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33 BROWNS LANE • BELLPORT, NY 11713 • (631) 286-8925

NANOTECHNOLOGY AND THE PUBLIC

Part I Appendix of Front-End Analysis in Support of Nanoscale Informal Science Education Network

Final Part I Appendix for
Nanoscale Informal Science Education Network

by
Barbara N. Flagg, Ed.D.
Director, Multimedia Research
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APPENDIX
NANOTECHNOLOGY AND THE PUBLIC
PART I OF FRONT-END ANALYSIS IN SUPPORT OF NISE NETWORK
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This appendix presents a paragraph summary of each Part I reference and a longer elaboration of the reference content as it pertains to the NISE Network's goals and audiences. Information outside of the Network's goals and audiences is not summarized. References are presently alphabetically. Percentages have been rounded off for easier reading. Any misinterpretations are solely the responsibility of the review author, Dr. Barbara Flagg, Director, Multimedia Research.

Bainbridge, W. S. (2002). Public attitudes toward nanotechnology. *Journal of Nanoparticle Research*. 4, 561-570.

Summary

Of almost 4000 volunteer adults responding to a National Geographic online survey, almost six out of ten agree that humans will benefit from nanotechnology, and less than one out of ten agree that 21st century technologies, including nanotechnology, are threatening to humans. Respondents associate nanotechnology with the space program, nuclear power and cloning research but not with pseudoscience.

Elaboration

This is an early exploratory study about public attitudes toward nanotechnology. A large survey about "Conservation, Community and Culture" was located on National Geographic's website.[1] Three questions on the survey related to nanotechnology and are the focus of this article. Respondents were recruited worldwide in the fall of 2001 through publicity by National Geographic and participating universities.[2]

Risks and benefits

A non-random snowball sample of 3909 adults rated their agreement with two statements:

- 58% agreed that "Human beings will benefit greatly from nanotechnology, which works at the molecular level atom by atom to build new structures, materials, and machines." More men (69.2%) than women (47.6%) agreed with the statement, but statistical difference was not assessed.
- 9% agreed that "Our most powerful 21st century technologies – robotics, genetic engineering, and nanotechnology – are threatening to make humans an endangered species."

[1] This background information was obtained from National Geographic's website, not Bainbridge's article.
[2] The article assumes that since NGS publicized and hosted the survey that the sample was drawn from a "science attentive" population; however, no background questions establish this description of the sample.

- Responses in favor of nanotechnology correlate significantly with agreement about statements supporting the space program, nuclear power and cloning research. Responses to nanotechnology statements have zero correlation with responses to two statements about pseudoscience. Bainbridge concludes "that nanotechnology has no measurable connection with pseudoscience in people's minds, even as they connect it strongly with other kinds of genuine technology." (p. 564).

An open-ended question asked one-quarter of respondents to comment on the nanotechnology statements. Qualitative analysis of 598 respondents generated 9 provisional categories and 108 questionnaire items for use in future surveys. Although examples are given in the article for the following response categories, frequency distributions are not:

confidence that nanotechnology will benefit mankind;
hope, with caveats, that nanotechnology will benefit mankind;
nanotechnology will contribute to the progress of science itself;
nanotechnology can lead to engineering breakthroughs that benefit industry and economy;
materials will benefit from nanotechnology;
nanotechnology can be applied in computers, electronics and communications;
nanotechnology will benefit medicine;
doubt and uncertainty about nanotechnology;
social concerns about exploitation.

BMRB Social Research (January, 2004). *Nanotechnology: Views of the general public.* (International report 45101666). Retrieved August 15, 2005, from http://www.nanotec.org.uk/Market%20Research.pdf

Summary

This report presents interview findings about the British public's awareness and knowledge of nanotechnology as well as perceived effect on quality of life. The public has a low awareness and knowledge of nanotechnology, influenced by age, gender and socioeconomic status. Definitions of nanotechnology by those who had heard of the term centered on small scale and/or potential applications. Of those who tried to give a nanotechnology definition, seven of ten feel it will improve our way of life in the future. The report also presents workshop[3] findings about public attitudes toward new technologies, including nanotechnology. Workshop participants feel that all technologies have positive and negative impacts, but their opinion about a technology was ultimately dependent on the extent of its positive impact on their lives. After hearing about potential nanotechnology applications, participants were interested in new materials and applications that might improve their quality of life but raised concerns about ethical, financial, social, political, environmental, privacy and safety impacts of nanotechnology.

Elaboration

Findings were collected via two methods:

1. Face-to-face brief interviews of a representative sample of 1005 adults, age 15 and older, were administered in homes throughout Great Britain, chosen through a random location sampling technique. The interviews focused on public awareness, knowledge and perceived effects on future quality of life.
2. Two three-hour workshops, including both plenary and break-out sessions, involved 40 participants, stratified by location, socioeconomic status, age, ethnicity and gender. Scientists participated in workshops to provide nanotechnology background and application information, permitting participants to react to fact rather than speculation. Workshops explored attitudes about new technologies generally; ideas about and attitudes toward nanotechnology; areas for concern and curiosities about nanotechnology; and the issue of control and regulation of nanotechnology.

The interviews revealed the following about the public's awareness and knowledge of nanotechnology and perceived quality of life:[4]

- Three out of ten respondents had "heard of nanotechnology" but only two of ten respondents could provide some sort of definition of "what nanotechnology is."
- Awareness and definitional knowledge were higher among men (40% and 30%) than women (19% and 10%).
- Awareness was somewhat higher among the younger respondents, with a third of those younger than 55 aware of nanotechnology compared with one-fifth of those older than 65 being aware. Those respondents aged 35-54 were most likely to give some definition.

[3] U.K. "workshop" refers to groups that hear from scientists in plenary meetings and then break out into smaller discussion groups.

[4] No statistics were given to obtain the reported comparative results.

- Awareness increased as socioeconomic status increased.
- The most common definition of nanotechnology focused on miniaturization or technology on a small scale (46% of those aware; 14% of total sample).
- The second most common definition of nanotechnology noted potential applications in computing, electronics or medicine (30% of those aware; 9% of total sample).
- Of those who tried to define nanotechnology, 68% feel "nanotechnology will improve our way of life in the next 20 years;" only 4% said it would make things worse.

Before discussing nanotechnology, the workshops explored public attitudes towards new technologies:

- The public primarily associated "new technologies" with consumer applications and secondarily with medical and forensic applications. Nanotechnology was not mentioned spontaneously.
- Respondents were concerned about the fast pace and information overload of technological change and advancements.
- The most important factor in respondents' feelings about a technology was whether or not it was likely to have a positive impact on their own quality of life. A perceived benefit to their own lives increased the tendency to discount possible negative effects of a new technology on their sense of morality, the environment, family unit and society, developing nations and health.

After discussing new technologies generally, a scientist presented a short verbal explanation of the concept of nanotechnology and answered participants' questions. Participants had difficulty forming an opinion about the concept without any information about applications. The scientist then presented some ways in which nanotechnology could be used in health, drugs, information technology, new materials, sensors and cosmetics. Discussion of the nanotechnology application scenarios revealed public interests in and concerns about nanotechnology:

- Respondents were positive toward creation of new materials and possible applications (particularly medical ones, in the hope that such contributions would improve quality of life.
- Although positive about applications, respondents were concerned about privacy and safety (side-effects, long-term use effects, reliability).
- Respondents raised ethical implications of controlling nature at the atomic level and whether such outcomes are morally desirable.
- Respondents asked about financial advantages and disadvantages to the government and to the individual.
- Respondents considered social and political impacts on employment, control over society by government and corporations, and positioning of developing nations vis-à-vis industrialized nations.
- Environmental impacts about disposability and use of fewer resources were discussed.
- Respondents raised the issues of controlling and regulating nanotechnology on national or international levels and how the public might be involved in such.

Canadian Biotechnology Secretariat. (March, 2005). ***International public opinion research on emerging technologies: Canada-US Survey Results.*** **Retrieved September 9, 2005, from http://www.bioportal.gc.ca/english/View.asp?pmiid=524&x=720**

Summary

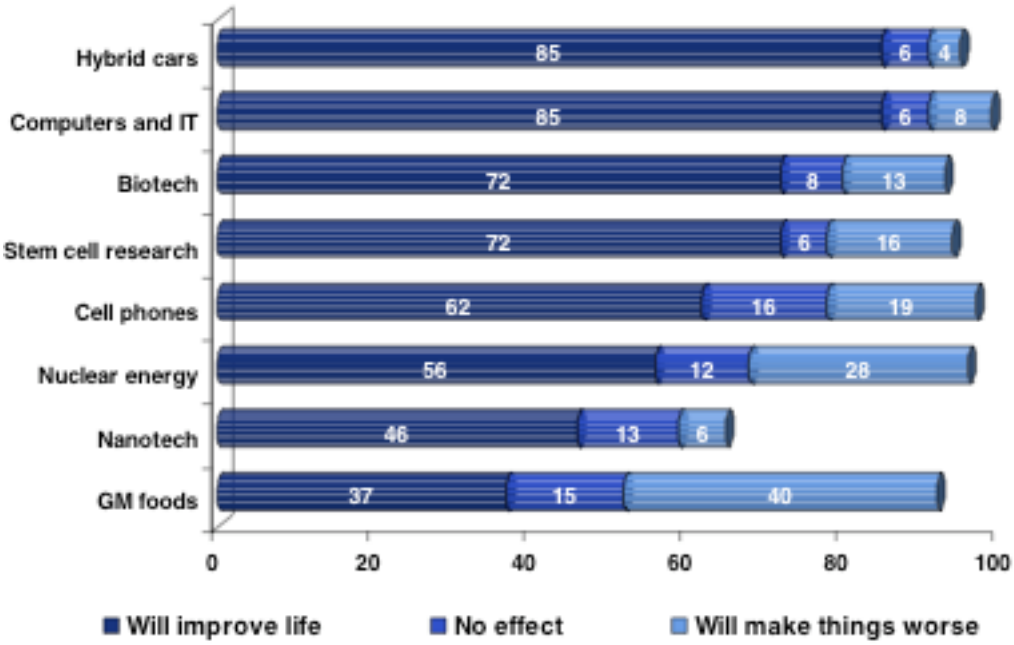
A 2005 Canadian-US telephone survey looked at emerging technologies including nanotechnology. After hearing a definition of nanotechnology, four out of ten Americans said they were familiar with nanotechnology and had read, seen or heard about it recently. Three of ten previously discussed nanotechnology. Half of American respondents are positive about the benefits of nanotechnology to their lives and to society, and 84% see benefits to the economy. About half of Americans assess nanotechnology as morally acceptable; trust that authorities will follow ethical guidelines; and believe that research has been carried out in consideration of their interests, values and beliefs. About three-quarters say that government should be involved in funding nanotechnology research and are confident of the scientists involved in the research and of the governing safety and regulatory approval systems. In terms of decision-making, a large majority feel that decisions about nanotechnology should be based mainly on expert advice and on scientific evidence of risk and benefit; however, people should be informed and decide for themselves whether they want to use nanotechnology products.
[For associated focus group data, see Decima Research Inc., March, 2005; For reanalysis of this survey data looking at attitudinal subgroups, see Priest, 2005]

Elaboration

Findings are from a Jan-Feb 2005 telephone survey, conducted with a random sample of 2000 Canadians and 1200 Americans. The study deals with a variety of emerging technologies: biotechnology, pharmacogenetics, stem cell research, GM trees, gene banks, genetic research and nanotechnology.

Future. Respondents were asked:
"I am going to read out a list of areas in which new technologies are currently developing. For each of these areas, do you think it will improve our way of life in the next 20 years, it will have no effect, or it will make things worse?"

The chart below, copied from p. 13 of the report, shows that Americans are less familiar with nanotechnology compared to the other 7 technologies: one-third of Americans did not have a view of nanotechnology's potential impact [observe missing part of nanotech bar for "don't know" answers]. Almost half (46%) of Americans said nanotech will improve life compared to 13% who said it would make things worse. This attitude is less positive than for technologies of which respondents were more aware.



Results only for nanotechnology for American respondents are presented below:

Awareness

- After hearing an explanation of nanotechnology,
  - 6% said they were "very familiar with nanotechnology"
  - 36% were "somewhat familiar"
  - 23% were "not very familiar"
  - 36% were "not at all familiar"

- Estimating their awareness of issues involving nanotechnology over the previous three months,
  - 7% had read, seen, or heard a lot
  - 34% had read, seen or heard a little
  - 23% had read, seen or heard nothing

- 27% had discussed nanotechnology research prior to the interview. Of those who had discussed nanotechnology,
  - 14% discussed frequently
  - 36% discussed occasionally
  - 50% discussed once or twice

Benefits and risks

- Assessing the benefit of nanotechnology research to society,
  - 32% said substantial benefit
  - 18% said some benefit
  - 37% said moderate benefit
  - 5% said not much benefit
  - 4% said no benefit

- Assessing the risk of nanotechnology research to society,
    - 6% said substantial risk
    - 8% said some risk
    - 49% said moderate risk
    - 16% said not much risk
    - 15% said no risk

- Assessing economic benefits to the U.S.,
    - 42% said major benefits
    - 42% said modest benefits
    - 10% said no significant benefits
    - 6% didn't know or didn't respond

Values

- Assessing the moral acceptability of nanotechnology,
    - 36% said morally acceptable
    - 18% said somewhat acceptable
    - 33% said morally questionable
    - 4% said somewhat unacceptable
    - 4% said morally unacceptable

- Assessing their values in relation to nanotechnology research,
    - 49% felt that "Nanotechnology research has been carried out in consideration of my interests, values and beliefs."
    - 38% felt that "Nanotechnology research has not been developed in consideration of my interests, values and beliefs."
    - 13% replied "don't know" or did not respond

- In terms of their trust in authorities to be ethical,
    - 55% "trust that those in authority to ensure that nanotechnology research that takes place in the US will follow strict ethical guidelines."
    - 41% do not trust those in authority
    - 5% replied "don't know" or did not respond

Government regulation and funding

- Determining government involvement in funding nanotechnology research,
    - 32% suggested active involvement in funding
    - 46% suggested moderate involvement
    - 20% suggested no involvement
    - 3% didn't know or didn't respond

- Assessing confidence in safety and regulatory approval systems governing nanotech,
    - 20% were confident
    - 50% were moderately confident
    - 23% were not confident
    - 7% didn't know or didn't respond

- Assessing their confidence that nanotechnology is in safe hands in terms of the scientists involved in the research,
    - 29% were confident
    - 50% were moderately confident
    - 16% were not confident
    - 6% didn't know or didn't respond

- As far as their overall view of nanotechnology,
    - 43% approved "of nanotechnology, as long as the usual levels of government regulation and control are in place"
    - 35% approved "of nanotechnology if it is more tightly controlled and regulated"
    - 13% did "not approve of nanotechnology except under very special circumstances
    - 5% did "not approve of nanotechnology under any circumstances

Decision-making

- In terms of who should make decisions about nanotechnology,
    - 74% felt that "decisions about nanotechnology should be based mainly on the views and advice of experts"
    - 21% felt that "decisions about nanotechnology should be based mainly on the views of the average American"
    - 5% replied "don't know" or did not respond

- In terms of the basis for making decisions about nanotechnology,
    - 65% felt that "decisions about nanotechnology should be based mainly on scientific evidence of risk and benefit"
    - 30% felt that "decisions about nanotechnology should be based mainly on the moral and ethical issues involved"
    - 5% replied "don't know" or did not respond

- In terms of letting people decide on their use of nanotechnology products,
    - 65% strongly agreed that "authorities should inform people about nanotechnology and let them decide for themselves whether they want to use products developed using these techniques"
    - 27% agree
    - 4% disagree
    - 2% strongly disagree

Future

- Assessing nanotechnology as the next frontier,
    - 32% strongly agreed that "Nanotechnology research represents the next frontier of human endeavor, a frontier that will lead to significant quality of life benefits for all Americans"
    - 49% agreed
    - 11% disagree
    - 5% strongly disagree

- Relative to the inevitability of nanotechnology,
    - 54% strongly agree that "although there may be some unknown risks, technologies like nanotechnology are an inevitable part of the future, so all we can do is make sure that its uses are as safe as possible"
    - 34% agree
    - 5% disagree
    - 5% strongly disagree

Cobb, M. D. (forthcoming). Framing effects on public opinion about nanotechnology. *Science Communication*.

Summary

A 2004 US national telephone survey looked at adult perceptions about nanotechnology. This article reports on how respondents' attitudes could be influenced when presented with differing frames of information about risks and benefits. Exposure to positive and negative information frames resulted in, at most, a minimal 10% change to attitudes. Hearing about health risks tended to increase the feeling that nanotechnology is risky and decrease hopefulness about nanotechnology. Information about non-health risks tended to increase the feeling that nanotechnology is risky and decrease trust in business leaders. Information about health benefits tended to increase responses that nanotechnology is beneficial and decrease feelings of anger about nanotechnology.

Elaboration[5]

Findings are from a Mar-Apr 2004 national telephone survey conducted with a random sample of 1536 American adults.[6] The survey included an experiment looking at the effect on attitudes of how an issue is framed for listeners. Respondents were randomly assigned to a control group (n = 330), who heard a brief neutral description of nanotechnology, and nine other treatment conditions (n = 134 each), who heard additional descriptive paragraphs of information framed in different ways.[7] Six information "frames" gave only one side of the story of risks or benefits; three were pro-nanotechnology and three were anti-nanotechnology. The remaining three information "frames" presented a two-sided balance of positive and negative.[8]

Five dependent variables were measured: (1) prediction of whether risks of nanotechnology will be greater than, equal to or less than benefits; (2) rating of trust in business leaders to minimize potential risks to humans; (3) feeling of hope about nanotechnology; (4) feeling of worry; and (5) feeling of anger.

Benefits and risks. The control group was relatively positive about nanotechnology: 40% thought benefits outweigh risks, 40% said they are equal, and 20% said risks outweigh benefits. Respondents who heard about potential health risks or multiple risks felt that nanotechnology would be more risky than the control group did, but the one-sided frames did not make this group

[5] The authors use $p \leq .15$ as acceptable significance. This summary presents only statistically results significant at $p \leq .05$, as is typically practiced in survey and evaluation research.

[6] See Cobb & Macoubrie for basic survey response data.

[7] All groups heard the control group description: "Nanotechnology is the process of manipulating materials at the minuscule level of atoms and molecules. Another way to say this is that nanotechnology refers to the manipulation of living and non-living matter at the level of the nanometer, one billionth of a meter."

[8] An example of a one-sided positive frame: Control group description plus "Some scientists say that we are not optimistic enough about nanotechnology. They say it is not possible to project the fantastic worlds which nanotechnology will continue to open up to us in the coming years. Science inevitably leads to human progress and the Earth is inexhaustible because new technologies create new resources. They say nanotechnology will improve human health, physical and mental abilities. Researchers expect to create new medical tools to detect diseases earlier and treat them more effectively; such as implanting tiny drug delivery systems that automatically administer drugs that go where they are needed most."

feel overall that nanotech would be more risky than beneficial. Respondents who heard only about potential health benefits (see footnote 14) felt that nanotechnology would be more beneficial than the control group did, but only 54% of this experimental group agreed that benefits outweigh risks after hearing the one-sided frame. The remaining one-sided and two-sided framing conditions did not influence respondents significantly in terms of attitudes toward risks and benefits.

Nanotechnology players. For the variable of trust in business leaders, two of the ten frames influenced respondents to express less trust. Most (54%) of the control group trusted industry "not that much" compared with 69% of those who heard the "conservative humanism" one-sided negative frame and 74% of those who heard the one-sided "multiple risks" frame.

Emotions. Framing effects on emotions were not large. Framing did not significantly influence expressions of worry. Most (83%) of the control group was hopeful about nanotech, whereas 10% fewer respondents were hopeful after hearing the one-sided frame on health risks. Compared to the control group (18%), significant fewer responses of anger were elicited after hearing the one-sided frames on health benefits (9%), multiple benefits (9%). and the two-sided frame on health risks and benefits (10%).

Cobb suggests four possibilities for the unexpected minimal impact of the framing conditions: (1) the difficulty that people have forming opinions on new and unfamiliar issues; (2) the difficulty of attending to information given verbally on the phone; (3) the lack of noting sources; or (4) the presentation of risks as non-catastrophic and controllable.

Cobb, M. D., & Macoubrie, J. (2004). Public perceptions about nanotechnology: Risks, benefits and trust. *Journal of Nanoparticle Research, 6*, 395-405.

Summary

A 2004 US national telephone survey looked at perceptions about nanotechnology. Although Americans are not really familiar with nanotechnology, they are positive about its potential benefits. Five out of ten Americans had heard of nanotechnology but eight of ten had heard little or nothing about the topic. On average, respondents answered correctly only one of three true-false nanotechnology knowledge questions. Large majorities of the sample were hopeful, not worried, and not angry about nanotechnology. Four of ten respondents agree that potential benefits of nanotechnology will outweigh the risks; those most likely to agree are white, more educated, more familiar with nanotechnology, more hopeful, less worried, and more positive about science overcoming problems. Almost six of ten Americans thought the most important benefit to achieve was new ways to detect and treat human diseases, whereas three of ten feared loss of personal privacy due to nanotechnology. Six of ten respondents did not trust nanotechnology business leaders to minimize potential human risks.

Elaboration[9]

Findings are from a Mar-Apr 2004 national telephone survey conducted with a random sample of 1536 American adults. The study focused on public knowledge about and attitudes towards nanotechnology and how knowledge affects attitudes.

The study included an experiment that is not reported in this article. The experiment involved 330 respondents who heard a brief objective description of nanotechnology and nine other conditions of 134 respondents each who heard additional information paragraphs, which framed nanotechnology's risks or benefits in different ways. The data below do not distinguish between the control group and those who heard extra framed information. Where appropriate, control group data are reported in footnotes, as pulled from Cobb (forthcoming), which reports on the experimental aspects of the survey study.

Awareness

- About five out of ten respondents indicated they had heard of nanotechnology but eight of ten had heard "little" or "nothing" about the topic:
    - 16% said they had heard "a lot" or "some"
    - 32% said they had heard "a little"
    - 52% said they had heard "nothing"

Knowledge

- Three true/false statements were asked at the end of the telephone interview to establish a knowledge indicator: (1) Nanotechnology involves materials that are barely visible to the naked eyes [F]; (2) Industry is already using nanotechnology to make products sold today

[9] The authors use $p \leq .1$ as acceptable significance. This summary presents only results statistically significant at $p \leq .05$, as is typically practiced in survey and evaluation research.

[T]; (3) Nanotechnology is predicted to be the next industrial revolution of the U.S. economy [T].
    - 3% answered all three correctly
    - 34% answered two correctly
    - 33% answered one correctly
    - 30% answered none correctly[10]

- The mean score was 1.1 on a four-point scale (0,1,2,3).

Emotions

- Assessing emotions about nanotechnology,
    - 70% said they were "very" or "somewhat" hopeful about nanotechnology
    - 80% said they were "not" worried about nanotechnology
    - 95% said they were "not" angry about nanotechnology[11]

Benefits and risks

- Assessing the potential benefits and risks of nanotechnology,
    - 40% said benefits of nanotechnology will outweigh the risks
    - 38% said risks and benefits will be about equal
    - 22% said risks will outweigh the benefits[12]

- Multivariate regression analysis reveals that white respondents ($p = .05$) and more educated respondents ($p = .02$) are more likely to say benefits outweigh risks. Other significant variables at $p \leq .01$ include familiarity with nanotechnology, feeling worried or hopeful, and a view of science overcoming obstacles. [adjusted $R^2 = .34$]

[10] Respondents heard various "framed" descriptions about nanotechnology's risks and benefits prior to being asked this question at the end of the phone survey. These data reflect the whole sample without differentiating the unique conditions. Cobb (forthcoming) does not report control group data for knowledge.
[11] Respondents heard various "framed" descriptions about nanotechnology's risks and benefits prior to being asked this question. These data reflect the whole sample without differentiating the unique conditions. Cobb (forthcoming) reports that of the control group, who did not hear a "framed" description, 83% were hopeful; 74% were not worried; and 82% were not angry.
[12] Respondents heard various "framed" descriptions about nanotechnology's risks and benefits prior to being asked this question. These data reflect the whole sample without differentiating the unique conditions. Cobb (forthcoming) reports that of the control group, who did not hear a "framed" description, 40% said benefits outweigh risks; 40% said they are about equal; 20% said risks outweigh benefits.

Attitudes toward applications[13]

- Choosing only one of five potential benefits of nanotechnology as the most important to achieve,
  - 57% said new ways to detect and treat human diseases
  - 16% said new ways to clean the environment
  - 12% said increased national security and defense
  - 12% said physical and mental improvements for humans
  - 4% said cheaper, better consumer products

- Choosing only one of five potential risks of nanotechnology as the most important to avoid,
  - 32% said losing personal privacy
  - 24% said arms race
  - 19% said breathing nano-particles that accumulate in body
  - 14% said economic disruption
  - 12% said uncontrollable spread of nano-robots

Nanotechnology players

- When asked how much they trust business leaders within nanotechnology industry to minimize potential risks to humans,
  - 5% said "a lot"
  - 35% said "somewhat"
  - 60% said "not much"[14]

- A logistic regression analysis reveals that the variance in trust responses is not well explained by demographic or background variables [Nagelkerke R^2 = .09]

Exposure to *Prey*

- 8% (n = 123) had read or talked about the novel *Prey*. Exposure was not significantly predictive of perceptions of risks vs. benefits.

[13] The respondents heard various "framed" descriptions about nanotechnology's risks and benefits prior to being asked these questions. These data reflect the whole sample without differentiating the unique conditions. Control group data are not reported in Cobb (forthcoming). Michael Cobb reports in a 9/29/05 email to Flagg that "the main framing effect was in the risk question, and it involved making more people afraid of an arms race. This finding is consistent with multiple small group experiments I am involved with where people consistently identify an arms race as the worst risk AFTER learning more about nanotechnology."

[14] Respondents heard various "framed" descriptions about nanotechnology's risks and benefits prior to being asked this question. These data reflect the whole sample without differentiating the unique conditions. Cobb (forthcoming) reports that of the control group, who did not hear a "framed" description, 42% said they trusted business leaders "some" or " a lot" and 58% said "not much."

Decima Research Inc. (March, 2005). ***A Canada-US public opinion research study on emerging technologies.*** **Report for The Canadian Biotechnology Secretariat Industry Canada. Retrieved September 9, 2005, from http://www.bioportal.gc.ca/english/View.asp?pmiid=524&x=720**

Summary

A 2005 Canadian-US focus group study about emerging technologies revealed that most participants think that nanotechnology involves "tiny machines" and is the "next big thing." They appreciated the significant benefits possible for health and the environment but were concerned about environmental risks, privacy issues, equal access to technologies and stringency of regulatory systems. They expressed a high level of trust of scientists and feel that their country should be a world leader in nanotechnology.
[see Canadian Biotechnology Secretariat, 2004, March, for associated telephone survey]

Elaboration

Findings are from 24 focus groups carried out in 7 Canadian cities and 3 US cities (San Francisco, St. Louis, Boston) in March, 2005. The study deals with a variety of emerging technologies: biotechnology, pharmacogenetics, stem cell research, GM trees, gene banks, genetic research and nanotechnology. [Results only for nanotechnology are summarized below.]

Knowledge. Most participants understand that nanotechnology involves "tiny machines" but beyond that specifics are not known. Group participants frequently raised nanotechnology as a revolutionary technology in general discussion and saw it as the "next big thing." Applications most often recalled included an ingestible camera; implantable devices to regulate drugs; implantable tracking monitors; and less invasive surgery.

Benefits and risks. It was felt that nanotechnology would bring jumps in health and environmental benefits. For health, the benefits were seen to outweigh risks in presented applications. However, for the environment, participants mainly asked "where do these nanomolecules go." Participants were concerned about the stringency of regulatory systems with respect to nanotechnology; their confidence in such systems was low to moderate in general.

The main negative spontaneously brought up related to potential privacy concerns, particularly for the US participants in light of the Patriot Act. Ethical issues were rarely raised for applications, although participants brought up the issue of equal access, which is typically on people's minds for all emerging technologies.

Nanotechnology players. The majority expressed a high level of trust in scientists, although people noted a fear of scientists going "too far;" a fear of amoral science; and a fear of negative corporate influences. Despite these fears, all felt that the US should be a world leader in nanotechnology.

Edu, inc. (undated). ***Windows on research: Front-end research: Evaluating museum visitors' readiness for and interest in learning new science*****. Retrieved August 15, 2005, from Nanozone Web site: http://www.nanozone.org/museum.htm**

Summary

This report is front-end research in support of Marco Molinaro's NSF-sponsored exhibit project at the Lawrence Hall of Science, which engages and informs the public about the leading edge of nanotechnology research. (The summative evaluation should be posted in early 2006.) Brief surveys about "nano" and "size" and focus groups were implemented with elementary students, teens and adults.

Elaboration

Teen and adult information is reported here to the extent that differentiated base data were available. The report presents some data from a total of 60 teens and adults via a "nano" survey and a "size" survey in upstate NY from both museum visitors and non-museum respondents:

- One out of ten respondents (n = 60) had heard of nanotechnology and said they learned about it from work, school, parents or self-study.
- Five out of ten respondents could rank atom, DNA, and cell in ascending order by size. Atom was the most difficult concept to articulate.
- Six out of ten respondents were "very interested" or "interested" in how scientists move individual atoms, although respondents reportedly had difficulty articulating the concept of an atom.

Guiding principles are focused on the exhibit's intended audiences of grades 4-8 with their teachers and parents:

- "Many museum visitors have a limited ability to articulate the science needed to understand current nanotechnology research."
- "Children learn based on known experiences and physical senses."
- "People surveyed need help building and crossing the Macro-Micro-Nano bridge."
- "Many people do not understand the concept of nano and have misconceptions about cells, atoms, and DNA."
- "People surveyed are interested in new science especially as it relates to improving their lives.
- "People surveyed get information about new science from popular media, publications and the Internet."

Gaskell, G., Ten Eyck, T., Jackson, J., & Veltri, G. (2005). Imagining nanotechnology: Cultural support for technological innovation in Europe and the United States. *Public Understanding of Science*, *14*(1), 81-90.

Summary
This paper compares European and US perceptions of whether nanotechnology will improve our way of life. Half of the US sample say "yes" compared to almost a third of the European sample. A third of the US sample say "don't know" compared to over half of the European sample. Americans are also significantly more optimistic than Europeans about the impact of eight other more familiar technologies. The authors conclude that "values lie behind people's views on technological innovations" (p. 86) and that the US respondents "assimilate nanotechnology within a set of pro-technology cultural values" (p. 81).

Elaboration

The Eurobarometer is a multistage random probability interview survey administered to some 15,000 European Union adults in the fall of 2002. The US data from 850 adults were collected via a random probability telephone survey a few months later.

Future. Respondents were asked:
"I am going to read out a list of areas in which new technologies are currently developing. For each of these areas, do you think it will improve our way of life in the next 20 years, it will have no effect, or it will make things worse?" Technologies included: nanotechnology, computers and information technology, solar energy, space exploration, genetic engineering, telecommunications, the Internet, mobile phones and nuclear power.

For nanotechnology, percentages saying "no effect" or "make things worse" were similar for both US and European samples. However, 50% of US respondents were optimistic with 35% saying "don't know" compared with 29% of European respondents being optimistic and 53% saying "don't know." The Americans were less likely to take the "wait and see" approach. An index of technological optimism was developed excluding 'nanotechnology' and focusing on the more familiar eight other technologies listed above. The mean for technological optimism is statistically higher for the US sample than the European sample.

Analyses conclude the probability of being optimistic about nanotech is significantly greater:
- in the US than in Europe;
- for males, younger people and those with more education;
- for those with a greater interest in science;
- for those with a more positive view of progress;
- for those with a more positive view of the robustness of nature; and
- for those with more confidence in key actors and decisions takers in biotechnology.

Suggesting that media coverage about nanotechnology might influence the public, a preliminary analysis finds that *The New York Times* referenced more benefits than risks in the last five years, whereas *The Independent* referenced more risks than benefits. However, coverage in both newspapers was low for nanotechnology.

Gilmartin, J. (2002). ***Nanotechnology: Front-end evaluation report.*** **Museum of Science and Industry: Chicago, IL. Made available by Barry Aprison, Museum of Science and Industry, August 18, 2005.**

Summary

Adult and teen visiting groups to the Museum of Science and Industry in Chicago revealed little familiarity and knowledge of nanotechnology but were most familiar with applications of high-speed computer chips, nanobots and biosensors. Comparing nano size to human hair helped visitors understand the small scale, but visitors had difficulty comprehending the physical structure of a nano object. Although most groups focused on potential benefits of described applications, some expressed concern about medical side effects, privacy issues and regulatory control. Visitors were most interested in the relevant benefits of everyday applications, recent developments, and the small scale of the science.

Elaboration

Open-ended interviews of 41 visitor groups were conducted at the Museum of Science and Industry in Chicago in the summer of 2002. Awareness and knowledge of nanotechnology was low:

- 44% of visitor groups had heard of the term "nanotechnology."
- 10% of visitor groups could correctly explain the term, typically referring to applications.
- Some related nanotechnology to time, as in nanoseconds.
- Visitors were most familiar with applications of high-speed computer chips, nanobots and biosensors, although some were uncertain whether the application they noted was actually a nanotech application.

The researcher notes that words like "molecules, atoms and matter, while familiar, provoked discomfort" among interviewees, particularly those without science background. The phrase "the building blocks of all physical things" was less discomforting.

Most groups saw only positive benefits to nanotechnology but some expressed general fears associated with any emerging technology. Issues raised concerned medical side effects, privacy and regulatory control.

Visitors were given the following definition of nanotechnology:

> "Nanotechnology is an emerging field of technology that is developing out of the science of the very small (one billionth of a meter) – the world of atoms and molecules, the building blocks of all physical things. Note: A nanometer is one billionth of a meter; a molecule is about 1 nanometer in size. Tools that can be used to see, pick up, and move atoms allow us to build nano-sized structures and devices with unprecedented capacities for information processing and storage, electrical conductance, and bio- and chemical- sensing."

Once introduced to the definition of nanotechnology, visitors were most interested in:

- The small scale of the science
- Personal benefits of technology applications

- Cutting-edge and contemporary nature of the topic.

More knowledgeable visitors were interested in applications, current developments and learning about how devices are made. Less knowledgeable visitors were interested in medical applications. Most everyone was intrigued by the small scale of nanoscale science. Comparing nano size to human hair was successful in helping visitors understand the small scale, but visitors had difficulty grasping the physical structure of a nano object.

From listening to visitors' reactions to exhibit ideas, the study concludes that visitors want to

- Learn about new technologies – applications; personal relevance; breaking news; risks;
- Try out some things that scientists are doing – manipulate atoms and materials
- See what's behind technologies – see devices and how they work
- See specific examples – e.g., see biosensor used

Strategies for exhibits in nanotechnology include:

- "Starting small" – creatively communicate the nano size
- "Emphasize the new" – present cutting-edge information
- "Capitalize on visitor excitement on breakthrough technology to demonstrate their role and involvement" – present information about publics role in science
- "Address fears and concerns" like self-replicating robots and bioimplants going awry
- "Present easily digestible information"

GolinHarris. (September 14, 2004). ***Press release: U.S. leadership in nanoscience should be a government priority, say survey respondents.*** **Retrieved May 15, 2005, from Semiconductor Industry Association Web site: http://www.sia-online.org/pre_release.cfm?ID=333**

Summary

This press release announces findings from an online survey of 400 adults by GolinHarris for the Semiconductor Industry Association. Respondents were highly supportive of governmental involvement in nanoscience.

Elaboration

Funding and regulation. GolinHarris, a public relations firm, conducted an online survey of 400 adults in 2004, finding:

- Nine of ten American adults "believe that continued U.S. global leadership in technology is important to the nation's economy."
- Eight of ten "cannot name a single company that is a leader in nanotechnology development."
- Almost eight of ten believe that "funding for research into the new fields of nanoscience and nanotechnology should be a priority of both federal and state governments."
- Six of ten "said the government should increase current funding levels for nanotechnology research."

Results were weighted to be representative of the general population with a margin of error of ± 4-5%.

Holladay, C. (2005). ***A year in review: Internship in nanotechnology museum exhibit design.*** **Master's Description Paper, University of Wisconsin, Madison, WI. Retrieved November 1, 2005, from www.mrsec.wisc.edu/Edetc/IPSE_exhibits/about/share.html**

Summary

A survey of a non-random sample of people aged 7 to 91 reveals that most do not think on the level of nanoscale when asked for the smallest thing they can think of; that most have never heard of "nanotechnology," and that most cannot correctly order in size the terms: cell, bacterium, water molecule, atom or the terms: housefly, eyelash, grain of salt, dust particle.

Elaboration

In support of prototype nanotechnology museum exhibits at Discovery World Museum in Milwaukee, WI, 495 individuals, aged 7-91, were surveyed about their awareness and understanding of nanoscale. Surveys were collected in 2004-2005 at a Madison, WI, WalMart; at Discovery World Museum in Milwaukee, WI, and in 2nd – 12th grade classrooms in Watertown, WI.

Awareness

- 41% of respondents say they have heard of "nanotechnology."
- 17% of the whole sample could define "nanotechnology," "mentioning a type of technology and small size. When asked where they had heard of nanotechnology, common sources included television, magazines and newspapers." (p. 14).

Knowledge

- Asked for the smallest thing they could think of, most (54%) 2nd-5th graders suggested small visible objects like bugs, raindrop. Microscopic objects like atoms, cells, bacteria and molecules were suggested by most (81%) 6th-8th graders, most (58%) 9th-12th graders and 43% of college-educated adults.
- When asked "what is the smallest thing you can think of," "nanoscopic" objects (e.g., proton, atom, molecule) were offered by
  - 5% of 2nd – 5th graders
  - 1% of 6th – 8th graders
  - 21% of 9th – 12th graders
  - 43% for college and over
- 7% of the sample correctly ordered in size: cell, bacterium, water molecule, atom; and 45% correctly answered that atom was the smallest item in the list of four.
- 45% correctly ordered in size: housefly, eyelash, grain of salt, dust particle.
- 80% reported that they know what an atom is, and 74% of these respondents answered three true/false questions about atoms correctly.

Benefits and risks

- On a scale of 1 to 4, respondents (n = 135) rated feelings about nanotechnology. On average, the sample found nanotechnology more beneficial than harmful, more important than

unimportant, more safe than dangerous, more exciting than boring, and more comfortable than uncomfortable.

Future

- 52% of respondents were neutral about nanotechnology's potential impact on life and society; 20% were "excited" and 13%, "very excited."

Lee, C. , Scheufele, D., & Lewenstein, B. (forthcoming). Public attitudes toward emerging technologies: Examining the interactive effects of cognitions and affect on public attitudes toward nanotechnology. *Science Communication*. Made available by Dietram Scheufele, August 20, 2005.

Summary

Data from a 2004 national telephone survey is used to test a model of decision-making about emerging technologies that argues that cognitive and affective factors have separate effects but also work interactively on public attitudes. Respondents use their knowledge about science in general to make decisions about supporting nanotechnology and assessing risks and benefits of nanotechnology. In the affective realm, trust in scientists and negative emotion toward nanotechnology also have significant effects on support of nanotechnology and assessment of risks versus benefits. Hypothesized interaction effects were partially supported: Knowledge about nanotechnology has a weaker effect on attitudes toward nanotechnology for respondents who show strong negative emotional reactions to nanotechnology.

Elaboration

Findings are from a fall, 2004, representative national telephone survey of 706 American adults.[15] The study focuses on assessing a model of decision-making about emerging technologies, looking at both separate and combined effects of cognitive and affective factors on support of nanotechnology and perception of risks vs. benefits of nanotech.

The authors assert that public opinion about nanotechnology is in the early stages of the issue cycle and can be affected by a wide range of cognitive and affective variables as citizens begin to make sense of the benefits and risks of the field. The study uses two outcome measures of public opinion: (1) general support for or opposition to nanotechnology; and (2) perception of risks versus benefits of nanotechnology. These measures are based on ten-point agree/disagree ratings of declarative statements.

The study uses three affective measures: (a) trust in scientists; (b) negative emotion toward science in general; and (c) negative emotion toward nanotechnology. The trust measure is an additive index of agree/disagree ratings for three declarative statements. Negative emotions are identified because of previous research that fear or worry are key influences on public attitudes. The two negative emotion measures are based on ratings of one statement each: fear about potential effects of scientific research and worry about nanotechnology.

The study includes two cognitive measures: (a) knowledge about science in general; and (b) knowledge about nanotechnology in particular. The cognitive measures are additive indices of true/false statements.

The study includes two media use variables measured with agree/disagree statements: (a) exposure and attention to public affairs media; and (b) exposure and attention to science and technology media. Media are defined as newspaper, TV, and web.

[15] See Scheufele & Lewenstein for the basic survey results and other model testing.

The following antecedent variables are included: age; gender; formal education; income; ethnicity; and how much guidance religion plays in respondents' everyday life.

Predictors of general support for nanotechnology. Hierarchical OLS regression analysis revealed significant relationships. The antecedent variables of gender and science media use are significant predictors of variance in general support for nanotechnology. Higher levels of knowledge about science in general and higher levels of trust in scientists are also positively related to support for nanotechnology. Higher levels of negative emotion toward nanotechnology are negatively related to general support for nanotechnology. A significant interaction effect was also supported by the data: Knowledge about nanotechnology demonstrated a significantly stronger effect on general support for nanotechnology for those with lower negativity toward nanotechnology than for those displaying high levels of negative emotion toward nanotech.

Predictors of perception of risks versus benefits of nanotechnology. Significant predictors of risk/benefit perceptions included gender; education; income, science media use, knowledge about science in general, trust in scientists and negative emotions toward science and nanotechnology. Females as well as those showing higher levels of negativity toward nanotech and science in general were likely to perceive more risks than benefits. Those falling in the categories of higher levels of education, income, science media use, general science knowledge and trust of scientists were likely to perceive more benefits than risks. The regression analysis yielded a significant interaction effect: Knowledge about nanotechnology had a significantly stronger influence on rating benefits over risks for respondents who showed low levels of negative emotion toward nanotechnology than for those who showed high levels of negative emotion.

Predictors of negative emotion toward nanotechnology. Women, older people, and ethnic minorities are significantly more likely to feel negative toward nanotechnology than their counterparts. Also, negative emotions toward science in general is significantly related to negative emotion toward nanotechnology.

Relevant to the NISE Network deliverables is the authors' observation: "Our findings suggest that the influence of new information on attitudes toward nanotechnology may be minimal if people rely on strong emotional heuristics to process this information. That raises the question of how useful public meetings really are, given that they are often attended by citizens who have strong positive or negative feelings toward the issue in the first place…. This point also highlights the importance of well-planned and moderated consensus conferences of "Citizens Technology Forums" … that maximize the range of viewpoints represented and also control the emotional involvement of the participants in the issue." (p. 27-28 in pre-publication document).

Macoubrie, J. (September 8, 2005). ***Informed public perceptions of nanotechnology and trust in government.*** **Project on emerging technologies at the Woodrow Wilson International Center for Scholars. Retrieved September 8, 2005, from Woodrow Wilson International Center for Scholars Web Site: http://www.wilsoncenter.org/index.cfm?fuseaction=events.event_summary&event_id=143410**

Summary

Groups of adults in three US cities became informed about nanotechnology by reading a short document about nanoresearch basics; known and projected applications of nanotechnology; and the roles of regulatory and political agencies. Prior to reading about nanotechnology, eight out of ten participants knew little to nothing about nanotechnology, and three-quarters were unaware that nanotechnology is anticipated to be the next industrial revolution. After reading the documents, "don't know" responses decreased as respondents took more informed positions. Feelings about nanotechnology became more positive. More respondents saw benefits outweighing risks and felt a ban on nanotechnology is overreacting. Trust in regulatory agencies to manage risks increased but was still low. A majority felt that government control is necessary, including an increase in safety tests before market and supplying more product information for the public. Medical applications and consumer products were benefits of most interest. Unpredictable outcomes, regulation and health risks were of most concern.

Elaboration

Findings are from written questionnaires and group discussion in 2005. Fifteen representative individuals were recruited to meet in groups for each of 4 reading conditions in 3 U.S. sites (Spokane, Dallas, Cleveland), yielding a total sample of 177 participants. Groups completed pretest questions and then read a 4-5 page scenario focusing on facts and applications relevant to nanotechnology. All participants read basic information plus information for each of four documents on:

1) Overview of nanotechnology applications in general;
2) Medical and industrial nanoresearch, current and anticipated uses, convergence of biotechnology and nanotechnology, regulatory and political bodies' roles in management;
3) Nanotechnology in consumable products; and
4) Applications at the convergence of nanotechnology and biotechnology.

After reading one scenario, participants wrote up to four concerns they have about nanotechnology and why they have that concern. They also wrote about the benefits of nanotechnology that they most anticipated. After these individual written responses, each group discussed concerns, benefits and roles of regulatory agencies. After the discussion, participants answered a post questionnaire. For analysis, benefits and concerns were classified and aggregated by topic and summarized quantitatively.[16]

[16] All data were collapsed together for analysis. The four reading conditions were not differentiated or compared for this article.

Knowledge

- Estimating their knowledge of nanotechnology, prior to reading about it,
  - 3% said they know a lot about nanotechnology
  - 17% said they know some
  - 26% said they know a little
  - 54% said they know nothing

- Relative to nanotechnology as the next revolution,
  - 24% agreed that "nanotechnology is predicted to be the next industrial revolution"
  - 75% said they did not know
  - 1% disagreed

- Most commonly noted sources of knowledge about nanotechnology were public TV and radio; magazines; and talking with another person.

Emotions

- Assessing emotions about nanotechnology,
  - 21% were "quite" or "mostly" positive about nanotechnology prior to reading about it, and 50% were positive after reading and discussion.
  - "Don't know" responses decreased from 41% to 3% after reading and discussion.
  - Feelings moved significantly from "don't know" toward "mostly" positive on the post-questionnaire.

Benefits and risks[17]

- Assessing the potential benefits and risks of nanotechnology in the pre and post-questionnaire,
  - 16% said benefits will exceed risks in pre and 41%, post
  - 14% said risks and benefits will be about equal in pre and 30%, post
  - 5% said risks will exceed benefits in pre and 15%, post
  - 65% "don't know" in pre and 14%, post

- Addressing a ban on nanotechnology until further study of possible risks,
  - 6% agree to total ban in pre, 9% in post
  - 36% say ban is overreaction in pre, 76% in post
  - 57% "don't know" in pre, 16% in post

- After reading about nanotechnology, participants identified benefits that were of most interest to them. Benefit categories garnering more than 10% of respondents include:
  - 31% noted potential medical applications
  - 27% mentioned consumer products
  - 12% identified general progress in the field

[17] No statistical analyses are reported for pre-post change.

- After reading about nanotechnology, participants identified their concerns. Concern categories garnering more than 10% of respondents include:
  - 13% wrote about true unknowns, that is, outcomes and effects that cannot be predicted by anyone including scientists
  - 13% noted regulatory concerns, both ineffective and overly restrictive regulation
  - 13% identified human health risks as their concern
  - 12% brought up concerns about testing and research for safety
  - 10% mentioned the effect on environment

Nanotechnology players[18]

- Before and after reading about nanotechnology, participants rated their trust in six regulatory agencies and two political entities to effectively manage risks:
  - Prior to reading the informational document, 33% - 46% of respondents answered "don't know" concerning their trust of these eight groups.
  - Prior to reading, the highest trust level was in the Center for Disease Control (39%) and the lowest trust level was in Congress (25%).
  - After reading the informational document, the "don't know" response rate decreased, and respondents moved towards both higher and lower levels of trust for all eight groups. However, the highest level of trust after reading was 50% who trusted that the CDC would effectively manage nanotechnology risks.
  - The order of the eight groups in terms of trust rating remained the same both before and after reading the informational document, so the reading changed the absolute trust levels but not the relative trust levels.[19]

- Assessing whether industry self-regulation can be sufficient,
  - 55% "feel government control beyond voluntary standards is necessary"
  - 33% are "not sure how they think about this"
  - 11% "feel voluntary standards would be adequate"

- Given choices of ways government could work to increase public trust, the top three included:
  - 35% "increase safety tests before going to market"
  - 25% "supply more product information so people can choose"
  - 12% "show how regulatory practices are sufficient"

- Given choices of ways industry could work to increase public trust, the top three included:
  - 28% "increase safety tests before going to market"
  - 28% "supply more product information so people can choose"
  - 19% "voluntarily use higher safety standards"

[18] No statistical analysis is reported for pre-post change.
[19] This bullet is a conclusion of Flagg's reading of the data, not the author Macoubrie.

Pollara Inc. (March, 2004). ***Public opinion research findings on emerging technologies.*** **Report for Biotechnology Assistant Deputy Minister Coordinating Committee (BACC), Government of Canada. Retrieved September 9, 2005, from http://www.bioportal.gc.ca/english/View.asp?x=524&mp=521**

Summary

A 2004 Canadian telephone survey and focus groups found that a quarter of Canadians are familiar with nanotechnology, and three-quarters are supportive of it after hearing a definition and specific applications. Three-quarters believe that nanotechnology is important for Canadian economy and society and believe it should be supported and regulated by the government.

Elaboration

Findings are from eight focus groups carried out nationwide in Canada in 2004, along with a telephone survey of a random sample of 1000 adults. The study deals with a variety of technologies: biotechnology, genomics, proteomics, and nanotechnology. [Results only for nanotechnology are summarized below.]

Awareness. About a quarter of Canadians are very or somewhat familiar with the term nanotechnology. Nanotechnology was then defined as "involving the study, manipulation and manufacturing of ultra-small structures and machines made of as few as one molecule, with applications in industry, health, and the environment." Some 7% more report familiarity after definition. Compared with women, men are significantly more familiar with nanotechnology (64% vs. 49%).

Support. Three-quarters of Canadians are supportive of nanotechnology. Support is higher among respondents who were familiar with the term. Compared with women, men show a higher level of support (87% vs. 81%).

Benefits and risks. Support has less to do with the technology and more to do with the specific applications. The larger and more personal the assessed benefit of a specific technology application, the more acceptable the risk and higher level of support:

- 92% saw as beneficial "a tiny wireless 'lab on a chip' that can be placed into the eardrum of deaf people that will enable them to hear."
- 73% saw as beneficial "advanced drug 'labs on a chip,' that would be placed in/on the body that would automatically monitor levels of drugs in the body and automatically administer treatments as needed."
- 83% saw as beneficial "the use of molecules that have magnetic properties to extract heavy metals in water treatment facilities."
- 83% saw as beneficial "the use of light-sensitive molecules that have the ability to detect pollutants in water and air, by the amount of light they emit."
- 69% saw as beneficial "the use of 'nanocatalysts' in oil sands development, which are molecules that separate the sand from the oil, that substitute for the energy intensive separation processes that are currently used."

Canadians are most concerned about long-term risks to human health and the environment and are most positive if an application provides personal benefit.

Importance to economy and society. The more familiar the technology, the more important it is seen for Canadian economy and society. Three-quarters believe that nanotechnology is important for the economy and society.

Funding and regulation. Canadians expect government to both regulate and support technologies. Three-quarters of Canadians believe nanotechnology should be supported and regulated. They hope that experts would make decisions about support based on individual applications.

Priest, S. (2005). International audiences for news of emerging technologies: Canadian and U.S. responses to bio- and nanotechnologies. In E. Einsiedel (Ed.), *Unpublished project report to Canadian Biotechnology Secretariat*, University of Calgary. Made available by S. Priest, University of South Carolina, August 20, 2005.

Summary

Comparative Canadian-U.S. January, 2005, survey data are analyzed to conclude that opinion differences are not country-based but due to differential distributions of subgroups who have different pre-dispositions toward technology policy and information sources. Those attempting to engage public audiences need to be aware that a communication strategy that appeals to one group may not address sufficiently the concerns of another group. [see Canadian Biotechnology Secretariat, 2005, March, for base survey report]

Elaboration

Previous work by Priest and Sturgis & Allum support the proposition that differences in attitudes toward science and technology are not attributable to knowledge alone but reflect underlying differences in values and beliefs. Statistical analyses of a random telephone survey of 2000 Canadian and 1000 American respondents during January, 2005, yield five subgroups of respondents, based on decision-making preferences. For example, the subgroup of "true believers" believe experts should make decisions about technology policy based on risks and benefits and see technology as having more benefits than risks; whereas "ethical populists" believe that lay people should decide on the basis of morality or ethics. In the U.S. data, "true believers" comprise 35% of the sample, "ethical populists," 14%. In the Canadian data, the distribution is 26% and 15% for these two subgroups. The three other subgroups are labeled as "utilitarians," "moral authoritarians," and "democratic pragmatists."

Support. Analyses conclude that differences in support of both biotechnology and nanotechnology are a function of subgroup rather than nationality or other demographics. For example, respondents were asked if nanotechnology has or has not been carried out in consideration of their interests, values and beliefs. Affirmative answers were given by 70% of "true believers" and 25% of "ethical populists," and 50% overall. Compared with biotechnology, "…the pattern [of subgroup differences] is even clearer for nanotechnology, arguably reflecting the relative importance of attitudinal predispositions in a newer area of technology for which a lower percentage of the public has had the opportunity to become informed about the technology" (p. 9).

Nanotechnology players. Subgroup differences also appear in analyses of respondents' level of trust in a variety of information sources. For example, "True believers" believe information from the scientific community; whereas "ethical populists" are more likely to trust information from non-scientific sources – religious, political and environmental.

Scheufele, D. A., & Lewenstein, B. (forthcoming). The public and nanotechnology: How citizens make sense of emerging technologies. *Journal of Nanoparticle Research*. Retrieved September 9, 2005, from http://www.scholar.google.com

Summary

A 2004 national telephone survey suggests that most Americans are not aware of and not knowledgeable about nanotechnology. Nonetheless, more aware respondents are significantly more likely to support use of and federal funding of nanotechnology compared with those who are not aware of the field. More aware respondents also give significantly more positive responses about the potential benefits of nanotechnology. On the other hand, six out of ten interviewees worried about loss of privacy due to nanoscale surveillance. Knowledge about nanotechnology is unrelated to attitudes about support or funding of nanotechnology, thus the survey data do not appear to support a scientific literacy model assumption that increased literacy will yield increased public support. Heavier users of science media are more supportive of nanotechnology than light users; thus the data appear to support a cognitive miser model, in which people's attitudes are influenced by factors other than knowledge, such as mass media. The study suggests that supporters of nanotechnology need to frame their messages in mainstream media to influence public attitudes.

Elaboration

Findings are from a Fall, 2004, representative national telephone survey of 706 American adults. The study focused on assessing a scientific literacy model versus a cognitive miser model for explaining attitudes toward emerging technologies and the potential role of media in shaping attitudes.

Awareness

- After hearing an explanation of nanotechnology,[20]
  - about one-quarter of respondents reported they had never heard of the issue
  - 16% felt at least somewhat informed about nanotechnology

Knowledge

- Responding to six true-false statements, beyond chance results were obtained for the following statements,[21]
  - Experts consider nanotechnology to be the next industrial revolution of the U.S. economy.
  - U.S. corporations are not using nanotechnology yet to make products sold today.
  - Nanotechnology involves materials that are not visible to the naked eye.
  - Nanotechnology allows scientists to arrange molecules in a way that does not occur in nature.

[20] Explanation read to interviewees: "Recently there has been a lot of talk about new technologies that allow scientists to manipulate materials at the level of tiny molecules. This could lead to the development of extremely small computers, or the improvement of existing materials. This is usually referred to as 'nanotechnology.'"
[21] Specific response percentages are not provided in the article.

- Responses did not differ significantly from 50% for the following T/F statements of specific technical knowledge,
    - A nanometer is a billionth of a meter.
    - A nanometer is about the same size as an atom.

- The mean score for the six T/F statements equals 3.90; *SD* = 1.55.

Support

- 52% of the sample support the use of nanotechnology
    - Of those aware of nanotechnology, 59% expressed support; significantly more than those unaware of nanotechnology (28%)

- 42% of the sample support federal funding of nanotechnology
    - Of those aware of nanotechnology, 49% expressed support for funding; significantly more than those unaware of nanotechnology (22%)

Benefits and Risks

- Respondents were asked how much they agree/disagree on a 10 point scale with the following statements about potential benefits and risks of nanotechnology. The majority of the sample is optimistic about nanotechnology. For the five statements below, those more aware of nanotechnology were significantly more positive than those less aware of the field.
    - 74% agree that "nanotech may lead to new and better ways to treat and detect human diseases (80% more aware vs. 57% less aware)
    - 64% agree that "nanotech may help us develop increased national security and defensive capabilities" (68% vs. 49%)
    - 62% agree that "nanotech may give scientists the ability to improve human physical and mental abilities" (67% vs. 46%)
    - 62% agree that "nanotech may lead to new and better ways to clean up the environment (67% vs. 48%)
    - 34% agree that "because of nanotech we may lose more U.S. jobs (33% vs. 40%)

- For the three statements below, awareness of nanotechnology had no influence.
    - 60% agree that "nanotech may lead to a loss of personal privacy because of tiny new surveillance devices"
    - 37% agree that "nanotech may lead to an arms race between the U. S. and other countries"
    - 16% agree that "nanotech may lead to the uncontrollable spread of very tiny self-replicating robots"

Explanatory models

The first research question of this study is:

- "Do people form a scientific literacy model or a cognitive miser model when forming judgments about nanotechnology as an emerging technology?"
  - The scientific literacy model assumes that the general public has an information deficit that when filled would reduce resistance to new technologies. The cognitive miser model of information processing suggests that people collect only as much information as they think they need to make a decision and thus will make decisions with little or insufficient information.
  - An ordinary-least-squares multiple regression reveals that -- after controlling for demographic variables, risk/benefit perceptions, and science media use -- knowledge about nanotechnology is unrelated to attitudes about support or funding. Thus, the scientific literacy model appears not to be supported. Increases in nanotech literacy will not necessarily lead to higher levels of public support.

The second research question of this study is:

- What is the role that media play in shaping public attitudes toward nanotechnology?
  - In the cognitive miser model, people do not use all available information to make decisions but are influenced by other factors such as ideological predispositions, religious beliefs or the way mass media frame issues.
  - Data indicate that heavier users of science media are more supportive of nanotechnology; e.g., 35% of frequent readers of science in newspapers indicate that benefits outweigh risks compared with 25% of infrequent readers. Ordinary least squares multiple regression models show that exposure and attention to science news in newspapers and television had significant positive impact on nanotechnology support. Thus, the cognitive miser model appears to be supported.
  - Currently, media coverage favors potential benefits rather than risks of nanotechnology. The authors note that this positive framing may change as mainstream media focus more on controversy.

A Wisconsin press release of this article quotes author Dietram Scheufele as saying, "The message to scientists is: The public is not going to come to you. You have to take your work to the public, and make it available where people look….It [nanotechnology] will be covered as one side versus the other. That makes it important to establish your turf. If you want to get your side heard, you have to communicate effectively, rather than waiting for an interest group to frame the issue." [Chaptman, D. (August 30, 2005). Press Release: Study examines public attitudes on nanotechnology. Retrieved September 28, 2005 from http://www.journalism.wisc.edu/%7Escheufele]

Schummer, J. (2005). Reading nano: The public interest in nanotechnology as reflected in purchase patterns of books. *Public Understanding of Science, 14* (2), 163-183.

Summary
A formal network analysis and content analysis of Amazon.com co-purchases of nanotechnology books reveals that the public reads mostly books on forecasting as well as general introductions. Schummer concludes that "due to the very small number of books that competently and comprehensibly introduce general readers to current and recent research, it is this futuristic literature of various qualities that shapes the public view of nanotechnology more than anything else" (p. 180). Moreover, readers of popular nanotechnology books are not inspired to buy nano-science fiction or vice versa.

Elaboration

This unique study focuses on books that people selectively purchase to inform themselves about the field of nanotechnology. To identify books, Schummer examined March, 2004, co-purchasing patterns on Amazon.com, which has the feature of "Customers-who-bought-this-book-also-bought-these-books." Network analysis looks at the cohesion of links of one book to another to identify a cluster of books.

Eight books that are fully linked to each other, making the densest of co-purchase clusters, include:

- Ratner & Ratner (2003) *Nanotechnology: A gentle introduction to the next big idea*
- Drexler (1992) *Nanosystems: Molecular machinery, manufacturing and computation*
- SciAmEd (2002) *Understanding nanotechnology from the editors of Scientific American*
- Uldrich & Newberry (2003) *The next big thing is really small: How nanotechnology will change the future of your business.*
- Drexler (1986) *Engines of creation: The coming era of nanotechnology*
- Wilson, Kannangara, Smith, Simmons & Crane (2003) *Nanotechnology: Basic science and engineering technologies*
- Crandall (Ed.) (1996) *Nanotechnology: Molecular speculations on global abundance*
- Gross (1999) *Travels to the nanoworld: Miniature machinery in nature and technology*

People tend to buy these books together. The book list includes both basic and advanced books of current and recent research as well as books on general and business forecasting about the future of nanotechnology.

Schummer's article discusses the pros and cons of the procedures and analyses used and describes at length the network and content analysis results. However, the main purpose for bringing this article to the attention of the NISE Network is its conclusion that readers of popular nanotechnology books are not inspired to buy nano-science fiction or vice versa. In terms of co-purchase patterns, nanobooks and science fiction novels have two rather separate networks. "In fact, despite its non-fiction appendix with references to the scientific literature, the co-purchase pattern of *Prey* shows not a single direct link to any non-fiction book whatsoever. Should the forthcoming movie have the disastrous impact on the public opinion of nanotechnology that many in the field are afraid of, it is very unlikely that this will in any way be corrected by the reading of non-fiction Nanobooks." (p. 180).

TNS Opinion and Social. (June, 2005a). *Eurobarometer 224/Wave63.1: Europeans, Science and Technology*. Retrieved September 9, 2005, from http://europa.eu.int/comm/research/press/2055/pr1306ben.cfm

Summary

A series of Eurobarometer interview-based surveys has asked European Union adults questions on emerging technology, although nanotechnology has been added only recently. Results from the 2005 Eurobarometer reveal that interest in nanotechnology developments is lower than interest in six other sci-tech fields but has doubled since the 2001 Eurobarometer.

Elaboration

During the winter of 2005, a multi-stage random sample of about 33, 000 respondents from 25 EU member states participated in face-to-face interviews at home. One question referred to nanotechnology.

Interest. Respondents, who were very or moderately interested in either "new inventions and technologies" or "scientific discoveries," were asked which of seven science and technology developments they are most interested in (medicine, environment, Internet, economics and social sciences, astronomy and space, nanotechnology). Nanotechnologies came in lowest, with only 8% expressing interest in developments in this field. Men expressed more interest than women, and those with higher education expressed more interest.

The same question was asked in 2001 in 15 EU member states. Comparing the 2001 result with the 2005 result for the 15 EU member states indicates a doubling in interest from 4% to 9%.

TNS Opinion and Social. (June, 2005b). ***Eurobarometer 225/Wave63.1: Social Values, Science and Technology*****. Retrieved September 9, 2005, from http://europa.eu.int/comm/research/press/2055/pr1306ben.cfm**

Summary

Since 1999, a series of Eurobarometer interview-based surveys has asked European Union adults questions on emerging technologies. In 2005, one question on nanotechnology was asked as to whether nanotechnology will have a positive effect, negative effect or no effect on our way of life in the next 20 years: 40% said "don't know" and 48% said positive effect. A similar question, asked of EU members in 2002, yielded 53% "don't know" and 29% "positive," indicating increased familiarity and movement toward a positive viewpoint. (See Gaskell et al., 2005, for 2002 results)

Elaboration

During the winter of 2005 a multi-stage random sample of 32,000 respondents over 15 years of age participated in face-to-face interviews at home. Approximately 1000 people from each of 25 EU member states answered questions about emerging technologies and one question about nanotechnology.

Future. Respondents were asked:
"I am going to read out a list of areas in which new technologies are currently developing. For each of these areas, do you think it will a positive, a negative or no effect on our way of life in the next 20 years?"

Almost half (48%) thought a positive effect would result, but 40% responded "don't know." The high "don't know" percentage indicates lack of familiarity with nanotechnology.

Waldron, A. M., Spencer, D., & Batt, C. A. (undated). ***Too small to see: The current state of public understanding of nanotechnology.*** **Made available by Carl Batt, Cornell University, October 7, 2005.**

Summary

A survey of a stratified sample of 1500 people aged 6 to 74 reveals that most do not think on the level of nanoscale when asked for the smallest thing they can think of; that most have never heard of "nano" or "nanotechnology," and that most cannot correctly order in size the terms: milli, micro, nano, or the terms: atom, molecule, germ.

Elaboration

In support of a traveling museum exhibit to help 8-13 year olds and adults learn about nanotechnology, 1500 individuals, aged 6-74, from Florida, North Carolina, New York and Hawaii, were surveyed about their awareness and understanding of nanoscale.

Awareness

- About 60% of respondents aged 14-59 say they have heard of "nano,: but "nano" was less familiar to those under 14 and over 60 years of age.
- 1% of the whole sample could define "nano" as one-billionth. "Nano" more often was defined as "small" or "really small" and sometimes interpreted as "an acronym, a Spanish word, or a term for grandmother." (p.6)
- About half of respondents aged 14-59 say they have heard of "nanotechnology," but "nanotechnology" was less familiar to those under 14 and over 60 years of age.
- 1% of the whole sample could define "nanotechnology" as "manipulation of matter at length scales of less than 100 nanometers." "Nanotechnology was making tiny things, science, or a type of computer technology. Many respondents offered science fiction worthy definitions of 'robots', 'nanobots' and 'tiny cameras that are injected into your body.' " (p. 6) Respondents who could provide some sort of definition say they learn about nanotechnology "because they were avid readers, science enthusiasts, NPR listeners, or investors." (p.6)
- College age respondents (18-22) expressed the most familiarity with "nano" and "nanotechnology" with 71% saying they have heard of the words.

Knowledge

- When asked "what is the smallest thing you can think of," "nanoscopic" objects (e.g., proton, atom, molecule) were offered by
  - 25% of 11-13 year olds
  - 40% of 14-17 years olds
  - 58% of 18-22 year olds[22]
  - 41% of 23-39 year olds[30]
  - 48% of 40-59 year olds[30]
  - 33% of those 60 and over

[22] These percentages are estimated by Flagg from the Figure 2 graph, p. 11

- Respondents ordered in size the measurement terms: milli, micro and nano, as well as the terms: germ, molecule and atom. "Respondents were more successful ordering units of measure than in putting 'germ,' 'molecule' and 'atom' in correct size order…. Only 15% of 11-13 year olds could correctly order germ, molecule and atom. Adults also had trouble putting germ, molecule and atom in the appropriate size context." (p. 7)[23]

[23] Quantitative results are not provided for these two ordering questions.

Assessing the role of nanotechnology and guiding its progression will require cross-sectoral involvement of scientists, governments, civil society organisations and the general public. Informed debate is essential to try to avoid the polarisation of views illustrated by the issue of genetic modification. This 'quick guide' aims to provide a range of relevant information for those who would like to better understand and take part in this important debate. Authors: Catherine Brahic and Mike Shanahan. Source: The Science and Development Network website. Download PDF Copy. Comments.