerce and industry—activities that they culturally value. Individualists also tend to have a positive view toward nuclear power, a

form of technology that symbolizes for them human initiative and mastery over nature and that has the potential to enable commerce and industry into the indefinite future. In an experiment, individualists who were told that nuclear power, a practice that *affirms* their worldview, furnishes a potential solution to global warming were significantly more likely to credit scientific information about the existence, causes and consequences of climate change than were individualists who were told that the solution to global warming is more restrictive anti-pollution regulations, a policy that *threatens* their worldview. Indeed, because they were threatened, the individualists who were told that anti-pollution regulations would be necessary were *less* likely to believe that global warming is occurring, is caused by humans and is dangerous for the environment than were individualists who had not been exposed to scientific information asserting these facts (Cultural Cognition Project 2007).

Study Design and Hypotheses

We conducted a study of the nanotechnology risk-benefit perceptions of a diverse sample of 1,600 Americans.[2] The subjects' worldviews had been previously measured using scales developed for the study of the cultural cognition of risk (Kahan, Slovic, Braman, Gastil & Mertz 2007; Kahan et al. in press). Those scales characterize individuals' values along two dimensions: "hierarchy-egalitarianism," which measures how much subject's value equality versus clearly delineated forms of social authority; and "individualism-communitarianism," which measures how much they value individual interests versus collective ones. Subjects reported their level of agreement or disagreement with three statements:

NANOBENEFIT. The benefits of nanotechnology are likely to be large.

NANORISK. The risks of nanotechnology are likely to be large.

NANOBALANCE. On the whole, the benefits of nanotechnology will outweigh the risks.

Responses to these items were combined into a single scale, NRISK (α = .62), that measured subjects' perception of risks relative to benefits.[3]

Before their perceptions were elicited, the subjects—85% of whom reported knowing "little" or "nothing at all" about nanotechnology before the study—were first assigned to one of four groups or conditions: "Consumer," "Regulation," "Green-to-Gold" or "National Security." Each group received a distinct version of a fictitious newspaper story that described a report in which scientists called for more research on the risks and benefits of nanotechnology (Figure 1). All four versions of the story contained a conspicuous shaded inset that set forth a brief definition of nanotechnology and two paragraphs of balanced information on its potential risks and benefits.[4] This material, presented without any additional framing, had been shown in the first CCP/PEN study to generate cultural polarization (Kahan, Slovic, Braman, Gastil, & Cohen 2007).

The four articles differed in their headlines and in their first and last paragraphs, which were worded to emphasize different applications of nanotechnology. The shaded inset common to all articles described a general range of potential benefits and risks, and the response measures solicited perceptions of benefits and risks generally. We hypothesized that the different applications made salient by the various articles would be alternately identity-threatening and-affirming to members of different cultural groups, and thus affect their perception of risks and benefits across conditions.

The article read by subjects in the "Consumer Condition" highlighted the use of nanotechnology in commercially produced consumer goods. We hy-

“Framing nanotechnology as risk-abating could have the paradoxical effect of causing individuals to see the risks of nanotechnology itself as outweighing its benefits.”

pothesized that this application of nanotechnology would be identity-threatening to subjects who hold relatively egalitarian and communitarian worldviews because these persons tend to associate commerce and industry with individual selfishness and unjust distributions of wealth. By the same token, we expected subjects holding hierarchical and individualistic worldviews—particularly white males with such outlooks—to be identity-affirmed, these types of persons tend to associate commerce and industry with individual freedom and the competence of social elites. Accordingly, we predicted that in the Consumer Condition, white male hierarchical individualists would see more benefit and less risk in nanotechnology than others, particularly egalitarian communitarians.

The article read by subjects in the “Regulation Condition” emphasized the potential of nanotechnology to “make government regulation of pollution emissions more effective” by “enhanc[ing] the cost-effectiveness of government monitoring of industrial pollution emissions.” Recognizing that “industrial pollution” is a problem implies that commerce and industry are harmful and worthy of restriction. Accordingly, we anticipated that highlighting the application of nanotechnology to promote government anti-pollution regulation would be identity-threatening to hierarchical individualists, particularly white males, and identity-affirming to egalitarian communitarians. We therefore hypothesized that in the Regulation Condition there would be a reversal of the pattern of risk-benefit perceptions we expected to see in the Consumer Condition.

The article read by subjects in the “Green-to-Gold Condition” described how “commercially developed” nanotechnology devices would create “new market opportunities for firms specializing in cleaning the environment.” By identifying how environmental protection can itself be a form of commerce, this application, we surmised, would be simultaneously identity-affirming for both egalitarian communitarians and white male hierarchical individualists. We thus expected subjects of both types to form more positive views of the risks and benefits of nanotechnology than their counterparts in their respective identity-threatening conditions (the Consumer Condition for the egalitarian communitarians, the Regulation Condition for white male hierarchical individualists).

The inspiration for the Green-to-Gold Condition was a new theme in environmentalist advocacy (Esty & Winston 2006). Itself a self-conscious exercise in framing, the green-to-gold argument seeks to extend the appeal of environmentalism by effacing its anti-market connotations (Nordhaus & Shellenberger 2007; Kysar 2008). Exponents of green-to-gold explicitly tout nanotechnology as one of the fonts of commercial enrichment likely to be stimulated by a mandate to make commerce cleaner and less destructive of non-renewable resources (Esty & Winston 2006, p. 17).We decided to test whether this manner of characterizing nanotechnology would likewise help free nanotechnology of associations that make egalitarians and communitarians instinctively fear the risk that a new commercial technology poses to the environment.

Figure 1. Framing Materials

Consumer

WEDNESDAY, MARCH 5, 2008

Scientists Call for More Research on Nanotechnology Consumer Goods

By Dave Maynard

WASHINGTON, D.C.—A new report by a team of scientists associated with major universities calls for more research on the risks and benefits of nanotechnology, including a wide variety of consumer goods that make use of it.

The market opportunity for nanotechnology, the report notes, is substantial. Analysts predict that the global marketplace for goods and services using nanotechnologies could grow to $1 trillion by 2015.

"Research is needed to assure society realizes all the potential benefits of nanotechnology while minimizing any potential risks," said Dr. Douglas Kabrastil, head of the scientific research team. "We need to determine whether the same novel properties that make nanomaterials so useful could also make them harmful, and if so, how to prevent that," Kabrastil explained.

Among the potential applications of nanotechnology, according to the report, are various consumer products, including food containers that kill bacteria, stain-resistant clothing, high performance sporting goods, faster and smaller computers, and more effective skincare products and sunscreens.

Facts on Nanotechnology

- Nanotechnology is the ability to measure, see, predict and make things on the extremely small scale of atoms and molecules. Materials created at the nanoscale are called nanomaterials, and they can often be made to exhibit very different physical, chemical, and biological properties than their normal size counterparts.
- 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.

Regulation

WEDNESDAY, MARCH 5, 2008

Scientists Call for More Research on Use of Nanotechnology in Government Regulation of Air Pollution

By Dave Maynard

WASHINGTON, D.C.—A new report by a team of scientists associated with major universities calls for more research on the risks and benefits of nanotechnology, including applications that would make government regulation of pollution emissions more effective.

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Green-Gold

WEDNESDAY, MARCH 5, 2008

Scientists Call for More Research on Market Potential of Nanotechnology for Cleaning Environment

By Dave Maynard

WASHINGTON, D.C.—A new report by a team of scientists associated with major universities calls for more research on the risks and benefits of nanotechnology, including commercially developed products to clean up the environment.

The market opportunity for nanotechnology, the report notes, is substantial. Analysts predict that the global marketplace for goods and services using nanotechnologies could grow to $1 trillion by 2015.

"Research is needed to assure society realizes all the potential benefits of nanotechnology while minimizing any potential risks," said Dr. Douglas Kabrastil, head of the scientific research team. "We need to determine whether the same novel properties that make nanomaterials so useful could also make them harmful, and if so, how to prevent that," Kabrastil explained.

Among the potential applications of nanotechnology, the report noted, are various "green" products—such as devices that reduce carbon emissions from power plants, and remove arsenic from groundwater—leading to new market opportunities for firms specializing in cleaning the environment.

Facts on Nanotechnology

- Nanotechnology is the ability to measure, see, predict and make things on the extremely small scale of atoms and molecules. Materials created at the nanoscale are called nanomaterials, and they can often be made to exhibit very different physical, chemical, and biological properties than their normal size counterparts.
- 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.

National Security

WEDNESDAY, MARCH 5, 2008

Scientists Call for More Research on Potential Use of Nanotechnology to Fight Enemies at Home and Abroad

By Dave Maynard

WASHINGTON, D.C.—A new report by a team of scientists associated with major universities calls for more research on the risks and benefits of nanotechnology, including applications to combat terrorism at home and increase the effectiveness of US armed forces abroad.

The market opportunity for nanotechnology, the report notes, is substantial. Analysts predict that the global marketplace for goods and services using nanotechnologies could grow to $1 trillion by 2015.

"Research is needed to assure society realizes all the potential benefits of nanotechnology while minimizing any potential risks," said Dr. Douglas Kabrastil, head of the scientific research team. "We need to determine whether the same novel properties that make nanomaterials so useful could also make them harmful, and if so, how to prevent that," Kabrastil explained.

Among the potential applications of nanotechnology, the report noted, are products that could be used to promote national security, including intelligent sensors and other methods for thwarting biological and chemical attacks in American cities or on foreign battlefields.

Facts on Nanotechnology

- Nanotechnology is the ability to measure, see, predict and make things on the extremely small scale of atoms and molecules. Materials created at the nanoscale are called nanomaterials, and they can often be made to exhibit very different physical, chemical, and biological properties than their normal size counterparts.
- 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.
- 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.

Table 1. Experiment Results

	Consumer		Regulation		Green-to-Gold		National Security	
	n	Mean	*n*	Mean	*n*	Mean	*n*	Mean
Overall	404	**3.06**	377	3.13	406	3.17	413	**3.26**
Male	182	**2.82**	183	3.09	190	**3.00**	184	**3.12**
Female	222	**3.26**	194	3.17	216	**3.32**	229	**3.38**
White	68	3.03	397	3.15	310	**3.12**	326	3.22
Non-white	336	3.18	70	3.07	96	**3.32**	87	3.40
Hierarchical Individualist (HI)	148	3.00	137	**3.23**	153	3.16	145	3.16
Egalitarian Communitarian	153	3.03	146	**3.01**	144	3.14	157	3.36
White HI Male	79	**2.74**	76	3.18	99	**2.89**	76	**2.99**
Everyone Else	325	**3.14**	301	3.12	318	**3.25**	337	**3.32**

Mean scores on 6-point NRISK scale. In the case of paired groups, **bold** *denotes difference between means of groups within condition significant at $p \leq .05$, underscored significant at $p \leq .10$. In case of "overall,"* **bold** *denotes difference between means across conditions significant at $p \leq .05$, underscored significant at $p \leq .10$*

Finally, subjects in the "National Security Condition" read an article that emphasized the deployment of nanotechnology to thwart the use of biological or chemical weapons by terrorists or enemy military forces. We expected this condition would drive a wedge between hierarchs and individualists: the former, we surmised, would be identity-affirmed by the invocation of dangers that underscore the need to defer to authority, while the latter would be identity-threatened by the specter of contingencies that have historically been used to justify governmental abridgements of liberty. We thus hypothesized that this condition would feature cultural alignments visibly different from those in the other three conditions.

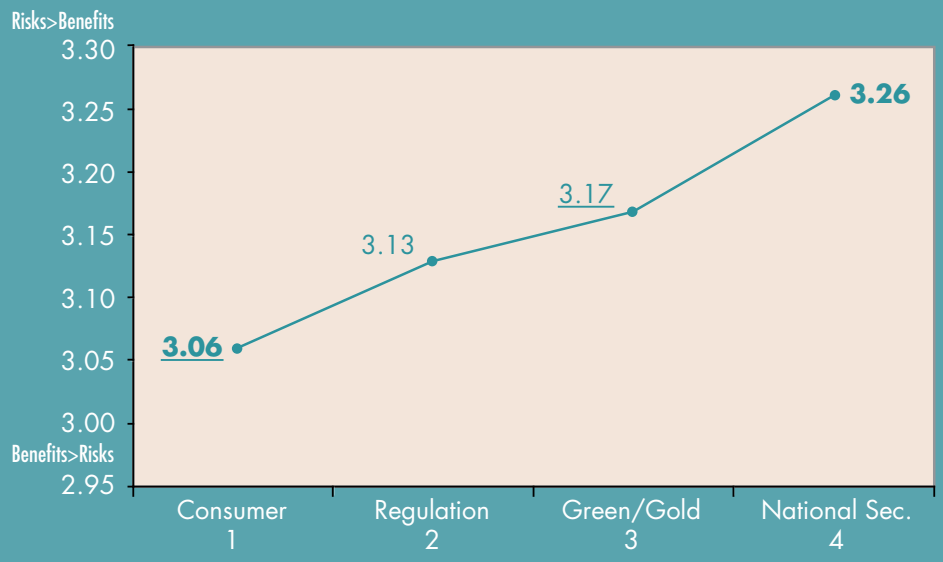
Results

Results of the experiment are reported in Table 1 and Figure 2 and Figure 3. They revealed significant framing effects both across and within conditions.

Across-conditions effects—differences in the mean NRISK scores in the various conditions—reflect the impact that making one or another nanotechnology salient had on risk-benefit perceptions generally. The Consumer Condition had the lowest NRISK score, and the National Security Condition had the highest. That is, study subjects on the whole tended to see nanotechnology as posing more risk relative to its benefits generally when its use for detecting chemical and biological weapons use was emphasized than when its use for consumer goods was emphasized. Surprisingly, the NRISK score of Green-to-Gold was higher than Consumer, although the significance of the difference was marginal ($p = .08$).

Within-condition effects—differences in the mean NRISK scores of different groups within particular conditions—reflect how framing affected the perceptions of individuals of varying characteristics. The effects in the Consumer and Regulation

Figure 2. Across-Condition Effects



6 pt. NRISK scale.
Bold denotes group means significantly different at $p \leq .05$
Underscore at $p \geq .10$

Figure 3. Within-Condition Effects

6 pt. NRISK scale. * denotes group means significantly different at $p \leq .05$

Conditions conformed to our hypotheses. Egalitarian Communitarians had a significantly higher NRISK score than did white male Hierarchical Individualists in the Consumer Condition (Figure 3). This was consistent with our expectation that the former would be identity-threatened and the latter identity-affirmed by the salience of commercial uses of nanotechnology. In contrast, we predicted that white male hierarchical individualists would be identity-threatened and egalitarian communitarians identity-affirmed, in the Regulation Condition. Consistent with that hypothesis, in that condition, the white male hierarchical individualists had the higher NRISK scores.[5]

The results in the Green-to-Gold Condition were inconsistent with our hypothesis. We expected that both egalitarian communitarians and white male hierarchical individualists would be affirmed in this condition and that as a result they would exhibit lower NRISK scores than their counterparts in the conditions in which these groups were identity-threatened (Consumer and Regulation, respectively). Instead, the NRISK scores of both groups were *higher* in Green-to-Gold than they were in their respective identity-threatened conditions. Relative to their counterparts in the Regulation Condition, egalitarian communitarians in Green-to-Gold perceived more risks relative to benefits, while white male hierarchical individualists perceived less. The result was a degree of cultural polarization akin to that in the Consumer Condition.

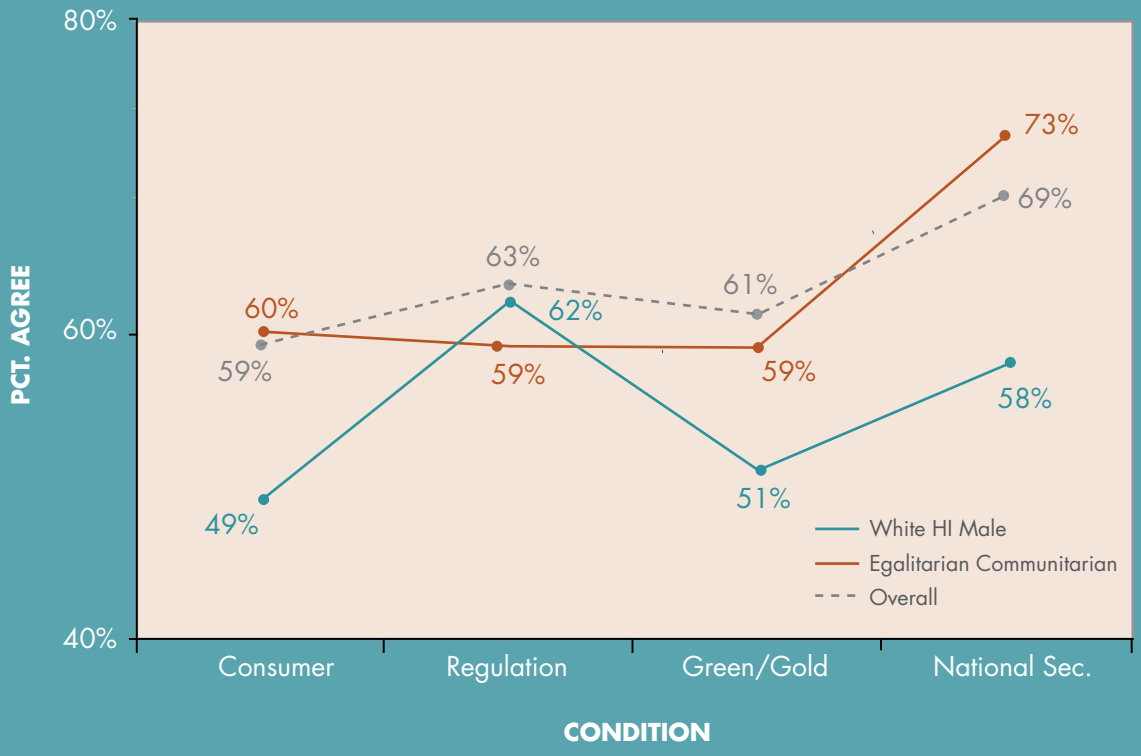
The result in the National Security Condition also failed to conform to our hypothesis. The expected gap between hierarchs and individualists did not emerge. Instead, we observed persistence of the pattern of cultural polarization observed in the Consumer and Green-to-Gold Conditions (egalitarian communitarian perceiving greater risk relative to benefit than did white male hierarchical individualists). The NRISK score of white male hierarchical individualists was lower, however, than that of individuals in the Regulation Condition, indicating that the magnitude of the increased concern on the part of egalitarian communitarians explained why National Security had the highest NRISK score across conditions.

Figure 4 examines responses to NANORISK, one of the three items that made up the composite NRISK scale. It tells the same story, but in terms that help illustrate the practical significance of the experiment results. A substantially higher percentage of white male hierarchical individualists (62%) agreed that "the risks of nanotechnology are likely to be large" in the Regulation Condition than in either the Consumer or the Green-to-Gold Condition (49% and 51%, respectively), illustrating the power of alternately affirming and threatening framings to alter their risk perceptions. However, the percentage of Egalitarian Communitarians who agreed that nanotechnology is likely to be risky remained relatively constant across those three conditions (60%, 59% and 59%, respectively). Responses to this single item did not reveal as negative a reaction to the Green-to-Gold framing as did the composite NRISK scale, but the risk-arousing power of the National Security framing is evident among the NANORISK responses of all classes of subjects.

Discussion

We designed information framings that we anticipated would alternately threaten and affirm individuals of diverse cultural identities, and thus alternately aggravate and mitigate closed-mindedness characteristic of cultural cognition. We observed results suggestive of the hypothesized effects in the Consumer and Regulation Conditions. But we did not see the distinctive pattern of identity-threatened and affirmation anticipated in the National Security Condition and the anticipated simultaneous pattern of identity affirmation anticipated in the Green-to-Gold Condition. Those conditions, moreover, also

Figure 4. Percentage of Subjects Agreeing Nanotechnology Poses Large Risks



generated perceptions of nanotechnology risk that were unexpectedly high in relation to those in the Consumer Condition.

We cannot fully explain why the results diverged from our hypotheses. In the case of Green-to-Gold, one possibility may be that for nanotechnology it simply is not the case that fusing pro-market and pro-environment themes have the power to be identity-affirming simultaneously for cultural groups that ordinarily disagree about environmental risks. Alternatively, the anticipated effect may have been impeded by some particular feature of our Green-to-Gold stimulus.

The *across-condition* effects observed in the experiment, while unanticipated, are nevertheless highly suggestive. The Green-to-Gold and National Security versions of the newspaper article did not make salient any risk from nanotechnology that was not made equally prominent in the other versions of the article. Indeed, relative to the version in the Consumer Condition, which emphasized the use of nanotechnology for production of consumer goods, these two versions of the article made the potential of nanotechnology to *mitigate* societal risks more conspicuous. Why then did subjects in the Green-to-Gold and National Security Conditions perceive the risks of nanotechnology to be higher relative to its benefits than did those in the Consumer Condition?

The answer, we surmise, has to do with the fear provoked by the *non*-nanotechnology risks that were featured in the Green-to-Gold and National Security Conditions. More *vivid* depictions of risk inflate estimations of the likelihood of such dangers because they arouse greater affective responses (Slovic, Finucane, Peters & MacGregor 2004; Loewenstein, Weber, Hsee & Welch 2001). The risks described in Green-to-Gold and National Security—"arsenic [in] groundwater," "biological and chemical attacks"—were characterized in much more vivid, and hence much more alarming, terms than any described in the Consumer Condition. One plausible conjecture, then, is that these risks created a greater state of anxiety, which then spilled over to subjects' assessments of the risks associated with nanotechnology. In other words, framing nanotechnology as risk-abating could have the paradoxical effect of causing individuals to see the risks of nanotechnology itself as outweighing its benefits.

CONCLUSION: THE RISKS AND BENEFITS OF NANOTECHNOLOGY RISK-BENEFIT FRAMING

Our results show that framing matters—in ways that we anticipated and in some important ones that we did not. What is the practical upshot of these findings?

To answer that question, one has to know why exactly one is asking it. If one knew *what* members of the public should think about nanotechnology—e.g., that it poses immense potential dangers and should be subject to significant restrictions, or that it poses little if any risk and should be shielded from regulatory interference—then one could arguably use data of the sort we have presented to help identify information framings crafted to induce the public (including specifically identifiable groups within it) to form the appropriate attitude.

But we don't have a position on precisely what the public should believe about the risks of nanotechnology. We don't believe anyone—or at least anyone who honestly wants the public to get it *right*—could have a strong view on that issue at this point, because the scientific research necessary to determine the risks nanotechnology involves is only now emerging (Behra & Krug 2008; Chen, Meng, Xing, Chen, & Zhao 2007).

The aim of our research is to contribute to the public's receptivity to whatever information such research ultimately reveals. There are many reasons not to take such receptivity for granted (Scheufele

2006). Principal among them is the demonstrated tendency of persons to attend selectively to information about risk in a way that fits their cultural predispositions toward environmental and technological risks. The series of studies conducted by CCP and PEN has been dedicated to identifying how cultural cognition might interfere with the dissemination of sound scientific information about nanotechnology, and what those who favor enlightened public deliberations about this important new science might do to counteract such inference.

From this perspective, we believe the current study teaches a number of practical lessons. Individuals react in a defensive, closed-minded fashion to information that they believe threatens their core values. Accordingly, information communicators should be sensitive to the emotional and symbolic associations that different applications of nanotechnology can trigger in the minds of culturally diverse members of the public. Emphasizing nanotechnology consumer goods, for example, suggests a link between nanotechnology and competitive market behavior, and thus reinforces the disposition of persons with egalitarian and communitarian outlooks to credit information that nanotechnology is dangerous. In contrast, individuals who are hierarchical and individualistic will downplay nanotechnology's benefits and attend more to its risks if they are first made aware of the contribution nanotechnology can make to anti-pollution regulation.

Individuals consider information more carefully and open-mindedly when they feel affirmed rather than threatened. Ideally, then, information about nanotechnology should be framed in a way that simultaneously affirms the values of diverse members of the public.

In our own study, however, we failed to identify a framing that achieves this result. Emphasizing how nanotechnology could create market opportunities for firms that specialize in cleaning the environment seemed, if anything, to be simultaneously *threatening* to egalitarian individualists and hierarchical individualists. At least as we structured it, "green to gold" was no silver bullet.

Still another practical lesson of our study involves the potential hazards of information framings that emphasize the potential of nanotechnology to mitigate societal risks generally. When exposed to information that made salient the power of nanotechnology to remove arsenic from groundwater, or to detect biological and chemical weapons, individuals concluded that nanotechnology *itself* was more risky than did individuals exposed to information that made the use of nanotechnology for consumer goods salient. In the former two cases, the anxiety aroused by especially vivid risks unrelated to nanotechnology infected the processing of information on the risks and benefits of nanotechnology generally, and dominated any identity-affirmation effects.

These findings underscore the importance of additional nanotechnology-risk communication research. Additional study is needed not only to devise universally affirming message framings and to identify techniques for avoiding the anxiety as-

"Individuals react in a defensive, closed-minded fashion to information that they believe threatens their core values."

sociated with information on risk mitigation. Research should also be conducted to determine how message framings interact with the credibility of culturally identifiable advocates, a dynamic that a previous CCP/PEN study showed to be especially important (Kahan, Slovic, Braman, Gastil, Cohen & Kysar 2008).

We acknowledge, in sum, that much work remains to be done before risk communicators can effectively manage the framing of nanotechnology risks. But we believe the study of nanotechnology risk perceptions has already advanced beyond the point where anyone can seriously question the utility of learning how to do so.

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APPENDIX A.
ON-LINE SAMPLE INFORMATION

1. Polimetrix

Polimetrix (http://www.polimetrix.com/) is a public opinion research firm that conducts on-line surveys and experiments on behalf of academic and governmental researchers and commercial customers (including political campaigns). It maintains a panel of over 1 million Americans that it uses to construct representative study samples through a population-matching algorithm. For more information, see http://www.polimetrix.com/documents/YGPolimetrixSampleMatching.pdf.

2. Demographic composition of sample for this study

a. Total number of subjects: 1,600

b. Gender: 53.8% female, 46.2% male

c. Race: 79.9% white, 8.4% African-American

d. Average age: 49 years

e. Median household income: $40,000–$49,000

f. Median education level: Some college

3. Period for Study

April 27–30, 2008

NOTES

1. One recent study examined framing effects in the nanotechnology context, finding that individuals' risk perceptions varied significantly depending on whether nanotechnology was framed as a field of "multinational companies" or "small and medium-sized companies," but not when framed as a field offering, variously, "health benefits," "economic benefits" or "environmental benefits" (Schütz & Wiedemann 2008). The current study similarly examines the impact of emphasizing particular beneficial applications of nanotechnology on overall risk-and-benefit perceptions; it goes further, however, to distinguish among subjects on the basis of their cultural outlooks.

2. Subjects were drawn from an on-line panel recruited by Polimetrix for public opinion research and participated in the study through Polimetrix's on-line testing facilities. For more information on the sample and on Polimetrix's sampling methods, see Appendix A.

3. NANOBENEFIT and NANOBALANCE were thus reverse coded.

4. The order of the benefit and risk paragraphs was rotated across subjects.

5. The difference between the NRISK score of white male hierarchical individualists and that of egalitarian communitarians in the Regulation Condition was not statistically significant, but the change in the *size* of the discrepancy of the scores of those two groups in the Regulation Condition relative to that in Consumer Condition was statistically significant. The significant *effect* of the Regulation Condition framing, in other words, eliminated the difference that existed between the groups in the Consumer Condition.

CULTURAL CREDIBILITY

Biased Assimilation, Polarization, and Cultural Credibility: An Experimental Study of Nanotechnology Risk Perceptions

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FEBRUARY 2008

INTRODUCTION AND SUMMARY OF CONCLUSIONS

This report describes the results of the second in a series of ongoing experimental studies of public perceptions of the risks and benefits of nanotechnology. The studies are aimed at identifying how public attitudes toward nanotechnology are likely to evolve as the public learns more about this novel science. They also seek to identify concrete strategies for improving public understanding of scientific information on the risks and benefits of nanotechnology as such information is developed. The first study in this series found that when individuals who know little about nanotechnology are exposed to information about it, they tend to polarize in their opinions along lines that reflect their cultural predispositions toward technological and environmental risks generally (Kahan, Slovic, Braman, Gastil, & Cohen 2007). This study examined whether and how the perceived cultural

outlooks of information *sources* would affect public reactions to arguments about the risks and benefits of nanotechnology.

Key findings and conclusions were as follows:

1. When unattributed to identifiable advocates, arguments about the risks and benefits of nanotechnology generate polarization of beliefs. Relative to persons not exposed to such arguments, individuals exposed to opposing sets of arguments divide along various lines, including *race* and *cultural orientation*. The gap between people who are generally inclined to credit and those generally inclined to dismiss claims of environmental risk widens dramatically after exposure to such arguments.

2. When such arguments *are* attributed to identifiable advocates, the impact of the arguments on subjects is highly sensitive to the perceived cultural outlooks of the advocates. When individuals of diverse cultural outlooks observe an advocate whose values they share advancing an argument they are predisposed to accept, and an advocate whose values they reject advancing an argument they are predisposed to resist, cultural polarization grows. If, however, individuals observe an advocate whose values they share advancing the argument they are otherwise predisposed to resist, and an advocate whose values they reject advancing the argument they are otherwise predisposed to accept, there is a complete inversion of the positions on nanotechnology risks normally associated with particular cultural outlooks. Finally, when there is no consistent relationship between the perceived values of advocates and positions taken on nanotechnology risk and benefits, cultural polarization is neutralized.

3. These findings reinforce the conclusion, reached in the first study in this series, that a strategy of public education that focuses only on disseminating accurate information cannot reliably be expected to generate convergence on accurate public beliefs about the risks and benefits of nanotechnology. People tend to credit and dismiss arguments about nanotechnology in patterns that reflect their cultural predispositions toward environmental and technological risks, and thus polarize on cultural lines, a phenomenon known as *biased assimilation* and *polarization*. The delivery of arguments by qualified experts will not necessarily counteract this effect, and indeed could easily accentuate it, because of the tendency of persons to assign greater credibility to policy advocates who share their values and who, as a result, are likely to be espousing positions that fit listeners' cultural predispositions.

4. Scientists, policymakers, and others interested in promoting enlightened public evaluation of the best available information on nanotechnology risks should take affirmative steps to create a *deliberative climate* that neutralizes biased assimilation and polarization. One such step would be to assure that members of the public do not form the impression that there is a link between the cultural values of policy advocates and particular positions on nanotechnology risks. Since credibility depends on trust, which depends largely on shared cultural outlooks, parties interested in communicating accurate information should be attentive to assuring that they avail themselves of information providers of diverse cultural orientations. In this condition of "advocacy pluralism," members of the public are less likely to divide along cultural lines.

5. Additional research is warranted to identify further concrete steps that can be taken to assure a culturally unbiased deliberative climate for public evaluation of sound information on nanotechnology's risks and benefits.

TOWARD A COMPREHENSIVE STRATEGY FOR PROMOTING INFORMED UNDERSTANDING OF NANOTECHNOLOGY'S RISKS AND BENEFITS

The future of nanotechnology will be determined in large measure by the public's assessment of its potential benefits and risks. The Cultural Cognition Project (CCP), with the support and collaboration of the Project on Emerging Nanotechnologies (PEN), is engaged in a series of studies to determine how the public's perceptions of those matters is likely to evolve. These studies are not aimed at promoting any particular view on the relative magnitude of the benefits and risks of nanotechnology—a matter that is likely not susceptible to definitive assessment at this time. The studies are motivated, however, by a commitment to identifying concrete steps that scientists, regulators, and others can take to assure that the public's assessment of nanotechnology's risks and benefits reflects the best available scientific information that is currently available and that will become available as evaluations of nanotechnology continue.

The first study conducted as part of this series underscored that such an outcome cannot necessarily be expected to occur spontaneously (Kahan, Slovic, Braman, Gastil, & Cohen 2007). That study used experimental methods to test a hypothesis suggested by existing public opinion polls relating to nanotechnology. Those polls show that the vast majority of the American public has heard little, if anything, about nanotechnology, but that those who are relatively familiar with it view it favorably (Peter D. Hart Associates 2007). A hypothesis one might form on the basis of these polls, then, is that as they learn more about it, members of the public currently unfamiliar with nanotechnology will likewise form the view that the benefits of nanotechnology predominate over its risks.

The results of the first CCP/PEN study furnished no support for this hypothesis. That study demonstrated that, when supplied with information, individuals unfamiliar with nanotechnology do not respond in a uniformly positive way. Indeed, they do not respond uniformly at all. On the contrary, such individuals *polarize* along cultural lines: when exposed to the same body of balanced and accurate information, persons who hold relatively egalitarian and communitarian values infer that nanotechnology is risky, whereas persons who hold relatively individualistic values infer that it is not (Kahan, Slovic, Braman, Gastil, & Cohen 2007).

This result derives from two interrelated psychological dynamics. One is *cultural cognition*, which refers to the tendency of people to conform their factual beliefs about putatively dangerous activities to their cultural appraisals of those activities (DiMaggio 1997; Douglas & Wildavsky 1982; Kahan & Braman 2006). It is easier, psychologically speaking, to believe that behavior one finds noble is socially beneficial, and that behavior one finds base is socially harmful, than vice

"When unattributed to identifiable advocates, arguments about the risks and benefits of nanotechnology generate polarization of beliefs."

"The future of nanotechnology will be determined in large measure by the public's assessment of its potential benefits and risks."

versa. Persons with individualistic outlooks value commerce and markets, and are thus predisposed to discount claims that such activities pose dangers to the environment that would justify restricting them. Persons who hold egalitarian values, in contrast, are very sensitive to environmental and technological risks, recognition of which justifies regulating activities—commerce and industry—that they view as sources of unjust forms of inequality. People who hold communitarian values also readily credit claims of environmental risk because they see unconstrained commercial activity as symbolic of unconstrained pursuit of self-interest (Kahan, Braman, Gastil, Slovic, & Mertz 2007).

The other relevant dynamic is *biased assimilation and polarization* (Lord, Ross, & Leper 1979). It has been shown that individuals are disposed to screen information in a biased way based on its consistency with their prior beliefs or predispositions (biased assimilation). As a result, when people with different beliefs and predispositions are exposed to factual information, they do not converge but rather grow even more extreme in their disagreements (polarization).

Putting these dynamics together, one would expect that when persons who are unfamiliar with nanotechnology are exposed to information about it, they would draw inferences from it consistent with their cultural predispositions toward environmental and technological risks generally. As a result, such individuals would polarize, rather than form a uniform, much less a uniformly positive, view. That is exactly what our experiment found.

Such a result suggests that one cannot take for granted the emergence of public consensus as sound scientific information about nanotechnology's risks and benefits is disseminated to the public. Those who find such information congenial to their values are likely to credit it, but those who find such information uncongenial will be inclined to dismiss it and rely instead on less- sound information that is more supportive of their predispositions.

This unhappy outcome, however, is not necessarily inevitable. Studies have identified various risk-communication techniques that counteract the biasing effects of cultural cognition (Cultural Cognition Project 2007; Kahan, Slovic, Braman, & Gastil 2006). CCP and PEN are currently studying how these techniques can be adapted to promote informed understanding of the risks and benefits of nanotechnology. The study that forms the basis of this report identifies one such technique.

Table 1. Effects of Unattributed Arguments Across Groups

MEAN RISK PERCEPTIONS ACROSS CONDITIONS				
	No-Argument Condition	Argument Condition	Diff.	Polarization
Overall	3.64	3.66	.02	NA
Male	3.52	3.46	-.06	.17
Female	3.76	3.87	.11	
White	3.65	3.59	-.06	**.27**
Nonwhite	3.64	3.85	.21	
Conservative	3.72	3.65	-.06	-.01
Liberal	3.55	3.48	-.07	
Republican	3.67	3.64	-.04	.13
Democrat	3.60	3.69	.09	
Hierarch	3.65	3.64	-.01	.06
Egalitarian	3.65	3.70	.05	
Individ	3.66	3.57	-.10	**.22**
Commun	3.63	3.76	.12	
Low Env Fear	3.54	3.48	-.06	**.19**
High Env Fear	3.76	3.89	.13	
High Know	3.35	2.73	-.61	**.59**
Low Know	3.67	3.64	-.03	

N ≈ 800, approximately 400 subjects per condition. Risk perceptions measured with a 6-point scale. Polarization refers to increase in size of difference of mean risk perceptions of paired groups across conditions. Boldface type indicates that the degree of polarization so measured was statistically significant ($p \leq .05$).

NANOTECHNOLOGY RISK PERCEPTIONS AND THE CULTURAL CREDIBILITY HEURISTIC

Overview

The aim of the current study was to examine how the *cultural credibility heuristic* interacts with biased assimilation and polarization in the setting of nanotechnology risk perceptions. Because most individuals lack the time and expertise necessary to make sense of scientific information on risk and other policy issues, they naturally rely on those whom they trust to determine what information to believe. The people they are inclined to trust are those who share their cultural outlooks (Kahan, Slovic, Braman, & Gastil 2006). This dynamic can accentuate cultural polarization if information providers and advocates themselves are generally divided along cultural lines—as one might expect them to be by virtue of cultural cognition. But the cultural credibility heuristic can also potentially ameliorate such polarization if information advocates take positions that run contrary to the cultural predispositions of those inclined to defer to them. The current study used experimental methods to examine these possible effects in the context of the debate about the risks and benefits of nanotechnology.

“Because most individuals lack the time and expertise necessary to make sense of scientific information on risk and other policy issues, they naturally rely on those whom they trust to determine what information to believe.”

Study design

The study involved a sample of approximately 1,600 American adults and was conducted over a period of several weeks between June and August 2007. The subjects were drawn from a nationally representative panel recruited by Knowledge Networks and participated in experiments using Knowledge Network’s on-line testing facilities.[1]

Data on various individual characteristics were measured before the study. These included subjects’ socio-demographic characteristics, political ideologies, and party affiliations. They also included subjects’ cultural worldviews, which were measured using two scales: (1) Hierarchy-Egalitarianism, which assesses subjects’ relative preferences for forms of social organization that reflect authority and role-based prerogatives, on the one hand, versus forms that reflect highly egalitarian relations, on the other; and (2) Individualism-Communitarianism, which assesses their relative preference for forms of social organization that give priority to individual and collective claims, respectively (Kahan, Braman, Gastil, Slovic, & Mertz 2007). Individuals were characterized as either “Hierarchs” or “Egalitarians” and as either “Individualists” or “Communitarians” depending on where their scores fell in relation to the median of all subjects on each scale.

The study occurred in two stages. The first stage evaluated how exposure to balanced arguments unattributed to identifiable advocates would influence subjects’

Figure 1. Argument Exposure and Racial Polarization

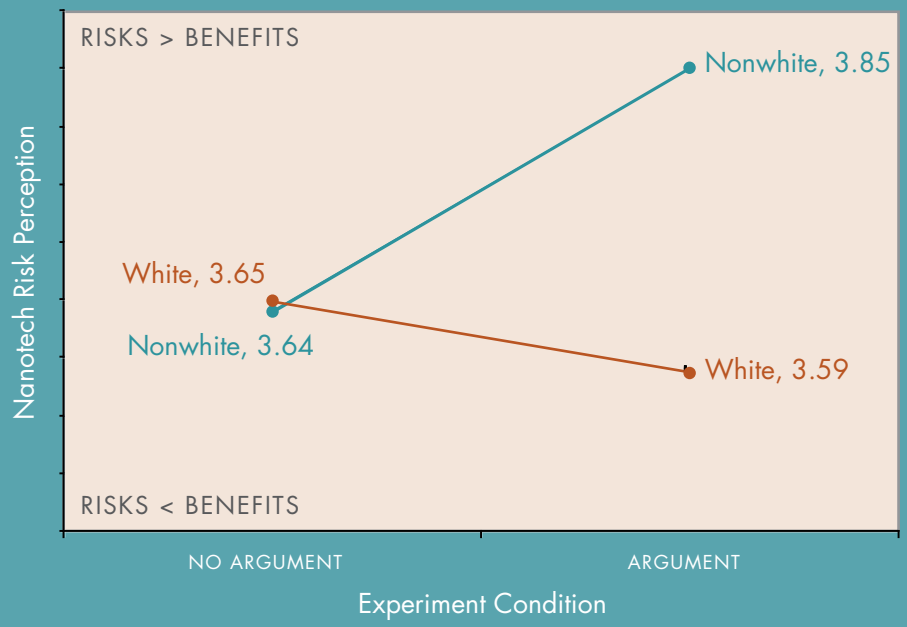
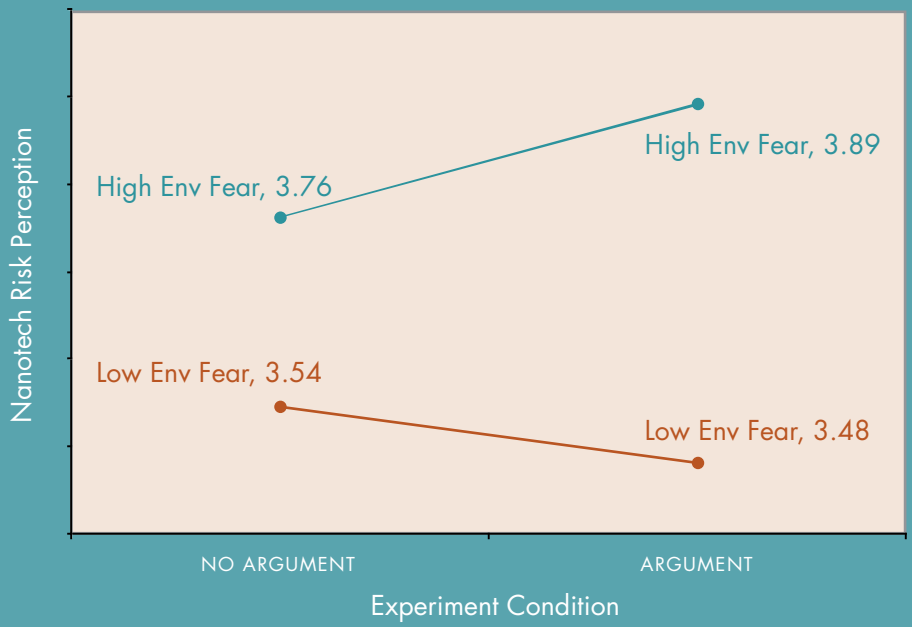


Figure 2. Effect of Argument Exposure on Subjects Defined by Environmental Risk-Sensitivity



perceptions of nanotechnology risks and benefits. The second evaluated how exposure to the same arguments would influence participants' perceptions when the arguments were attributed to advocates recognized as holding one or another set of cultural values.

Stage 1: The polarizing effects of arguments

The first stage of the current study involved approximately 800 subjects. Half the subjects (the "no-argument condition") received no information about nanotechnology aside from a brief description of it.[2] The other half ("the argument condition") received brief and balanced arguments, one proposing the suspension of nanotechnology development pending further research into its potential risks, and the other defending continued development pending such research.[3] Subjects' perceptions of the risks and benefits of nanotechnology were measured on a six-point scale composed of seven items. The scale was coded so that the higher the score, the greater the concern with nanotechnology risks relative to benefits.[4] Much like the first CCP/PEN study of nanotechnology, this component of the current study permitted us to assess the effects of information exposure—albeit in a more argumentative form—on persons of different attributes.

"As in the previous study, we found that the vast majority of the subjects (92%) had heard "little" or "nothing" about nanotechnology before the study."

As in the previous study, we found that the vast majority of the subjects (92%) had heard "little" or "nothing" about nanotechnology before the study. Overall, subjects exposed to argumentative information did not form risk perceptions significantly different from those of individuals not exposed to such arguments. However, as in the previous study, we found that various groups exposed to information became polarized relative to groups not exposed to information (Table 1).

One dimension along which polarization occurred was racial. Whereas whites and nonwhites in the no-argument condition held relatively uniform views, nonwhites were significantly more fearful than whites in the argument condition (Figure 1).

Subjects also polarized along cultural lines. Relative to their counterparts in the no-argument condition, individualists in the argument condition grew less fearful and communitarians grew more fearful. A gulf also emerged between egalitarians and hierarchs and between conservatives and liberals, although the size of the degree of polarization was not statistically significant in either case.

Relative to the no-argument condition, women became more concerned, and men less, in the argument condition. The degree of cultural polarization measured in terms of mean risk scores missed statistical significance. However, a multivariate regression confirmed that being female predicted greater concern with nanotechnology risks in the argument condition (Table 2).

We also observed polarization among subjects based on their fear of environmental risks in general. Using items that measured our subjects' expressed concerns about global warming and nuclear power, we constructed a reliable "environmental fear"

Table 2. Multivariate Regression Analyses of Nanotechnology Risk Perceptions

	NO ARGUMENT	ARGUMENT
Female vs. Male	.097	.076*
White	.007	-.098**
Age	.127	.005
Income	-.103**	-.005
Education Level	-.058	-.082*
Republican vs. Democrat	.052	.093**
Independent vs. Democrat	.005	.053
Conservative vs. Liberal	.069	.084
Hierarchy vs. Egalitarianism	-.037	.042
Individualism vs. Communitarian	.026	-.047
Prior Knowledge of Nano	-.160***	-.252***
Environmental Risk Fear	.162***	.266***
R^2	.17	.27

***Dependent variable is** nanorisk**. regression coefficients are semi-partial correlations. *** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$.*

“Individuals disposed to worry about environmental risks can be expected to worry about nanotechnology when they first learn of it, and to become even more alarmed as they consider arguments about its risks and benefits.”

scale ($\alpha = .77$).[5] Low-fear subjects (those who displayed scores below the median degree of concern on the scale) had a higher degree of concern about nanotechnology risks than did high-fear subjects (those who displayed scores above the median) in both conditions. But again, the *size* of the gap between the two groups was dramatically larger in the argument condition (Figure 2). In other words, individuals disposed to worry about environmental risks can be expected to worry about nanotechnology when they first learn of it, and to become even more alarmed as they consider arguments about its risks and benefits.

Finally we found cultural polarization based on prior knowledge about nanotechnology. “High-knowledge” subjects (those who claimed they knew either a “moderate amount” or “a lot” about nanotechnology before the study) had less concern about risk than did “low-knowledge” subjects (those who claimed than that they knew “nothing” or “only a little”) in both conditions. But the *size* of the differential was significantly *larger* in the argument condition.

As we found in our previous experiment, then, the existing correlation between knowledge about nanotechnology and low concern for risk in the general population does *not* imply causation of the latter by the former. It suggests only that persons inclined to perceive the benefits of nanotechnology are more likely to learn about it on their own. When those who know little learn more, in contrast, those predisposed by cultural values or other influences to worry about environmental risks become *more* fearful.[6]

Stage 2: Credibility and polarization

The second stage of the study involved an additional 800 subjects. These subjects were exposed to the same arguments as those in the argument condition of Stage 1 of the study. Now, however, the arguments were randomly assigned to advocates (fictional constructs presented to subjects in photographs as “policy experts at major universities”) whom we had determined in separate pretests (involving different subjects) were perceived as holding different combinations of the values associated with the cultural worldview scales (Figure 3). Thereafter, subjects’ views on the risks and benefits of nanotechnology were measured with the same scale used in Stage 1 of the study.

The results revealed that cultural polarization interacts strongly with the relationship between subjects’ cultural worldviews and the perceived worldviews of those advocating one position or another on nanotechnology (Figure 4). This was especially so along the Hierarchy-Egalitarianism dimension of cultural orientation. When subjects observed an egalitarian policy expert defending suspension of nanotechnology development pending additional research on risk, and a hierarchical one defending continued development pending such research, cultural polarization increased relative to that in the no-argument and argument conditions in Stage 1. When, however,

Figure 3. Culturally Identifiable Policy Advocates

HIERARCHIST

Books:
- The Immigrant Invasion: Threatening the American Way of Life
- The War on American Manhood
- Selfishness Is Not a Vice: Individual Freedom and the Public Good
- Why Big Government Doesn't Work

Books:
- The Crisis of Authority: The Assault on Traditional Values in America
- How "Women's Liberation" Hurts Women—and Men and Children Too!
- Community First: Fighting Selfishness in American Society
- The Limits of Individual Rights

INDIVIDUALIST

COMMUNITARIAN

Books:
- Against Race and Sex Discrimination. For Individual Freedom
- A Free Market Defense of Workplace Equality
- Respect for Individual Choice: the Cornerstone of a Free and Equal Society
- Stop Treating Us Like Infants: Why Government Shouldn't Tell Adults What to Do

Books:
- Three Social Evils: Sexism, Racism, and Homophobia
- Raising Children: Avoiding Sexual Stereotypes
- People Before Profit! Fixing Corporate America
- Society as Family: One for All and All for One

EGALITARIAN

Figure 4. Impact of Culturally Identifiable Advocates on Hierarchs and Egalitarians

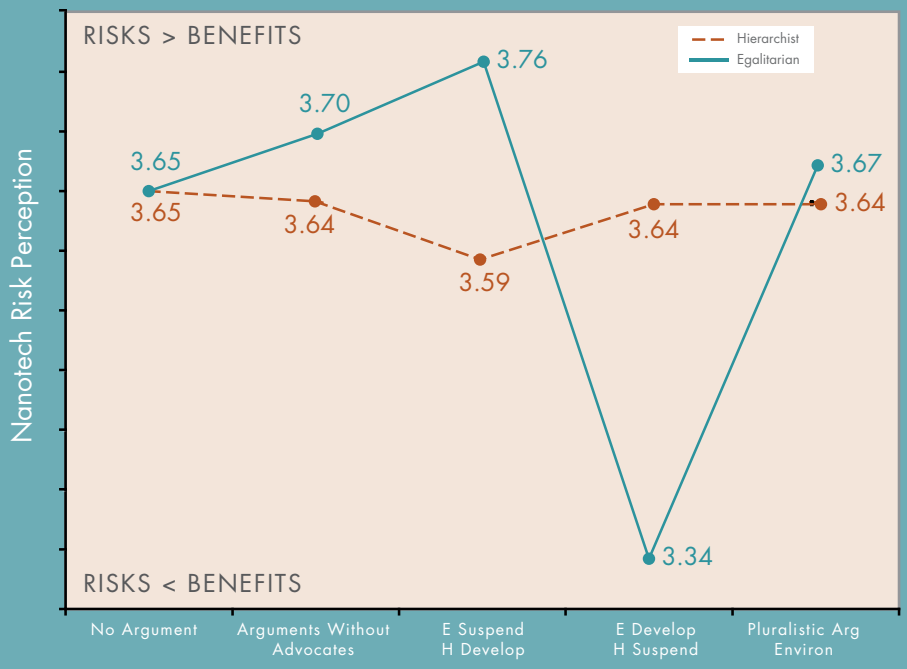
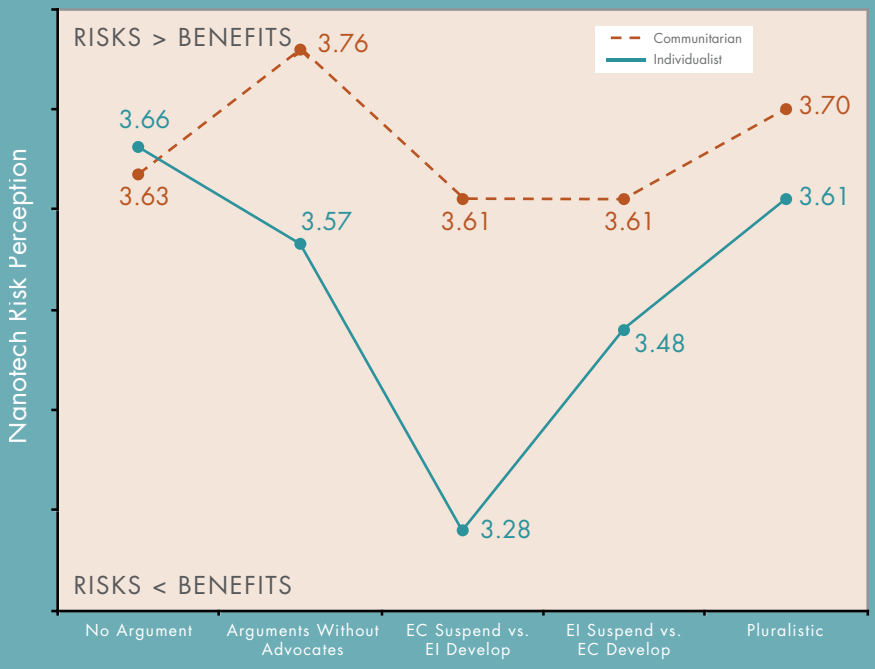


Figure 5. Impact of Culturally Identifiable Advocates on Individualists and Communitarians



a hierarchical advocate defended suspension, and an egalitarian advocate defended continued development, subjects holding these respective worldviews swapped positions: among subjects confronted with this alignment of arguments and advocates, egalitarians became so convinced of nanotechnology's benefits that they displayed a more positive view of the balance of benefits and risks than did hierarchs.

Such a dramatic inversion of the cultural identity of advocates and the cultural resonances of arguments is unlikely to be experienced outside the laboratory. Less unrealistic, though, is the possibility of a *pluralistic-argument environment*—one in which advocates of diverse persuasions are as likely to be found on one side of the issue as on another. We found that in an experimental condition in which subjects were equally likely to see hierarchs and egalitarians on both sides of the issue—and for that reason seeing arguments *among* hierarchs and egalitarians as ones between them—cultural polarization was essentially eliminated.[7] In a pluralistic-argument environment, disagreement persists, but egalitarians are not significantly more or less likely to conclude that nanotechnology benefits predominate over risks than are hierarchs.

We found similar results along the individualism-communitarian dimension of cultural worldviews. When the advocate identifiable as holding a combination of Egalitarian and Communitarian views (Figure 3, lower right) defended suspension of development pending risk research, and the advocate identifiable as a combination of Hierarchical and Individualistic ones (Figure 3, upper left) defended continued development, polarization increased, mainly because that alignment increased the risk-skepticism of individualists. When the position of these advocates was reversed, polarization diminished. Other argument-advocate pairings produced less-dramatic results, possibly because a general correlation between individualism and hierarchy muted the credibility effect. Finally, in a pluralistic environment—one in which arguments both for and against continued development were as likely to be assigned an individualist advocate as to a communitarian one—there was, once more, relatively little polarization (Figure 5).[8]

CONCLUSION: LESSONS LEARNED AND ISSUES REMAINING TO BE INVESTIGATED

This most recent study in the CCP/PEN series yields a number of important insights. Some of these relate to the understanding of formation of risk perceptions generally. Others speak to how information about nanotechnology in particular should be conveyed in order to maximize the likelihood that public assessments reflect the best scientific understandings that are now available and that will become available in the future on nanotechnology's risks and benefits.

The first theoretically interesting lesson from this study relates to the profound significance of the *cultural credibility heuristic* in the formation of beliefs about novel risks. As shown in the first CCP/PEN study and confirmed in this one, individuals process information about novel risks in diverse ways that reflect their disposition to reach conclusions congenial to their cultural values. But the current study shows that this type of biased assimilation appears to be much weaker than the tendency of persons to credit the assessments of experts and advocates whose cultural values they share. When those advocates take positions that reinforce individuals' cultural predispositions, the tendency of persons to form views in keeping with those predispositions is, not surprisingly, accentuated. But when those advocates take positions that *contravene* individuals' cultural predispositions, the impact of biased assimilation can be counteracted. Indeed, the normal association between positions on risk and particular cultural orientations can be completely inverted when advocates of opposing cultural identities simultaneously adopt positions contrary to the predispositions of individuals who share their respective outlooks.[9]

This finding enriches the general picture of the psychology of cultural cognition. It is well-known that individuals use heuristics to compensate for lack of firsthand knowledge with complicated issues of risk and for lack of the time and training necessary to acquire knowledge through engagement with scientific literature (Kahneman, Slovic, & Tversky 1982). The theory of cultural cognition says that many of these heuristics possess an important connection to individuals' core values (Kahan, Slovic, Braman, & Gastil 2006). The CCP/PEN studies of nanotechnology suggest that there is natural hierarchy among the heuristics that cultural cognition comprises. The first study suggested that individuals can make use of even a small bit of balanced information to orient themselves very rapidly on a novel issue of risk, likely as a result of their responsiveness to affective resonances in that information that allow individuals to assimilate their attitude toward a novel risk to more-familiar risk issues to which they have a culturally conditioned response (Kahan, Slovic, Braman, Gastil, & Cohen 2007). But that initial heuristic judgment, the current study suggests, is not particularly robust. The positions taken by particular policy experts who share individuals' cultural values exert a much stronger heuristic influence on individuals as they try to make sense of a novel risk issue. Likely this is so

because individuals assume that these policy advocates, whom they trust by virtue of a cultural affinity, have more knowledge about the risk issue in question than individuals themselves are able to acquire from the content of opposing sets of arguments. Alternatively, or perhaps simply in addition, the position of the expert might imply that the position the expert is espousing is in fact widely held by others who share that advocate's cultural outlooks, a cue that is likely subconsciously to induce listeners who hold that outlook to gravitate toward that view in order to affirm their connection with their cultural peers (Cohen 2003).

A number of important practical conclusions follow for those interested in assuring enlightened public deliberation on the risks and benefits of nanotechnology. One is reinforcement of the lesson that enlightened response to sound information *cannot* be taken for granted. Again, the existing positive correlation that exists between familiarity with nanotechnology and the perception that its benefits predominate over its risks in public opinion polls might be thought to imply that the simple dissemination of information about nanotechnology will generate a similarly positive view among that segment of the general population (the vast majority) currently unfamiliar with it. That position—which likely misunderstands the causal direction of the current relationship between a positive view of nanotechnology and familiarity with it—was shown to be false in the first CCP/PEN study.

The current study suggests that the expertise of persons disseminating information about nanotechnology also should not necessarily be expected to generate enlightened consensus about its risk and benefits. Just as individuals often lack the time and capacity to assess the soundness of information on their own, they also often lack the time and capacity to assess the training and knowledge of information providers. Moreover, on almost any risk issue of significance—from global warming to domestic terrorism, from school shootings to vaccination of school-age girls for human papillomavirus—members of the public will be confronted with dueling advocates whose expert credentials (scientific training, university affiliations, and the like) are roughly comparable. In that situation, they will almost certainly decide whom to trust in exactly the way they normally do, namely, by assessing *who* it is in the debate at hand who seems most *like* themselves. That judgment of likeness will almost certainly involve a tacit judgment of *cultural* affinity.

The impact of this cultural credibility heuristic can easily amplify the polarizing impact of simple information dissemination. The same forces that motivate individuals generally to adopt positions on risk issues that are congenial to their cultural outlooks can induce policy advocates to do so. As a result, a deliberative climate can emerge in which members of the public consistently see advocates they culturally identify with presenting arguments those members of the public are culturally predisposed to accept, and advocates they do not identify with presenting arguments they are culturally predisposed to reject. The state of public division that emerges when members of the public are impelled simultaneously by the combined forces of

“On almost any risk issue of significance… members of the public will be confronted with dueling advocates whose expert credentials… are roughly comparable.”

biased assimilation and cultural credibility makes the prospect for convergence on sound scientific information exceedingly remote.

Nevertheless, the results of the current study also vindicate the supposition that the polarizing tendencies of cultural cognition are not immutable. Precisely because the cultural credibility heuristic seems to exert greater force than the power of biased assimilation, it can, at least theoretically, be harnessed to counteract polarization.

The results of Stage 2 of the study suggest that it is imperative that those who have a stake in enlightened public assessment of nanotechnology attend not just to *what* is said about its risks and benefits but also to *who* says it. It is critical that care be taken to avoid creating the impression in the mind of the public that one or another position on nanotechnology is strongly associated with one or another cultural outlook. Such an impression can easily arise by accident; indeed, it is likely in the nature of things for such an impression to emerge. To counteract it, proponents of enlightened decisionmaking should make a conscious effort to include as information providers experts and other risk communicators whom persons of diverse cultural outlooks will identify with and hence trust.

Even if it is a necessary part of any strategy to promote enlightened public deliberation on nanotechnology, securing a culturally pluralistic argument environment of this sort is unlikely to be sufficient. Studies suggest that information-framing techniques—in particular ones that affirm, rather than threaten, individuals' cultural values—also make a vital contribution to guaranteeing that individuals of diverse outlooks remain maximally receptive to sound information (Cultural Cognition Project 2007). In the absence of message framings that make sound information about nanotechnology's risk and benefits congenial to persons of diverse cultural outlooks, it will likely be impossible to foster or maintain culturally pluralistic advocacy of such information. Accordingly, experimental studies currently being conducted by CCP and PEN are aimed specifically at adapting to nanotechnology information the sorts of identity-affirming framing techniques that have been used in other contexts.

Differences of opinion, to be worked out in the normal course of democratic decisionmaking, will almost certainly be a part of the future of nanotechnology in the United States. This will be so, at a minimum, because people naturally place different values on the myriad benefits that nanotechnology might confer and also on avoiding the types of risks that it might entail.

But no matter how they come out on these questions, citizens of diverse values have a common interest in ensuring that their deliberations are informed by the very *best* understanding of nanotechnology's risks and benefits that science is able to attain. They have a common interest, then, in creating a deliberative climate that is free of influences that impede their capacity to recognize what that information is.

The CCP/PEN studies show that the dynamics of cultural cognition can be one of those influences. But the studies also show that it is possible to devise procedures of information dissemination that counteract this source of distortion.

Continued development of a comprehensive strategy for furnishing information accessible to persons of diverse cultural outlooks should be among the highest priorities of those who want to promote enlightened public debate on this important and novel science.

NOTES

1. Additional information on the characteristics of the sample and on Knowledge Networks' on-line testing facilities appears in Appendix B.

2. "Nanotechnology is a relatively new form of science that involves 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." The instrument used for both stages of the study is attached as an Appendix A.

3. See Appendix A for the wording of the arguments.

4. The items included in the scale appear in Appendix A. The scale proved reliable in both conditions, but was more so in the argument condition (α=.84) than in the no-argument condition (α=.68). This is not at all surprising, because so few subjects (8%) had heard more than "a little" about nanotechnology before the study, one would expect the perceptions of subjects afforded more information to display greater internal consistency.

5. See Appendix A for item wording.

6. The public opinion polls contained in Peter D. Hart Associates (2007) do not demonstrate nearly as striking an effect from information exposure. This is not surprising since these polls reflect a within-subjects ("before-and-after") design, in which there is a tendency for subjects who initially express one view—particularly ones who acknowledge that they are unfamiliar with the issue in question—to indicate they have altered their position after receiving information in order to signal the socially desirable trait of open-mindedness. The between-subjects design used in this study avoids this effect and thus, we believe, furnishes a more valid indication of how information exposure is likely to affect members of the general public, particularly individuals who previously have not been exposed to comparable information.

7. Differences in relative positions across conditions were statistically significant ($p < .05$).

8. Differences in relative positions across conditions were statistically significant ($p < .05$).

9. We obtained results similarly dramatic in independent experiments involving the cultural credibility heuristic and responses to arguments over the proposal for mandatory vaccination of school-age girls for human papillomavirus (Cultural Cognition Project 2007).

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APPENDIX A.
SELECT EXPERIMENT SURVEY INSTRUMENT ITEMS

1. Cultural Orientation Scales

Six-point response scale for all items: Strongly Disagree, Moderately Disagree, Slightly Disagree, Slightly Agree, Moderately Agree, and Strongly Agree.

Individualism–Solidarism Scale

IINTRSTS.	The government interferes far too much in our everyday lives.
SHARM.	Sometimes government needs to make laws that keep people from hurting themselves.
IPROTECT.	It's not the government's business to try to protect people from themselves.
IPRIVACY.	The government should stop telling people how to live their lives.
SPROTECT.	The government should do more to advance society's goals, even if that means limiting the freedom and choices of individuals.
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.
SNEEDS.	It's society's responsibility to make sure everyone's basic needs are met.
INEEDY.	It's a mistake to ask society to help every person in need.
SRELY.	People should be able to rely on the government for help when they need it.
IRESPON.	Society works best when it lets individuals take responsibility for their own lives without telling them what to do.
ITRIES.	Our government tries to do too many things for too many people. We should just let people take care of themselves.
IFIX.	If the government spent less time trying to fix everyone's problems, we'd all be a lot better off.
IENJOY.	People who are successful in business have a right to enjoy their wealth as they see fit.
IMKT.	Free markets—not government programs—are the best way to supply people with the things they need.
IPROFIT.	Private profit is the main motive for hard work.
IGOVWAST.	Government regulations are almost always a waste of everyone's time and money.

Hierarchy-Egalitarianism Scale

HEQUAL.	We have gone too far in pushing equal rights in this country.
HREVDIS1.	Nowadays it seems like there is just as much discrimination against whites as there is against blacks.
EWEALTH.	Our society would be better off if the distribution of wealth was more equal.
ERADEQ.	We need to dramatically reduce inequalities between the rich and the poor, whites and people of color, and men and women.
EDISCRIM.	Discrimination against minorities is still a very serious problem in our society.
HREVDIS2.	It seems like blacks, women, homosexuals and other groups don't want equal rights, they want special rights just for them.
HCHEATS.	It seems like the criminals and welfare cheats get all the breaks, while the average citizen picks up the tab.
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.
HWMNRTS.	The women's rights movement has gone too far.
ESEXIST.	We live in a sexist society that that is fundamentally set up to discriminate against women.
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.
HFEMININ.	Society as a whole has become too soft and feminine.
EROUGH.	Parents should encourage young boys to be more sensitive and less rough and tough.

2. Environmental Risk Items

Six-point response scale for all items: Strongly Disagree, Moderately Disagree, Slightly Disagree, Slightly Agree, Moderately Agree, and Strongly Agree.

GWPOLICY.	It is important to take steps to reduce global warming.
GWRISK.	Global warming poses a serious environmental risk.
NUCDANGER.	It is dangerous to live near a nuclear power plant.

3. Nanotechnology Familiarity Item

PRIORKNOW. Before today, how much would you say you knew about nanotechnology? [Nothing, A Little, A Moderate Amount, A Lot]

4. Balanced Arguments

Juxtaposed and rotated; assign randomly to advocates in Stage 2 credibility experiment.

5. Nanotechnology Risk-Benefit Items

Six-point response scale for all items: Strongly Disagree, Moderately Disagree, Slightly Disagree, Slightly Agree, Moderately Agree, and Strongly Agree.

NANOBENEFIT.	The benefits of nanotechnology are likely to be very large.
NANORISK.	The risks of nanotechnology are likely to be very large.
NANOBALANCE.	On the whole, the benefits of nanotechnology will outweigh the risks.
SAFETYFIRST.	Government should prohibit commercial development of nanotechnology until studies have been done on how to control any risks nanotechnology might involve.
GOFORIT.	Restricting commercial development of nanotechnology until more studies are done is a bad idea because it will discourage essential investments in the nanotechnology industry.
PRECAUTION.	In the face of uncertainty about risk, the best course of action is to conduct safety studies before allowing nanotechnology to be developed.
OPPCOST.	Preventing development of nanotechnology while safety studies are being done will deprive society of too many potential benefits from nanotechnology.

Develop Now, Regulate Later.
Nanotechnology is likely to create immense benefits for society. Some examples are food containers that kill bacteria, stain-resistant clothing, high-performance sporting goods, faster and smaller computers, and more effective skincare products and sunscreens. Nanotechnology also has the potential to create better ways to treat disease, clean up the environment, enhance national security, and provide cheaper energy. It's fine for government to study and monitor the nanotechnology industry as it develops. But if restrictive government regulations discourage companies from making the necessary start-up investments in this new technology, society will suffer for sure.

Regulate Now, Develop Later.
While there's no conclusive evidence yet on the potential risks of nanotechnology, there are many reasonable concerns about it. For example, no one knows for sure whether release of nanomaterials could damage the environment, or whether nanomaterials could harm humans when breathed in or absorbed through the skin. It's also possible that invisible nanotechnology-based monitoring devices could pose a threat to national security or lead to invasions of personal privacy. It's just common sense to wait until these issues have been investigated and resolved before allowing commercial development of products using nanotechnologies.

APPENDIX B.
STUDY SAMPLE

1. Knowledge Networks

Study subjects consisted of a nationally representative general population sample of approximately 1,600 Americans who were recruited by Knowledge Networks and who participated in study experiments via Knowledge Network's on-line testing facilities. 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. Gender: 51% female, 49% male.
c. Race: 73% white, 9% African-American.
d. Average age: 47 years.
e. Median household income: $35,000 to $40,000.
f. Median education level: Some college.

AFFECT AND CULTURALLY BIASED ASSIMILATION

Nanotechnology Risk Perceptions: The Influence of Affect and Values

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INTRODUCTION AND SUMMARY OF CONCLUSIONS

Its immense range of potential applications—scientific, commercial, and medical—marks nanotechnology as one of the most promising new forms of applied science. The future of nanotechnology, however, will depend not just on anticipation of its likely benefits but also on fear of its possible risks. Many members of the public, often upon hearing of nanotechnology for the first time, react with near-instantaneous concern about the hazards it may pose to the environment and to human health. Despite the nascent state of the nanotechnology industry, moreover, efforts to subject it to comprehensive regulation are already under way.

What explains existing public reactions to nanotechnology, particularly among people who know little about it? How are public attitudes likely to evolve as people learn more?

The Cultural Cognition Project conducted a study to investigate these questions. The study involved an experimental survey of 1,800 Americans. The study sample, its methods and its results are set forth in the attached paper, "Affect, Values, and

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Table 1. Public Opinion on the Relative Risk and Benefits of Nanotechnology

	BENEFIT > RISK	RISK > BENEFIT
Overall	53%	36%
Men	59%	31%
Women	47%	40%
Whites	54%	34%
Blacks	36%	49%
White Males	61%	30%
White Females	46%	39%
Republicans	55%	35%
Democrats	54%	37%
Liberals	58%	33%
Conservatives	55%	35%
Low Knowledge	47%	40%
Moderate Knowledge	80%	19%
High Knowledge	83%	14%

Nanotechnology Risk Perceptions: An Experimental Investigation" ("Experimental Investigation"). This report highlights some of the key findings and the principal recommendation of the study.

Findings:

1. Peoples' attitudes toward nanotechnology derive from their *affective* or *emotional responses* to it. Those who know little or nothing about the concept of "nanotechnology" experience a quick, visceral reaction to it that strongly influences their judgment about the relative size of nanotechnology's potential risks and benefits. That visceral reaction is strongly influenced by their perceptions of more familiar environmental risks, such as those associated with global warming and nuclear power.

2. As people learn more about nanotechnology, their reactions depend heavily on their *values*. When exposed to balanced and accurate information, people who hold largely individualistic and hierarchical cultural outlooks tend to see nanotechnology as more beneficial. People who hold largely communitarian and egalitarian outlooks, in contrast, tend to see nanotechnology as more risky when exposed to that same information. These patterns of opinion, too, are consistent with ones that characterize conflict over more familiar environmental issues. The same polarization occurs between people who, in political terms, describe themselves as conservatives and those who describe themselves as liberals.

3. Relatedly, it does *not* appear that learning more about nanotechnology tends in general to make people more favorably disposed to it. There is at present a positive relationship between how much people know about nanotechnology and the belief that its benefits outweigh its risks. But when people who know little or nothing are supplied with more

information, they do not become uniformly more favorable: some form a more positive impression, some a more negative one, depending (again) on their values. This finding suggests that the relationship now observed between knowledge about nanotechnology and a favorable view toward it is based on the causal influence of the latter on the former. That is, people who are already predisposed to like nanotechnology (most likely because of their values or emotions) have been more inclined so far to learn about it than have those who are predisposed to dislike it.

Recommendation:

The results of this study point up the need for additional research on techniques for effectively communicating information about nanotechnology. Because people with different values are predisposed to draw different factual conclusions from the same information, it cannot be assumed that simply supplying accurate information will allow members of the public to reach a consensus on nanotechnology risks, much less a consensus that promotes their common welfare. Those interested in promoting informed public responses toward nanotechnology must therefore attend not only to the content of information but also to the framing of it. To enable informed public deliberation, it is essential to develop strategies for communicating scientifically sound information that make it possible for people of diverse values to draw the same factual conclusions from it.

STUDY DESIGN

The sample consisted of approximately 1,850 Americans recruited by Knowledge Networks, a leading on-line survey firm, for participation in scholarly public opinion analysis. The sample was demographically diverse (51% female, 49% male; 72% white, 10% African-American) and weighted to assure national representativeness. The subjects completed an on-line survey experiment that collected information on relevant individual characteristics and attitudes toward nanotechnology risks. To enable an experimental test of the effect of information exposure, a 350-subject subsample was furnished with more detailed information about the risks and benefits of nanotechnology (as described in more detail below) before their views were elicited. Survey responses were collected between December 14, 2006, and December 28, 2006.

CURRENT PUBLIC OPINION TOWARD NANOTECHNOLOGY

The responses of the 1,500 subjects not exposed to additional information were used to assess existing public opinions toward nanotechnology. Consistent with past surveys (Peter D. Hart Research Associates, 2006), the results suggested that Americans

“The future of nanotechnology… will depend not just on anticipation of its likely benefits but also on fear of its possible risks.”

Figure 1. Prior Knowledge of Nanotechnology

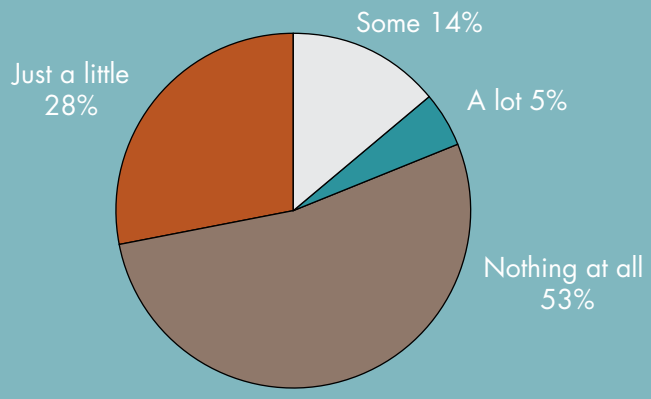
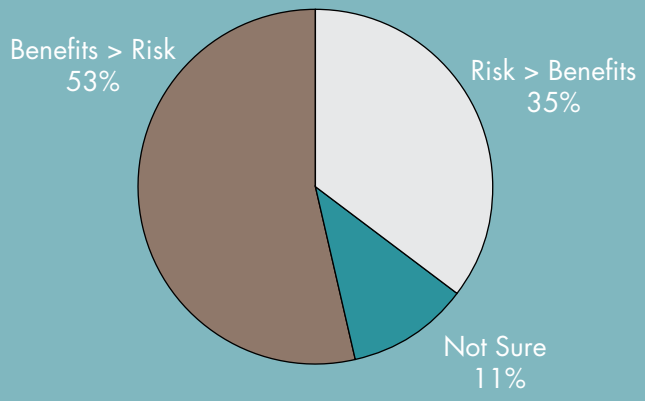


Figure 2. Risks vs. Benefits of Nanotechnology



Margin of Error ± 2.5%

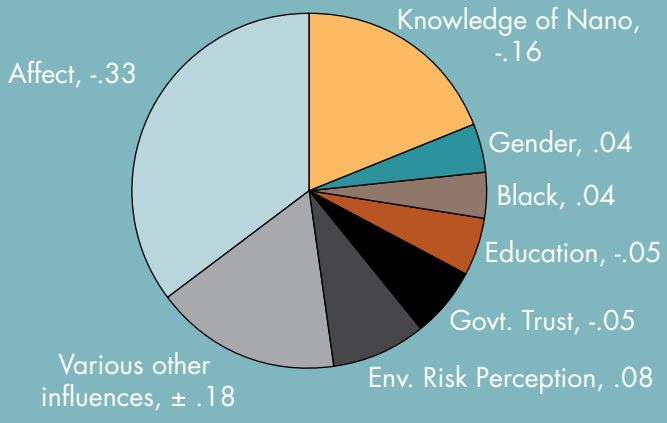


Figure 3. Relative Size of Influences on Opinions Toward Nanotechnology Risk Perceptions (Reflected in Semi-partial Coefficients in Multivariate Regression)

are largely uninformed about nanotechnology: 81% of subjects reported having heard either "nothing at all" (53%) or "just a little" (28%) about nanotechnology prior to being surveyed, and only 5% reported having heard "a lot."

Nevertheless, most subjects—89%—reported having an opinion on whether the benefits of nanotechnology outweigh its risks or vice versa. A slight majority (53%) appears to view benefits as outweighing risks.

Looking at subgroups, however, reveals more division. Men (59% to 36%) are significantly more likely than women (47% to 40%) to think that risks outweigh benefits. Moreover, whereas a majority of whites (54%) believe that risks outweigh benefits, a plurality of African-Americans (49%) view risks as outweighing benefits. White males were the most pro-benefit (61% to 30%). The differences among persons grouped by political ideology or party affiliation were fairly minor.

Also consistent with previous surveys (Peter D. Hart Research Associates, 2006), the study found differences of opinion based on how much subjects had heard of nanotechnology. Whereas those who had heard "little" or "nothing at all" ("low knowledge") were slightly inclined to see benefits as outweighing risks (47% to 40%), those having heard "some" ("moderate knowledge") and those having heard "a lot" ("high knowledge") were decidedly tilted toward in that direction (80% to 19% and 83% to 14%, respectively).

EXPLAINING CURRENT OPINION: THE ROLE OF AFFECT

A multivariate regression analysis was used to assess the sources of individual differences of opinion toward nanotechnology risks.[1] This statistical technique allows the effect of each one of a set of influences on some matter of interest—here nanotechnology risk perceptions—to be evaluated controlling for the effect of the remainder.

Among the influences included in the analysis was the subjects' *affective* reaction to nanotechnology. Affect—a person's positive or negative emotional orientation—has been shown in previous research to be one of the most powerful influences on peoples' perceptions of risk (Slovic *et al.*, 2004). Subjects in this study were asked to indicate whether nanotechnology made them feel "very bad," "bad," "neither good nor bad," "good," or "very good." This measure of affect has been shown to be a valid and reliable indicator of all the emotional reactions—from visceral feelings to more-complex emotional states (like anger and fear) to positive and negative symbolic imagery—that risks evoke (Peters & Slovic, in press).

The results of this analysis reveal that affect is in fact the single largest determinant of individuals' attitudes toward nanotechnology risks. How positively or negatively a subject reacted to nanotechnology had an impact (sr = -.33, $p \leq .001$) eight times as large as whether that person was male or female (sr = .04, $p \leq .10$), or was African-American or white (sr = .04, $p \leq .05$). The impact of affect was approximately seven times larger than the impact of confidence in government to regulate risks effectively (sr = -.06, $p \leq .001$), six times larger than the impact of education (sr = -.05, $p \leq .05$), and four times larger than the impact of perception of other environmental risks (sr = .08, $p \leq .01$). The next biggest influence—how much subjects reported knowing about nanotechnology before the study (sr = -.16, $p \leq .01$)—was less than half that of affect. In sum, as they do with respect to myriad other putatively dangerous activities (from nuclear power to pesticides to genetically modified foods to handguns), individuals form a

1. The regression output can be found in "Experimental Investigation," p. 19 tbl. 2.

perception of the relative benefits and risks of nanotechnologies that mirrors their emotional appraisals of it.

These results naturally beg the question, What explains individuals' affective responses toward nanotechnology? Another multivariate regression analysis identified a number of influences.[2] One was our subjects' views of other environmental risks, including global warming and nuclear power: the more concerned they were with those risks, the more negative their affective response toward nanotechnology (sr = -.08, $p \leq .01$). Another influence was their values. Individuals who subscribe to a relatively *individualistic* worldview—one that prizes the autonomy of markets and that chafes at collective inference with individual initiative—was associated with a relatively positive view of nanotechnology (sr = .06, $p \leq .05$). Being female (sr = -.08, $p \leq .01$), and African-American rather than white (sr = -.06, $p \leq .01$), were associated with negative nanotechnology affect.

"As people learn more about nanotechnology, their reactions depend heavily on their *values*."

THE IMPACT OF INFORMATION: CULTURAL/IDEOLOGICAL POLARIZATION

In addition to analyzing existing public attitudes toward nanotechnology, the study included an experiment designed to determine the likely evolution of public opinion as people learn more about this novel science. A subsample of 350 subjects received information about nanotechnology before their views were elicited. The information consisted of two paragraphs, one identifying potentially beneficial applications of nanotechnology and the other identifying potential nanotechnology risks:

> *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.*

The attitudes of subjects who received this balanced factual information were then compared to those of the remaining subjects.

Exposure to this information produced no overall shift in risk/benefit perceptions.

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2. The regression output can be found in "Experimental Investigation," p. 21 tbl. 3.

Table 2. Differences in Benefit/Risk Perceptions Across No-Info/Info Groups

	MEAN BENEFIT/RISK PERCEPTION		
	No Info Group	Info Exposure 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**
Liberals	2.78	2.62	d**
Conservatives	2.66	2.71	d**
Hierarchs	2.64	2.72	e*
Egalitarians	2.67	2.58	e*
Individualists	2.62	2.73	f**
Communitarians	2.70	2.54	f**
Low Knowledge	2.51	2.50	
Moderate Knowledge	3.18	3.10	
High Knowledge	3.33	3.14	

Shared alphabetic notation indicates that the size of the difference in mean scores of indicated groups was significantly different across conditions: * $p \leq .10$, ** $p \leq .05$, ***$p \leq .01$, 1-tail.

The percentages of persons who believed that benefits outweighed risks and that risks outweighed benefits were not significantly different between the two groups (53% to 36% in the "no information" group; 57% to 38% in the "information exposure" group).

Balanced information exposure *did* produce significant differences, however, among subgroups of respondents. Evaluated in terms of their mean scores on a four-point scale that measured perception of benefits relative to risks, the differences between various subgroups were even more pronounced in the "information exposure" group than in the "no information" group.

Thus, demographic differences observed among "information exposure" subjects were even greater than those among the "no information" subjects. Whites exposed to information were even more likely to see benefits, whereas African-Americans were more likely to see risks. A similar widening of the perception gulf occurred among men and women, but was not statistically significant ($p = .11$).

There were even more dramatic differences in the reactions of subgroups of subjects defined in terms of their values. The theory of "cultural cognition" posits that individuals process information in a way that reflects and reinforces their general preferences about how society should be organized (Kahan *et al.*, 2006). Egalitarians and communitarians, for example, tend to be sensitive to claims of environmental and technological risks because ameliorating such risks justifies regulating commercial activities that generate inequality and legitimize unconstrained

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

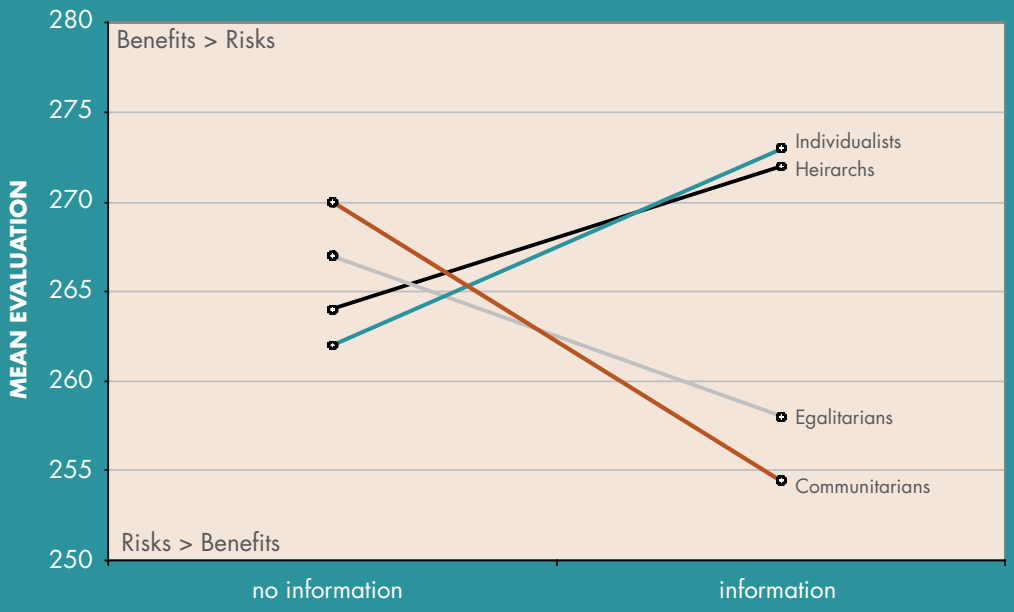
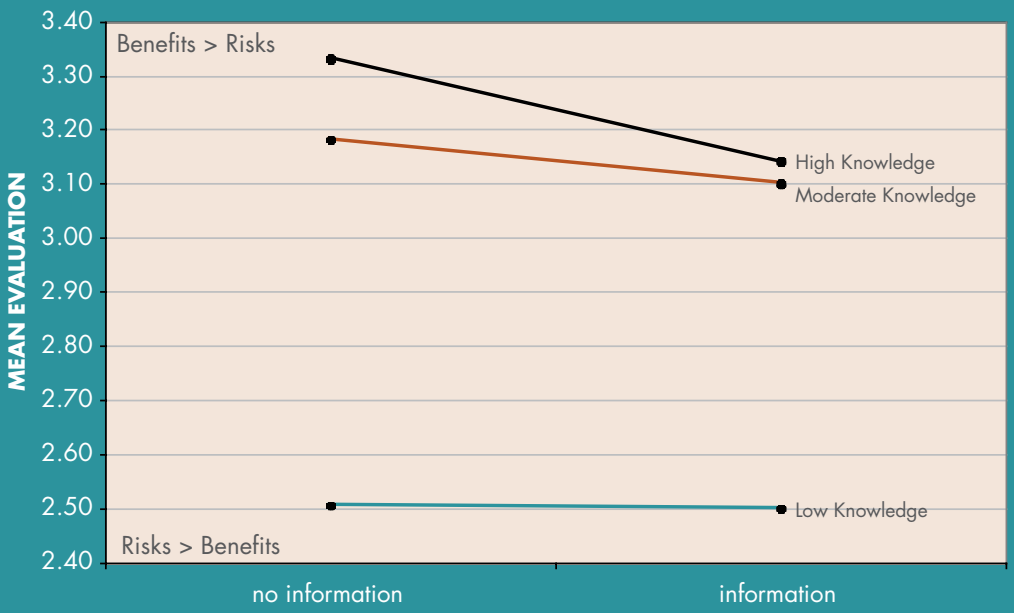


Figure 5. Impact of Information Across Groups by Prior Knowledge Level



pursuit of self-interest. Individualists, in contrast, tend to be skeptical about such risks, in line with their concern to ward off contraction of the sphere of individual initiative. So do hierarchists, who tend to see assertions of environmental technological risks as challenging the competence of governmental and social elites (Douglas & Wildavsky, 1982). Whereas subjects who subscribed to these various worldviews did not have markedly different attitudes in the "no information" group, those in the "information exposure" group divided along exactly these lines.

Exposure to information also seemed to excite recognizable ideological divisions. Liberals, who held a slightly more positive view of nanotechnology among the subjects in the "no information group," actually traded places with conservatives in the "information exposure" group, assuming a stance of risk concern more characteristic of their ideology.

Exposure to information did not shrink the difference in attitudes associated with prior knowledge. The substantial gap among those who reported previously knowing a modest or high amount and those who reported knowing little or nothing was as large in the "information exposure" group as in the "no information" group.

Combined with the failure of information exposure to produce a general shift in assessments, this finding weighs strongly *against* the inference that people can be expected to form a more positive view of nanotechnology as they learn more about it. The most plausible interpretation of the observed positive correlation between prior knowledge and a positive view in general is that individuals who are already exposed—most likely by affect or by their values—are naturally disposed to learn more about nanotechnology.

Indeed, as those who are naturally disposed by their values to be concerned about risks learn more—as they almost certainly will as this novel science assumes a larger profile in society—they might well form a more *negative* view of nanotechnology. The theory of "biased assimilation and polarization" holds that persons of differing views tend to process information in a way that supports their predispositions and thus become even more divided as they learn more (Lord, Ross & Leper, 1979). The results of the current study demonstrate how exposure to even a small amount of balanced information about nanotechnology can have this effect among persons defined in terms of their cultural and political commitments. The results could be even more dramatic in the real world, where people are likely to be exposed not only to a higher volume of information but also to extremely unbalanced forms of it due to the tendency of people to choose information sources that match their political and cultural predispositions.

CONCLUSION: THE FUTURE OF NANOTECHNOLOGY?

The findings of this study do not by any means permit the future of nanotechnology to be predicted with complete confidence. Nonetheless, they should help those

"It would be a mistake, this study suggests, to assume that nothing more needs be done than to supply people with scientifically sound information."

who want to assure informed development of nanotechnology identify the steps necessary to make that outcome more likely.

It would be a mistake, this study suggests, to assume that nothing more needs be done than to supply people with scientifically sound information. People adopt an initial stance toward nanotechnology that tends to reflect their general emotional orientation toward environmental hazards; that stance then takes an even more partisan shape as they conform information about nanotechnology to their cultural and political values. If this process is permitted to unfold unchecked, it spells a future for nanotechnology marked by the sort of conflict and division that historically attended nuclear power and today characterizes the global warming debate. Whatever one anticipates science will reveal about the relative risks and benefits of nanotechnology, no one who favors constructive, democratic deliberation, much less the adoption of sensible risk regulations, should be heartened by this prospect.

At the same time, there is nothing in this study to suggest that such a future is inevitable. It seems unlikely that the tendency of people to filter information through emotion and values can be neutralized. But the tendency of these information-processing mechanisms to *divide* people certainly can be. Social psychology is making important advances in techniques for framing information on controversial issues of policy in a manner that makes it possible for people of diverse values to derive the same factual information from it (Cohen *et al.,* 2000; Cohen *et al*., in press). With further study, it is likely that these techniques can be used to guide risk communication and thus enhance democratic deliberations about risk-regulation policy—on nanotechnology and on other issues (Kahan *et al*., 2006).

The practical lesson of this study, then, is that those who favor informed public deliberations over nanotechnology should be neither sanguine nor bleak. Instead, they should be psychologically realistic. And if they are, they will see the urgent need for additional efforts to develop risk-communication strategies that make it possible for culturally diverse citizens to converge on policies that promote their common interests.

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The **PROJECT ON EMERGING NANOTECHNOLOGIES** was launched in 2005 by the Wilson Center and The Pew Charitable Trusts. It is dedicated to helping business, governments, and the public anticipate and manage the possible human and environmental implications of nanotechnology. www.nanotechproject.org

The **CULTURAL COGNITION PROJECT AT YALE LAW SCHOOL** is a group of scholars from Yale and other universities interested in studying how cultural values shape the public's risk perceptions and related policy beliefs. In research funded by the National Science Foundation and the Oscar M. Ruebhausen Fund at Yale Law School, Project members are using the methods of various disciplines—including social psychology, anthropology, communications, and political science—to chart the impact of this process and to identify the mechanisms through which it operates. The Project also has an explicit normative objective: to identify democratic procedures that enable society to resolve culturally grounded differences in belief in a manner that is both congenial to people of diverse cultural outlooks and consistent with sound public policymaking. For more information about the Project, go to http://research.yale.edu/culturalcognition/.

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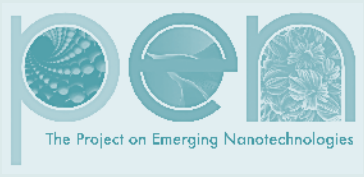

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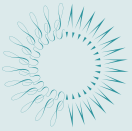

THE PEW CHARITABLE TRUSTS

FSC logo here.
white knock-out, horizontal

Printed with Vegetable-based Inks