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# Cultural cognition of the risks and benefits of nanotechnology

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**How is public opinion towards nanotechnology likely to evolve? The 'familiarity hypothesis' holds that support for nanotechnology will likely grow as awareness of it expands. The basis of this conjecture is opinion polling, which finds that few members of the public claim to know much about nanotechnology, but that those who say they do are substantially more likely to believe its benefits outweigh its risks[1–4]. Some researchers, however, have avoided endorsing the familiarity hypothesis, stressing that cognitive heuristics and biases could create anxiety as the public learns more about this novel science[5,6]. We conducted an experimental study aimed at determining how members of the public would react to balanced information about nanotechnology risks and benefits. Finding no support for the familiarity hypothesis, the study instead yielded strong evidence that public attitudes are likely to be shaped by psychological dynamics associated with cultural cognition.**

Cultural cognition refers to the tendency of people to base their factual beliefs about the risks and benefits of a putatively dangerous activity on their cultural appraisals of these activities[7,8]. From a psychological point of view it is easier to believe that behaviour one finds noble is socially beneficial, and that behaviour one finds debased is dangerous, than vice versa[9,10]. Those who are 'individualistic' and 'hierarchical' in their cultural worldviews tend to dismiss claims of environmental risk, for example, because acknowledging such hazards would threaten the autonomy of markets and the authority of social elites. Persons who hold 'egalitarian' and 'communitarian' worldviews, on the other hand, take environmental risks seriously because they believe unregulated markets are a source of inequality and, therefore, harmful to society[11,12]. Consistent with this dynamic, researchers have found evidence that people of opposing cultural outlooks polarize on various environmental and technological risks—from nuclear power[13] and global warming[14] to genetically modified foods and 'mad cow' disease[15].

The 'cultural cognition' hypothesis holds that these same patterns are likely to emerge as members of the public come to learn more about nanotechnology. That is, rather than adopt uniformly positive attitudes, as the familiarity hypothesis suggests, members of the public who hold relatively egalitarian and communitarian worldviews will perceive its risks to be greater and its benefits smaller than will those who hold relatively hierarchical and individualistic worldviews.

We designed a public opinion study to test the familiarity and cultural cognition hypotheses. The study reflected an experimental design aimed at detecting causal links, if any, between information exposure and attitude formation. We divided a diverse, national online sample of 1,862 Americans into two groups. Those in the 'no-information condition' were told nothing about nanotechnology other than it is a scientific process for producing and manipulating very small particles. Those in the 'information-exposed condition,' in contrast, were furnished with two paragraphs of equal length and comparable information content, one identifying possible benefits of nanotechnology, the other possible risks. We then compared the two groups' perceptions of nanotechnology risks and benefits to see what effect information exposure had.

Like most members of the American public[1,2], our study subjects reported being relatively unfamiliar with nanotechnology. The vast majority—over 80%—reported having heard either 'just a little' (28%) or 'nothing at all' (54%) about it. Only 4% reported having heard 'a lot' about nanotechnology before the study, and 14% reported having heard 'some,' an amount in between 'just a little' and 'a lot.' Among subjects in the no-information condition, familiarity with nanotechnology was positively correlated with the perception that nanotechnology's benefits outweigh its risks ($r_s = 0.38$, $P < 0.001$), a finding also consistent with previous public opinion studies[1–4].

Information exposure had no discernable main effect on subjects' perceptions of nanotechnology risks and benefits. The mean assessment on a four-point risk–benefit measure (NANORISK) for subjects in the information-exposed condition ($M = 2.37$, s.d. $= 1.03$) was virtually identical to the mean assessment for subjects in the no-information condition ($M = 2.34$, s.d. $= 0.99$).

To assess whether the impact of information exposure varied based on either familiarity with nanotechnology or cultural worldviews, we performed a multivariate regression analysis. The dependent variable for the analysis was whether subjects perceived the benefits of nanotechnology to be greater than its risks or vice versa. Independent variables included cultural worldview measures, the interaction of those worldviews, the degree of self-reported knowledge, and appropriate interactions of these variables with the experimental condition to which subjects were assigned. This analysis (see Supplementary Information, Fig. S1) can be used to determine how information exposure influences individuals either conditional on their cultural worldviews holding their level of familiarity constant, or conditional on their level of familiarity holding their cultural worldviews constant.

The results are illustrated in Fig. 1. Holding cultural worldviews constant (at the sample mean), information exposure does not have a significant effect on the likelihood that either a subject who is relatively unfamiliar with nanotechnology or one who is relatively familiar with it will perceive the benefits of nanotechnology to be greater than its risks (Fig. 1a).

In contrast, information exposure has a relatively large and statistically significant impact on subjects defined with reference to their cultural worldviews (Fig. 1b). In the no-information condition,

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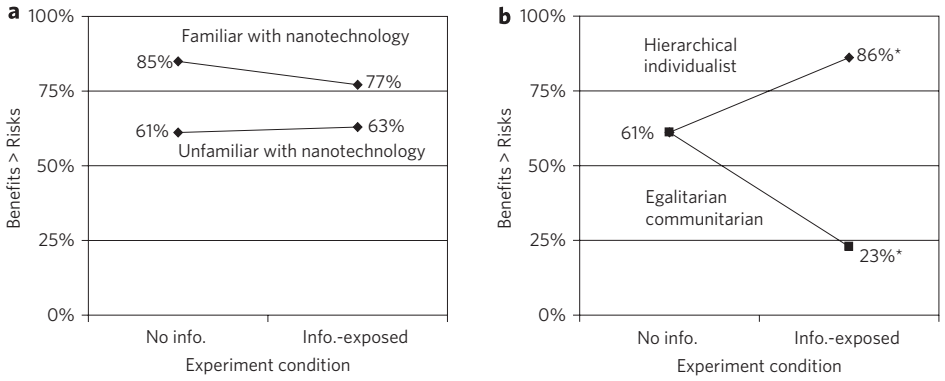


**Figure 1 | Effect of information on risk–benefit perceptions of subjects defined by self-reported familiarity with nanotechnology and cultural worldviews.** Likelihoods of response are derived by statistical simulation[29] from the logistic regression analysis (see Supplementary Information, Table S1). **a**, Likelihoods of response for the benefits of nanotechnology exceeding the risks in the no-information and information-exposed conditions when cultural worldviews are controlled (set to their means) for respondents who are unfamiliar (bottom line) and familiar (top line) with nanotechnology. **b**, Likelihoods of response across conditions when familiarity is controlled for (set to its mean) and the culture variables are set at values that reflect the worldviews of modestly hierarchical and individualistic subjects (top line), and modestly egalitarian and communitarian ones (bottom line). $N = 1{,}672$. *Change in likelihood across conditions significant at $P \leq 0.05$.

subjects whose cultural worldviews are moderately hierarchical and individualistic, on the one hand, and subjects whose worldviews are moderately egalitarian and communitarian, on the other, are equally likely (61%) to see the benefits of nanotechnology as outweighing its risks if we hold their level of self-reported knowledge constant (at the sample mean). In the information-exposed condition, however, the likelihood that hierarchical individualists will perceive benefits as greater than risks grows by 25%, while the likelihood that egalitarian communitarians will do so shrinks by 38%—opening up a 63% gap (86% to 23%) between them.

These results support the cultural cognition hypothesis but not the familiarity hypothesis. Our subjects did not react uniformly, much less in a uniformly positive manner, when exposed to information. Instead, they reacted divergently, in a manner consistent with their opposing cultural predispositions toward technological risk generally. This finding displays the signature of 'biased assimilation and polarization'—the tendency of persons to conform information to their predispositions and thus to become more, not less, divided when exposed to balanced information[16].

This result also raises the question why those who report greater familiarity with nanotechnology—in the no-information condition of our study and in previous opinion surveys—tend to see the benefits of nanotechnology as great and the risks as small. One possibility is selection bias. The relatively small portion of the population who say they have heard either a modest amount or a great deal about nanotechnology are obviously different from the vast majority who have heard little or nothing. The same set of forces that creates their unique motivation to learn about nanotechnology might also be uniquely disposing these persons to form positive views about it.

The study also yielded two other findings that reinforce this conclusion. First, we found that the subjects (in both conditions) who reported being relatively familiar with nanotechnology—the 18% who claimed to have heard either 'a lot' or 'some' about it—were not only less likely to perceive the risks of nanotechnology as greater than its benefits. They were also less likely than nanotechnology-unfamiliar subjects to be concerned with all manner of risk—whether from genetically modified foods, mad cow disease, nuclear power generation or the internet (Fig. 2). Obviously, it is not plausible to think that their familiarity with nanotechnology is the reason these persons are relatively unworried about these other risks. Instead, it is more sensible to think that

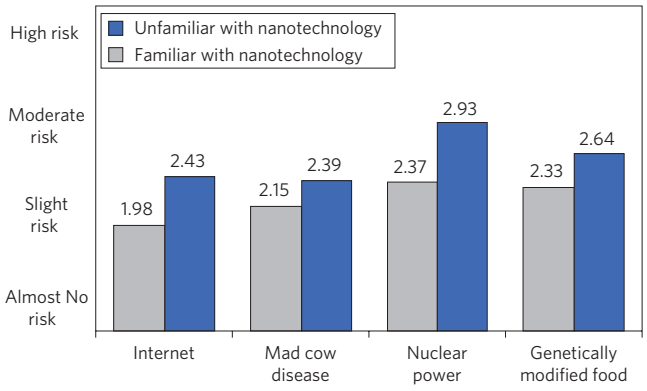


**Figure 2 | How people familiar and unfamiliar with nanotechnology view the risks and benefits of other technologies.** Risk variables are four-point measures of 'risk to people in American Society' posed by the internet, mad cow disease, nuclear power and genetically modified food. Canonical correlation between familiarity and the risk measures significant at $P \leq 0.01$. Differences between group means all significant at $P \leq 0.01$.

there is something else that is causing people who are generally sceptical of environmental and technological risks to learn more about (or at least claim they have learned more about) nanotechnology.

The second finding sheds some light on what that influence—or set of influences—might be. Regressing self-reported familiarity with nanotechnology on various individual characteristics revealed that being simultaneously hierarchical and individualistic predicted greater familiarity with nanotechnology (see Supplementary Information, Table S2 and Fig. S1). Because these worldviews generally dispose individuals to be sceptical about technological risks[13–15,17], it is no surprise that experimental subjects of this sort reacted positively when exposed to balanced information on nanotechnology. By the same token, it is no surprise that egalitarians and communitarians, who are less likely in the normal course to learn about nanotechnology, react less favourably when such information is brought to their attention.

In total, the study findings suggest a particular model of how cultural predispositions and exposure to information about nanotechnology work (Fig. 3). In the model, such predispositions both affect

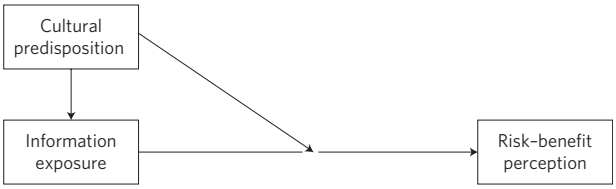


**Figure 3 | Relationships between cultural worldviews, information exposure and risk-benefit perceptions.** The study results suggest that cultural worldviews influence perceptions of the risks and benefits of nanotechnology both by influencing how likely subjects were to be exposed to information (or report being exposed to information) about nanotechnology, and by determining what effect—positive or negative—they gave to that information.

the likelihood of information exposure and moderate how information affects risk–benefit perceptions. People who have a pro-technology cultural orientation are thus more likely to become exposed to information about nanotechnology and to draw positive inferences from what they discover. Individuals who lack that predisposition, in contrast, are less likely to become exposed to information, and when they do become exposed to it they are significantly more likely to react negatively.

Our study reinforces the conclusions of other researchers who have cautioned against assuming that enlightened public opinion will spontaneously emerge from accumulating scientific information on the risks and benefits of nanotechnology[5,18]. Indeed, because individuals in the real world are likely to select information in a biased fashion that matches their cultural and political dispositions[19], one might anticipate even more extreme polarization outside the psychology laboratory than we observed in it when we exposed our subjects to a small bit of balanced information.

At the same time, nothing in our study suggests that cultural polarization over nanotechnology is inevitable. Social psychology is making important advances in identifying techniques for framing information on controversial policy issues in a manner that makes it possible for people of diverse values to derive the same factual information from it[20]. With further study, it is likely that these techniques can be used to guide risk communication and thus enhance democratic deliberations on risk-regulation policy—on nanotechnology[6] and other issues[21].

The practical lesson of our study, then, is that those who favour informed public deliberations on nanotechnology should be neither sanguine nor bleak. Instead they should be psychologically realistic. 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.

## Methods

The sample consisted of 1,862 adults recruited by Knowledge Networks to be members of a probability-based online panel representative of the United States population. There has been considerable study of how probability-based online sampling, which is becoming increasingly common in scholarly public opinion research, performs relative to random-digit-dial telephone and other survey methods[22–24]. More information on the sampling methods of Knowledge Networks can be found at http://www.knowledgenetworks.com/ganp/index.html. Subjects participated in the study using Knowledge Networks' online facilities in December 2006.

In addition to standard demographic data, the study collected data on subjects' cultural values. Measures, adapted from previous studies of cultural cognition and the cultural theory of risk[13,17,25], assessed subjects' values with two scales, 'Individualism–Communitarianism' ($\alpha = 0.83$) and 'Hierarchy–Egalitarianism' ($\alpha = 0.81$). Each scale was designed to measure a separate dimension of the 'group-grid' worldview typology proposed by Mary Douglas[26]. In the regression-based simulation (Fig. 1), the culture variables for 'hierarchical, individualists' were set at values one standard deviation from the mean towards the hierarchy and individualist ends of the those scales; the culture variables for 'egalitarian communitarian' subjects were set at values one standard deviation from the mean towards the egalitarian and communitarian ends of those scales.

Subjects' perceptions of nanotechnology were also solicited. All subjects responded to a self-reported knowledge item (NANOKNOW) used in previous studies[1–4] that stated, 'How much have you heard about nanotechnology before today?' and permitted the responses, 'nothing at all', 'just a little', 'some' or 'a lot'. For certain analysis (see Supplementary Information, Table S2 and Figs 1, 2), subjects who answered 'some' or 'a lot' were deemed 'familiar' with nanotechnology, and those who answered 'nothing at all' or 'just a little' were deemed 'unfamiliar'. All subjects also responded to a four-point item (NANOBENEFIT), which required them to indicate whether they believed (1) 'the risks of nanotechnology will greatly outweigh its benefits', (2) 'the risks of nanotechnology will slightly outweigh its benefits', (3) 'the benefits of nanotechnology will slightly outweigh its risks', or (4) 'the benefits of nanotechnology will greatly outweigh its risks'. A reverse-coded item (NANORISK) was used to compute the mean scores for subjects in both conditions. In the multivariate logistic regression analysis (see Supplementary Information, Table S1), responses to this item were collapsed into a dichotomous 'Benefit > Risk' (0) and 'Risk > Benefit' (1) measure.

Before responding to NANOBENEFIT, all subjects read this introductory statement:

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

Subjects assigned to the information-exposed condition were also asked to read the following two paragraphs (the order of which was rotated) before responding to NANOBENEFIT:

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.

All subjects, before responding to the items relating to nanotechnology, also indicated their perceptions of a variety of other risks on a four-point scale that permitted them to characterize a set of activities or states of affairs as presenting 'almost no risk', 'slight risk', 'moderate risk' or 'high risk'. This item, too, was patterned after one used in previous risk-perception studies[27,28]. Because few subjects ever report seeing 'no risk', 'almost no risk' has been shown more accurately to separate out the subjects who are the most risk-sceptical from those who are the next most risk-sceptical.

The complete study instrument is available on request from D.M.K.

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## Author contributions

All authors participated in the design of the study, in analysis of the results, and in drafting and revision of the paper.

## Additional information

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