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ABSTRACT

Recently, the nature of science has enjoyed renewed attention in science education circles as a primary component of scientific literacy. This paper describes an investigation meant to assess the influence of a person's understanding of the nature of science on his or her decision-making regarding science- and technology-based issues, and to delineate the factors and reasoning people use when making these types of decisions. The decision-making processes of a group of college professors and a group of research scientists who held disparate understandings of the nature of science were examined. Results indicate that there were few differences in the factors influencing the two groups' decisions on complex, controversial science- and technology-based issues, and factors associated with the nature of science played an insignificant role for a minority of the respondents and no clear role for the majority. The questionnaires and responses are appended. (Contains 45 references.) (WRM)

Testing Assumptions Underlying the Science Education Reforms: Decision-Making on Science and Technology Based Issues

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Testing Assumptions Underlying the Science Education Reforms: Decision-Making on Science and Technology Based Issues

Recently, the nature of science has enjoyed renewed attention in science education circles as a primary component of scientific literacy (American Association for the Advancement of Science, 1989, 1993; Bybee, 1997; National Research Council, 1996; National Science Teachers Association, 1982). These documents mandate that teachers of science from kindergarten to graduate school should not only teach in a manner consistent with current views of the scientific enterprise, but should purposively instruct students in specific aspects of the nature of science. This amounts to a huge and uncertain undertaking, since research has shown that, for the most part, few students or teachers are able to articulate adequate understandings of this elusive construct (Duschl, 1990; Lederman, 1992, among others).

From an educational perspective, most agree that educating children to simply recall scientific facts, laws, and theories is not enough. Rather, teachers and science educators want students to know why scientific knowledge and ideas have merit and may be trusted. For example, Munby (1982) promoted science instruction that fosters "intellectual independence" and provides students with "all the resources necessary for judging the truth of knowledge independently of other people" (p. 31). Norris (1992) extended this argument to the "rational trust" of experts when firsthand evidence is impractical. These issues attain practical significance for individuals deciding whether to accept the advice or opinion of scientific "experts" and how to respond to public issues related to science and technology. Thus, public understanding of the nature of science is considered a critical component of democracy, in which people must make decisions on science and technology based issues.

Reform documents agree that, in order for these changes to come about, less emphasis should be placed on teaching isolated science facts and concepts and more emphasis placed on broad, overarching themes, including scientific inquiry and the nature of science. The nature of science, also known as epistemology of science, or science as a way of knowing, refers to the values and assumptions inherent to scientific knowledge (Spector & Lederman, 1990). These values and assumptions include, but are not limited to tentativeness, creativity, subjectivity, and parsimony (AAAS, 1989; 1993; Kimball, 1967-68; Rubba & Anderson, 1978).

Recent commentary has linked nature of science instruction to the ultimate goal of scientific literacy: to improve citizens' abilities to make reasoned decisions in a world increasingly impacted by the processes and products of science (Carey & Smith, 1993; Collins & Shapin, 1986; Cotham & Smith, 1981; Driver, Leach, Millar, & Scott, 1996; Kuhn, Amsel, & O'Loughlin, 1989; Lederman, 1983; Millar & Wynne, 1988). By knowing the characteristics of scientific knowledge and the way it is constructed, the argument proceeds, citizens will be better able to recognize pseudoscientific claims, distinguish good science from bad, and apply scientific knowledge to their everyday lives. Driver, et al. (1996) labeled this the "democratic argument" for nature of science instruction:

> The democratic argument for promoting public understanding of science focuses on the understandings needed to participate in the debates surrounding [science and technologically based] issues and in the decision-making process itself...an understanding of the issues requires not just knowledge of science content, but also an understanding of the nature of science and scientific knowledge. (p.18)

Given the importance science educators have placed on the ultimate outcome of nature of science instruction and scientific literacy, it is disconcerting to realize that little research exists delineating the role of the nature of science in decision making. If science educators and reform documents are promoting this rationale for teaching the nature of science, there should be some empirical evidence that the desired outcomes will be achieved.

Researchers exploring decision making and the formation of moral judgments on science and technology based issues have reported a variety of factors that influence peoples' decisions. Zeidler and Schafer (1984) suggested that comprehension of science, positive attitudes, and a strong commitment toward a particular issue were all positively related to the level of moral reasoning used to make social judgments. Fleming (1986a) found that adolescents primarily viewed science and technology based issues in ways that stressed the social aspects of the issue. When adolescents used nonsocial cognition, their reasoning focused on their perceptions of scientists as finders and keepers of "true" facts (Fleming, 1986b). The single study that directly addressed the role of nature of science conceptions in decision making found that students did not base decisions about their daily conduct on their understandings of the tentative nature of scientific knowledge (Lederman & O'Malley, 1990).

Piaget (1972) and Iozzi (1978) theorized that individuals tend to reason at more sophisticated levels in areas which they have more knowledge. If the nature of science is related to decision making on science and technology based issues, as is commonly assumed, then it follows that those who understand the nature of science should reason differently on these issues than those who do not.

The purposes of this investigation were to assess the influence of people's understanding of the nature of science on their decision making regarding science and technology based issues and to delineate the factors and reasoning people use when making these types of decisions. The research questions guiding the investigation were

1. What is the relationship, if any, between understandings of the nature of science and decisions regarding science and technology based issues?

2. What is the relationship, if any, between understandings of the nature of science and the factors used to reach decisions on science and technology based issues?

3. What is the relationship, if any, between understandings of the nature of science and the reasoning used to reach decisions on science and technology based issues?

Method

Participants

This investigation focused on adults for two reasons. First, previous research indicates that it would be extremely difficult, if not impossible, to find K-12 students who possess the current conceptions of the nature of science this study required (Aikenhead, 1987; Bady, 1979; Lederman, 1992; Miller, 1963; Rubba, Horner, & Smith, 1981). Second, although children do make some choices about how to conduct their everyday lives, adults are generally in the position to make substantial personal decisions and public decisions on science and technology based issues.

During the fall of 1998, initial inquiries to attract individuals willing to participate in the investigation were sent via e-mail to university professors and research scientists across the United States. From this initial query, 21 participants agreed to participate in the investigation. In order to assess the impact of divergent views of the nature of science on decision making, these participants were purposively selected to create two groups of adults most likely to possess disparate conceptions of the nature of science.

The first group consisted of 10 university professors and research scientists whose education and research provided ample opportunities for them to reflect on the nature of science (i.e., science educators, science philosophers, and research scientists). These individuals were selected because they were highly likely to possess desired understandings of the nature of science and, thus, provide a "best case" scenario for the nature of science to impact their decision making. The second group consisted of 11 university professors, who, while possessing equivalent amounts of education, were unlikely to have spent much time contemplating the nature of science (i.e., historians, English professors, and business professors). It should be kept in mine that while this purposive selection increased the likelihood of obtaining two groups possessing divergent views of the nature of science, it did not assure this outcome. Therefore, the final group assignments were based on formal assessment of each individual's understandings of the nature of science as described in the next section.

Procedures

Each of the 21 participants were administered two questionnaires, the first designed to gather information about their decision making, and the second to assess their conceptions of the nature of science. Each participant's vita was also collected to provide biographical and academic background data. Following the return of each completed questionnaire, participants were individually interviewed via phone. A total of 42 interviews were conducted, each lasting approximately 45 minutes.

Instruments

Open-ended questionnaires in conjunction with follow-up interviews were used to assess participants' decision making and their conceptions of the nature of science. Such instrumentation was employed to mitigate concerns inherent to the use of standardized, forced-choice instruments (Lederman, 1992; Lederman, Wade, & Bell, 1998).

The Decision Making Questionnaire (DMQ). A panel of experts consisting of four science educators and two research scientists established the face and content validity of this questionnaire. The DMQ's scenarios and items were modified according to the panel's suggestions for improvement. The final version of this questionnaire contained four different scenarios concerning science and technology issues, including fetal tissue implantation, global warming, the relationship between diet and cancer, and the relationship between cigarette smoking and cancer (see Appendix A). Each scenario was followed by three to five questions designed to elicit "yes" or "no" decisions, and to encourage respondents to explicate the factors and reasoning patterns influencing their decisions. Following this questionnaire, the participants were interviewed to provide opportunities for them to clarify and elaborate on their responses to the DMQ. All interviews were audiotaped, transcribed, and subsequently used in conjunction with their responses to the DMQ to construct summary profiles of the participants' decisions and reasoning patterns.

The Nature of Science Questionnaire (NOSQ). This questionnaire (see Appendix B) consisted of six open-ended items adapted from Lederman and O'Malley (1990) and Abd-El-Khalick, Bell, and Lederman (1998). As with the DMQ, the advice of six experts was used to enhance the face and content validity of the instrument. The NOSQ focused on several aspects of the nature of science believed to be relevant to K-12 students and their subsequent participation in decision making as adults in a democratic society (Lederman & Abd-El-Khalick, 1998; Smith et al., 1997). These aspects included tentativeness, empirical basis, subjectivity, creativity, observation versus inference, the role of social and cultural contexts in science, and the functions and relationships among theories, hypotheses, and laws. In order to provide in-depth assessment of the participants' understandings of these aspects of the NOS, individual items asked participants to justify their answers and to support them with relevant examples.

Semistructured interviews were conducted following the administration of the NOSQ, giving participants the opportunity to clarify and elaborate on their answers. Individual profiles of their views of the nature of science were constructed from each participant's responses to the NOSQ and follow-up interview. These profiles were subsequently used to group participants according to their understandings of the nature of science. The 9 participants whose understandings were most consistent with current conceptions (as delineated in philosophy of science literature and science education reform documents) were assigned to Group A. The 9 participants whose understandings were largely inconsistent with current conceptions were assigned to Group B. The 3 participants whose views were mixed and did not clearly fall within either category were dropped from consideration to create a greater distinction between the two groups. Table 1 provides a summary of the academic backgrounds of the participants assigned to both groups.

Data Analysis

Once these group assignments were made, participants' individual DMQ responses were used in conjunction with the corresponding follow-up interview transcripts to construct profiles of each group's decision making. These profiles included total "yes," "no," and "undecided" responses to the DMQ items, lists of factors participants said influenced their decisions, and general reasoning patterns. Each group's profile was then searched for patterns and categories, which were checked against the data and modified accordingly. Several rounds of category generation, confirmation, and modification were conducted to satisfactorily reduce the data. Finally, the research questions were answered by comparing the decision making profiles of Group A and Group B.

Results

Comparison of Group A and Group B Decisions

Participants' "yes" and "no" responses to the 15 DMQ items were tallied for each group and summed separately for each individual DMQ item and the total DMQ. A few DMQ responses were unclear or the respondents were unwilling to commit to a decision for a particular question. These responses were categorized as "undecided."

Table 2 illustrates a comparison of the Group A and Group B decisions for each question on the DMQ. It is clear that there was little difference in the two groups' overall decisions, despite their disparate views of the nature of science. None of the responses to individual questions, whether "yes," "no," or "undecided," differed between Group A and Group B by more than two. Furthermore, 93% of responses differed by one or less, and 29% did not differ at all. As the comparison of the total number of responses at the bottom of Table 2 indicates, the small differences between Group A and Group B responses to the DMQ could largely be attributed to three additional "undecided" decisions of the Group A participants.

Comparison of the Factors that Influenced Group A and Group B Decisions

Group A and B responses to the DMQ were also used to generate a list of the factors that participants said had influenced their decisions. To encourage the listing of such factors, the questions following each of the four scenarios instructed respondents to list the reasons for their decisions. The resulting overall lists of factors generated from the responses of the two groups were used to determine (a) the relative influence of the nature of science in reaching these decisions, and (b) whether there were any differences in the kinds of factors listed between the two groups.

The first step in the analysis of factors was to examine each participant's answers to individual DMQ items for references to factors influencing their decisions. Identified factors were then listed separately for each group per scenario. In most cases, participants listed multiple factors. Next, the four resulting lists of factors were grouped into common categories, such as the nature of science, moral/ethical issues, pragmatism, and personal choice. In all, eight categories were created for the 26 factors identified in the DMQ responses. Note that the first category for each scenario in Table 3 (Nature of Science) was included because of its relevance to the research questions of this investigation, rather than the frequency with which it was cited. Remaining factors were placed in a second broad category (Other). Under "Other," factors mentioned by 3 or more participants in one of the groups were listed separately. For clarity of presentation, factors cited by only one or two participants in a scenario were grouped under the "Miscellaneous" heading.

Scenario 1: Fetal Tissue Implantation. The first scenario dealt with an experimental procedure involving the use of fetal tissue implantation for the treatment of Parkinson's disease. While this scenario contained a strong ethical/moral component, it also provided opportunities for respondents to comment on a variety of nature of science issues, including the subjective nature of the definition of life, the ways in which science can inform ethical dilemmas, and whether the treatment needed to be proven as effective before participants were willing to recommend it.

The data in Table 3 clearly indicate that the nature of science was not a major contributing factor in the Scenario 1 decisions reached by the members of either Group A or Group B. None of the Group A or Group B participants directly referred to characteristics of scientific knowledge in their discussions of how they had reached their decisions. In fact, the only participant who referred to science at all indicated that it was not appropriate for answering the principle questions of the scenario:

> On a final note, just like science alone cannot and should not provide society with a definitive answer regarding when human life begins; it cannot and should not alone decide if and how fetal tissue should be donated. (A5, DMQ)

Noticeably absent from the participants' responses were any references to scientific evidence or the subjective nature of the definition of life. Furthermore, none of the participants indicated that the experimental nature of the treatment influenced their decisions when explicitly asked during the follow-up interviews.

The vast majority of factors identified in Group A and Group B responses to Scenario 1 items fell into the "Other" category. These responses focused on personal values and the social/ethical components of the issue:

> The desire to stay alive and the desire to assist a family member in staying alive is strong and in itself justified if that chance of a cure doesn't negatively impact anyone else in a significant fashion...I can't see any ethical reason why such a treatment regime would not be permitted or even recommended. (A2, DMQ)

> I believe the right to an abortion (before the fetus becomes human) should not be restricted by law...I believe that this group of cells is part of the woman's body and should be treated accordingly. (B8, DMQ)

> If society (and by extension, the legal and medical professions) continues to view a fetus as part of a woman's body, then like organs, donors should be able to request donation of fetal tissue to specific people. (A5, DMQ)

Scenario 2: Global Warming and Green House Gas Emissions. The second DMQ scenario dealt with the connection between greenhouse gas emissions and global warming. The questions following the scenario asked respondents to make decisions having both personal and public impacts, such as whether they would be willing to pay for technology to reduce automobile pollution and whether the US should adopt binding limits on greenhouse gas emissions. The lack of consensus among scientists regarding the reality and potential impact of global warming provided an opportunity for respondents to discuss aspects of the nature of science, including tentativeness and disputes concerning data analysis and interpretation, as influencing their decisions.

Categories of the self-reported factors influencing the respondents' decisions in the second scenario are listed in Table 3. Less than half of the participants' in both groups cited factors that may be interpreted to reflect their views of the nature of science. Only 7 of the 21 participants mentioned the use of scientific evidence in their decision making. In general, Group A respondents tended to focus on the inconclusive nature of the evidence.

> I recognize that research on the relationship between gas emissions and global warming is equivocal: The scientific community has yet to reach consensus on this issue. (A5, DMQ)
>
> Uncertainties about the potential of greenhouse gases to alter climate are still substantial, though a wise reading would indicate a likely connection. (A9, DMQ)

In contrast to these responses, two of the Group B participants referred to the *certainty* of scientific knowledge as a factor in their decisions.

> This is potentially the greatest issue we face, and I discount all propaganda from the energy industries that this is as yet unproven. (B2, DMQ)
>
> No, the US should not agree to legally binding limits until research conclusively shows that the global warming phenomenon is real. (B9, DMQ)

A third Group B participant seemed to hold a belief more in line with currently accepted views of the tentative nature of science:

> Yes, I think that the risk of global warming is real. Even if actual global warming cannot be scientifically determined, this is not a gamble we should make. (B7, DMQ)

While there appear to be differences in the ways some Group A and Group B participants viewed the certainty of the evidence for global warming, it is important to note that the majority did not mention scientific evidence at all. As is shown in Table 3, social/political issues and personal philosophy—even pragmatism—were reported by the participants much more frequently as factors in their decision making. The most frequently cited factors were also cited about equally between the two groups, although economics was mentioned more often in Group B.

<u>Scenario 3: Diet, Exercise, and Cancer</u>. The third DMQ scenario dealt with the possible links between diet, exercise, and cancer. The three questions following the scenario asked how the participants' knowledge of the benefits of a particular dietary program and exercise had impacted their lives and whether they would support legislation prohibiting the sale of certain foods associated with cancer. As with the previous scenarios, these questions were designed to give the participants opportunities to describe factors that influence their personal choices when the scientific evidence is equivocal.

Factors related to the nature of science were cited more frequently in this scenario than in the previous two (Table 3). However, it should be noted that the majority of the factors listed in the nature of science category consisted of rather superficial references to "scientific evidence" or "data." Two Group A responses reflected more in-depth understandings by focusing on the weight of the evidence and the lack of consensus among scientists:

> In addition, researchers (and governments!) often draw conclusions that are not based on strong evidence (indeed, many epidemiological studies cannot, by their very nature, produce strong evidence) and I'd hate to proliferate science based on weak evidence (or on evidence of weak impacts). (A9, DMQ)

> While I find current studies on diet and cancer compelling enough to change my own habits, I am uncertain there is enough scientific research or consensus among members of the scientific community to support legislation on foods associated with cancer. (A5, DMQ)

However, it is important to note that evidence alone did not determine Group A's decisions.

> I also recognize that science can and should be only one of many voices in deciding how and what legislation is passed: I wonder if current scientific evidence would outweigh economic losses and public outcry. (A5, DMQ)

The two participants in Group B who mentioned science (both in response to Item 3 about legislation) viewed science as being inadequate to produce a clear-cut answer.

> I must admit, however, that given the scientific flip-flopping over the years about the merits and demerits of certain foods, I am somewhat skeptical about the research results. (B1, DMQ)

> No—this is an imperfect science at best. We don't know exactly how diet, exercise, heredity, and stress interact to cause cancer, so it is premature to focus on one factor. (B6, DMQ)

Viewing the progression of scientific knowledge as flip-flopping or as imperfect is consistent with the more absolute views of scientific knowledge expressed by Group B on the NOSQ. What is surprising is that more Group B participants did not respond this way.

Values, including factors such as convenience, self-image, and especially personal benefit, were cited by every participant in this scenario. A small but roughly equal number of participants in both groups referred to moderation in regard to diet ("I can't believe all of these 'bad' things are necessarily bad if taken in moderation" B7, DMQ). The miscellaneous category included factors such as societal rights and social issues, economics, and morals/ethics. All factors were mentioned with similar frequency in both groups.

In both groups, even when they were convinced of the benefits of proper diet and exercise, participants admitted to having trouble acting on their convictions.

> I like to think that as a type A guy I am always on the go, but in all honesty I do not have a regular exercise plan. This is one area where my knowledge of the facts say one thing and my actions do not conform to what I know to be true. (A2, DMQ)

> Yes, I try to eat broccoli and fish more often and red meat less often. I am not as good about this as I would like, due to laziness, but I have tried to improve. (B8, DMQ)

When pressed in the interview about what kind of evidence would convince them to change their diet and exercise habits, many participants indicated that the issue for them was not weak science, but weak willpower:

> I don't know if science could do any more at this point. I think it's a matter of saying, "Okay, this is something that needs incorporated in my own personal lifestyle. I need to be exercising and eating right." It has to be more of a personal concern, like a family thing, you know, "We're worried about you and your cholesterol. We want you around for a while." It has to be a more personal level to lead to that kind of motivation. (B9, DMQ)

> I think the evidence that regular exercise is beneficial is pretty unarguable, as I understand it from a wide range of features, such as cardiovascular health, happiness with what level of activity you're having, and ability to do the things you enjoy — all those things are persuasive that exercise regularly is a good idea. And the reason I don't is just a little irrational, I suppose, but not having found any regular exercise that is enjoyable, has made it easy to be a little slothful and not do the optimal thing. (A9, DMQ)

Scenario 4: Cigarette Smoking and Cancer. The last DMQ scenario dealt with the possible links between cigarette smoking and cancer in humans. The questions following the scenario asked about prohibiting smoking, limiting the availability of cigarettes for minors, and banning smoking in public buildings.

Three Group A participants and one Group B participant mentioned the existence of scientific evidence when justifying their decisions (Table 3). Only one of these went beyond a simple reference to unspecified, general evidence. This Group A participant described using consensus among scientists as a factor in decision making.

> If one were to use only scientific criteria in deciding whether or not to render smoking illegal, there appears enough rigorous research and consensus within the scientific community to support such anti-smoking legislation. Proponents of tobacco who claim "lack of proof" distort the purposes, language, and practices of science to further their own agenda. Of course, legislators can and should not look solely to science to make this decision; they must consider economic issues, social norms, and lessons of history (to name just a few). (A5, DMQ)

For the Other category in this scenario, values such as personal choice and personal convenience were cited most frequently in both groups (Table 3). Five participants in Group A and 8 in Group B expressed the importance of protecting minors from cigarettes, even though it meant limiting their freedom. Pragmatism ("it wouldn't work") was cited as a factor about twice as often in Group A, mainly in response to Item 1 about making cigarette smoking illegal. In the miscellaneous category, a few participants in both groups cited social and economic issues. Two participants in Group B cited moral/ethical factors.

Overall, the lists of factors generated from the Group A and Group B responses to the DMQ indicated that the nature of science played, at best, a minor role in participants' decision making on the science and technology based issues. In the relatively few times the participants referred to factors related to the nature of science, their responses typically failed to go beyond simple acknowledgement of the existence of scientific evidence. Other factors, including social/political issues, ethical considerations, and personal values, were described more frequently and elaborately.

Comparison of Group A and Group B Reasoning

Both the DMQ and the follow-up interviews were intended to provide opportunities for participants to describe and elaborate on their reasoning on science and technology based issues. The interviews, in particular, were designed to elicit the participants' reasoning related to their decision making. In this regard, participants were asked two or three questions emphasizing the equivocal nature of the science related to one or more of the scenarios.

For example, in Scenario 1, participants were asked how the experimental nature of the fetal tissue treatment affected their decisions. In Scenario 2, participants were presented with an alternative explanation for global warming (land-form alterations), based on the most current science. In view of this conflicting evidence, participants were asked how they could make decisions about regulating carbon emissions. In Scenario 3, the researcher asked participants how they could make decisions about nutrition when researchers, based on scientific evidence, have altered their recommendations, as in the case of the inclusion of Omega-3 fatty acids in the diet. The Scenario 4 probing question asked whether participants would change their decisions based on some scientists' assertions that the links between tobacco and cancer have never been proven. These probing questions were intended to elicit participants' reasoning on controversial science and technology based issues and prompt the participants to illuminate how their views of the nature of science impacted their reasoning.

The DMQ responses and interview transcripts were searched for participants' reasoning patterns as they responded to the probing questions. Not all participants clearly elucidated their reasoning, but most provided multiple decision making strategies that could be classified. A total of six different reasoning patterns were identified and were remarkably similar between the two groups (Table 4). This similarity was consistent with the other findings of this study regarding the participants' decisions and factors they used in reaching these decisions.

Group A General Reasoning. All 9 participants in Group A said they considered the "evidence" when making decisions on science and technology based issues. While they realized scientific evidence on such issues is often equivocal or incomplete, they found it useful in informing their decisions and often spoke of using the "best available evidence."

Respondents also referred to historical evidence in the first item of Scenario 4 of the DMQ to argue that banning cigarette smoking would not work. They often compared banning cigarette smoking to the prohibition of alcohol in the 1920s. These arguments emphasized the similarities between banning alcohol consumption and banning cigarette smoking, as well as the negative outcomes of prohibition:

> I do not believe such legislation should be passed. Even if smoking could be made illegal, smokers would find ways of getting tobacco. I imagine a situation similar to Prohibition would arise. (A6, DMQ)

Although all referred to considering evidence, none of them claimed to use evidence alone in their decision making. Four expressed a personal philosophy related to conservatism. For these participants, if the evidence did not provide a clear-cut answer, they decided the issue by maintaining the *status quo*, deciding in favor of safety, or using moderation:

> Researcher: And what do you do when you look at the empirical evidence and scientists are saying that greenhouse gas emissions are causing global warming and others saying that either it isn't happening, or if it is happening, we don't know whether it's the greenhouse gases that are causing it?
>
> Subject: Take two scientists and call me in the morning. I want to hear from more people. I think before you ask an entire nation to change their diet, for instance, you need to be pretty darn sure that it is a reasonable way to proceed. So, as far as I'm concerned, we just need more data.
>
> Researcher: And if you're asked to make a decision before you have "enough data?" What do you do?
>
> Subject: *Status quo*. My general rationale about these types of initiatives, for instance, is to maintain the *status quo*, unless there is clear evidence that one should alter the *status quo*. (A2, DMQ-interview)

Four participants cited risk analysis as a strategy for decision making when the evidence was equivocal:

> For example, living in a cave would greatly reduce my chances of being killed by a meteorite. The risk is real, the outcome severe—but the probability is incredibly slight. Similarly, if I aim to reduce my risk of cancer by 20%, I'd need to know the actual probability of cancer. If 1 in 20 people get cancer, then a 20% reduction in risk would be worth a large sacrifice. If 1 in 2000 get this type of cancer, then less sacrifice would be rational. (A9, DMQ)

A similar reasoning pattern involved making a cost/benefit analysis, including the costs of being wrong, additional benefits whether wrong or right, and/or a balance of evidence and values.

Three participants specifically said they tempered the scientific evidence with their values or emotions on the issue. As with the written responses to the DMQ, values or emotions weighed heavily in their verbal responses to the interview questions:

> I think scientific evidence in any new area is going to be equivocal. Because that's just the way science is done. Look at the history of science. There's always lots of ideas brought forth when there's a new area under investigation. It takes a while for scientists to reach consensus on what are the one or two views they're going to have on that topic. So, I think that as a citizen, you take the scientific information, but then you also have to make decisions based on values and societal, cultural, and personal goals. And that's true of any sort of everyday decision that relates to science and technology. I don't think anybody takes scientific information, whether it's equivocal or unequivocal and incorporates it whole clause into their everyday experience. (A5, DMQ-interview)

Group B General Reasoning. Like their Group A counterparts, all of the Group B participants claimed to consider evidence when making decisions on science and technology based issues. There were differences, however, in the ways some viewed the evidence. While the Group A participants viewed the evidence as imperfect and equivocal but still useful, some of the Group B participants looked for long-term consistency and absolute "proof." They were skeptical of science when these could not be provided.

Researcher: In Question #3 in the second paragraph, you had a really interesting comment. Here you said, "I must admit however that given the scientific flip-flopping over the years about the merits and demerits of certain foods, I am somewhat skeptical about the research results." What do you mean by flip-flopping?

Subject: It seems to me they have gone back and forth on a number of foods. For a considerable amount of time they said caffeine was bad for you, I just read recently that in moderation it can be very good for stimulating blood circulation....Yeah, it's stuff like that; it's the same with wine, eggs, etc. It seems to me in all the fields, that is the one with the most flip-flopping back and forth, what's healthy and what's not healthy. That makes me skeptical. (B1, DMQ-interview)

Otherwise, reasoning patterns were remarkably similar to those of Group A. Five participants said that when the evidence was equivocal, they fell back on a conservative philosophy, acting in favor of safety or using moderation (phrases like "balanced diet" and "variety" came out especially in Scenario 3 on nutrition). One participant, the nuclear scientist, said he used risk analysis, trying to determine what was "most likely to happen." Two looked at costs versus benefits. One reasoned that understating the problem could be catastrophic, while overstating the problem had less significant consequences. The other compared impacts on freedom to impacts on health and safety.

Three participants cited values and emotions in their reasoning process, things like a "gut feeling," "common sense," and a "familiar way of life." One participant who was trying a vegetarian diet because he believed it was good for his health admitted that sometimes he deviated for reasons having little to do with scientific evidence:

> I don't know, I'm in a quandary about this. My daughters want to be vegetarians and when they're at home, I generally make vegetarian meals for them. I think that there are reasons for becoming vegetarian, and then, on the other hand, every two to three weeks I'm feeling low on energy, so I go out and buy a steak. (B8, DMQ-interview)

In summary, both Group A and Group B participants used six different categories of reasoning to justify their decisions on the NOSQ. While all the participants referred to the use of evidence in their reasoning, only a few specifically spoke of aspects of evidence related to the nature of science. The majority of participants in both groups found evidence useful for making decisions even though the evidence was not absolute. This finding was consistent with Group A's responses to the NOSQ, but inconsistent with Group B's more absolute responses. Even though all participants cited evidence as a consideration in their decision making, evidence was not the sole influence, nor did it appear to be the primary influence for any of the participants. Consistent with the decision factors the participants had listed on the DMQ, their reasoning patterns focused on personal values and the social and political perspectives of the issues.

Discussion and Implications

The purposes of this investigation were to assess the influence of understandings of the nature of science on decision making regarding science and technology based issues and to delineate the factors and reasoning used when making these types of decisions. To explore this question, the decision making of two groups of college professors and research scientists who held disparate understandings of the nature of science was examined.

This examination found that there were few differences in the factors influencing the two groups' decisions on complex, controversial science and technology based issues. Factors associated with the nature of science played an insignificant role for a minority of the respondents and no clear role for the majority. Other factors, including social/political issues, ethical considerations, and personal values, appeared to dominate the participants' decision making. These factors were in line with the results of previous research on socio-scientific decision making (Fleming, 1986a, 1986b; Zeidler & Shafer, 1984).

The processes the two groups used to reach their decisions were generally similar, although not always consistent with their views of the nature of science. However, in both groups an understanding of the nature of science regarding evidence emerged as only one of several reasoning patterns. Once again, it appeared to play only a minor role in influencing decisions.

Finally and perhaps most important, the actual decisions reached by the members of the two groups were not substantially different. Therefore, even if the minor differences in reasoning were viewed as significant, the differences have little practical significance because the two groups' decisions were largely equivalent. The participants had to have based their decisions on factors other than their understandings of the nature of science to come to the same conclusions.

Surprisingly most of the Group B participants' reasoning was remarkably similar to that of Group A in that they did not need absolute scientific evidence before they could make decisions on science and technology based issues. This finding contrasts with previous studies in which those with less sophisticated understandings of the nature of science required more absolute knowledge from science before they could make personal and public decisions (Lederman & O'Malley, 1990; Miller & Wynne, 1988). But why was Group B respondents' reasoning on these scientific and technology based issues less absolute than their views of the nature of science?

One possibility is that the decisions reflected the participants' general epistemologies of knowledge, rather their views of science epistemology. Group B participants consisted of 3 scientists and 6 academicians in the humanities. When responding to the science-specific items of the NOSQ, which required metacognition about the construction of scientific knowledge, participants' absolute views of science were evident. But, when responding to the issues of the DMQ, which had a social component, the participants found themselves on more familiar ground and were able to apply their general epistemologies of knowledge (as described by Schommer & Walker, 1995). Future research should focus on the relationship between general epistemologies of knowledge and decision making to see if this relationship is supported.

The participants' high level of intellectual development is another possibility for the inconsistency between the majority of Group B participants' views of the absolute nature of scientific knowledge and their acceptance of tentative scientific evidence in making decisions. Perry (1970) described intellectual development in college students as progressing through four distinct stages. Each stage is characterized by different views of knowledge, starting with a positivist stance (Dualism) and culminating in a view of knowledge as constructed, contextual, and tentative (Commitment to Relativism). It is possible that while many Group B participants held absolute views of the nature of science, a topic that was relatively unfamiliar to them, their use of knowledge in general was mediated by the relativistic views associated with their high levels of intellectual development. If a connection between intellectual development and decision making is established by subsequent studies, then elementary and secondary school students may not be developmentally ready for the type of nature of science instruction that this study implies. Students who are not ready for relativistic type thinking (Perry, 1970) may become frustrated or cynical when exposed to instruction about the tentative nature of scientific knowledge. Such instruction may do more harm than good (Winchester, 1993).

There is a more straightforward explanation for the apparent discrepancy between the Group B participants' more absolute views of the nature of science and their willingness to use equivocal scientific evidence in their decision making. It may be that their decision making was primarily impacted by factors other than the nature of science, such as values and ethics. This conclusion is not only supported by the analyses of the two groups' decisions, factors influencing decisions, and reasoning patterns, but is consistent with prior research on decision making (Fleming, 1981a, 1981b). Group A and Group B participants commonly spoke of using values to help in their decision making on the scientific and technology based issues of the DMQ. For the Group A participants, values were used in conjunction with their understandings of the relevant science:

> So, I think that as a citizen, you take the scientific information, but then you also have to make decisions based on values and societal, cultural, and personal goals. And that's true of any sort of everyday decision that relates to science and technology. I don't think anybody takes scientific information, whether it's equivocal or unequivocal and incorporates it whole clause into their everyday experience. (A5, NOSQ-interview)

The Group B participants, most of who knew little science content, tended to rely on values *instead of* the science:

> Researcher: How does this equivocal nature of the information you get from nutritionists and doctors affect your decision making?
>
> Subject: I think I probably just kind of roll with the punches and use my good common sense. I'm sure that eating a lot of fat red meats and stuff like that is not good, but that doesn't mean I don't go out and have a Whopper once a month, you know... I think I have a reasonably balanced diet, so I kind of don't worry about it one way or another. (B2, NOSQ-interview)

Either way, it was evident that personal values were much more prevalent in the decision making of the members of the two groups than their understandings of the nature of science. That being the case, moral development may be an important consideration when assessing decision making strategies on science and technology based issues. This conclusion is consistent with prior research focusing on college students' responses to socio-scientific dilemmas (Zeidler & Schafer, 1984) and suggests the need for research that explores the relationship between decision making and moral development.

The results of this study alone should generalizable to the entire population of adult decision makers. The investigation was based upon a stratified, nonrandom sampling of a nonrepresentative segment of the voting adults. While the sampling and methodology allowed for a best-case test of the assumption that understandings of the nature of science significantly impact decision making on science and technology based issues, the results of the investigation are not generalizable to the public as a whole. Future work should seek to increase the generalizability of the research reported here by sampling populations more representative of the voting public.

Should the results of subsequent investigations support the generalizability of the negative results of the present study, the question of why teach the nature of science becomes even more critical. Answering this question provides implications for science education and direction for future research. For example, some have argued that nature of science instruction can facilitate the learning of other science content (see Driver, et al., 1996). Typically, students experience a wide range of direct instruction and conformational, cookbook-style laboratory experiences in their science instruction. It is not surprising that in such an environment, students often develop the misconception that scientific knowledge is portrayed as the result of steady and unproblematic accumulation of confirmed hypotheses (Carey & Smith, 1993). This view is essentially inductivist or empiricist and overemphasizes the role of data in the construction of scientific knowledge (Hodson, 1985, 1988; Nadeau & Desautels, 1984; Strike & Posner, 1985).

However, in the actual practice of science, scientific concepts and controversies are almost never decided by data alone (Collings & Pinch, 1996; Kuhn, 1970, Popper, 1988). Without an appreciation of the conjectural nature of scientific knowledge, students may adopt an inefficient, passive learning style, or simply decide that science is not for them (Driver, et al., 1996). Indeed, science educators have argued that learning science content would be enhanced by drawing attention to the similarities between students' conceptual change and the nature of scientific revolutions (Hodson, 1988), and learning and reflecting on the history of the development of scientific knowledge (Solomon, 1991). Previous studies provide initial support for these ideas by suggesting a relationship between views of the nature of science and conceptual understanding in science (Kuhn, et al., 1988; Shapiro, 1989, 1994; Songer & Linn, 1991). Future research should be directed at delineating any relationship between what students know about science and their understandings of science content.

It is possible, perhaps even likely, that results of the suggested empirical studies will not support the assumptions and hopes that many science educators hold for the nature of science. If this is the case, the science education community may be forced to decide between empirical evidence and what it values. In other words, even if the nature of science is not typically used in decision making, the science education community may decide that it *should* be. After all, it appears intuitive that knowledge about science would be helpful in deciding science and technology based issues and dilemmas. Perhaps the public would make better decisions on science and technology based issues if they were taught how to apply current understandings of the nature of science to their decision making. Therefore, explicit instruction on how to use current views of the nature of science in decision making may be warranted. Curricula promoting this kind of instruction should emphasize the relevance of the nature of science to students' everyday experiences and decisions, as well as provide opportunities for students to use their understandings to make decisions on controversial science and technology based issues.

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APPENDICES

APPENDIX A

DECISION MAKING QUESTIONNAIRE

Last six digits of your social security number: xxx - ____ - _______

Instructions

Answer the following questions, using the back of the page if you need more space. Please note that there are no "right" or "wrong" answers to these questions. I am simply interested in your views on a number of issues about science.

Scenario I

In the past decade, research has opened the doors to fetal tissue transplantation, a procedure that typically involves transferring tissue from an aborted fetus to another human. The procedure could potentially provide therapy for victims of a variety of debilitating diseases, including diabetes, Parkinson's disease and Alzheimer's disease. As in many areas of biotechnology, the development of this technique has outpaced the development of ethical policy. Please read the following scenario and thoughtfully answer the questions that follow.

> Bill and Sally are a happily married couple in their late 30s. They enjoy a comfortable life style and a stable home life with their two teen-aged children. Recently, Sally's elderly father was diagnosed as having Parkinson's disease, a slowly progressive disabling ailment marked by tremor and increasing muscular stiffness. His symptoms are mild but his physician has explained that he will become more and more incapacitated with time.
>
> Close to the time that she learns about her father, Sally reads an article in the local newspaper about a research project being run at a local university. A team of researchers, led by Dr. Harrison, have applied to the federal and state governments for permission to do a study with Parkinson's victims. She visits with Dr. Harrison to learn more about the disease. During the course of their discussions, she finds out that the progression of Parkinson's can be slowed and possibly reversed by implanting fetal brain cells in the brain of the patient.
>
> Two months later Sally is surprised to learn that she has become pregnant. Due to the unexpected nature of the pregnancy, Sally considers aborting the fetus. Furthermore, as her father's condition begins to deteriorate, she and Bill consider some therapeutic options for him. Recalling her discussions with Dr. Harrison, Sally and Bill begin to discuss the option of using tissue from the fetus in her womb to donate the cells to cure her father.

Questions:

1. Given the experimental nature of fetal tissue transplant treatments, are Sally and Bill justified in considering the procedure for her father? Why or why not?

2. If Bill and Sally decide to abort the fetus, should they be allowed to donate the fetal tissue for transplantation? Why or why not?

1. Should Bill and Sally be allowed to designate Sally's father as recipient of the fetal tissue? Why or why not?

2. Should Sally be allowed to have the abortion if her primary reason for wanting it is to provide a source of tissue for transplantation into her father? Why or why not?

3. Should Dr. Harrison be allowed to continue his work on fetal brain tissue transplantation as a treatment for Parkinson's disease? Why or why not?

Scenario II

Today, global climate change is a major environmental issue facing the United States and the international community. According to one side, the prospect of human-induced global warming is a near certainty, and failure to address the problem will have catastrophic ecological consequences. According to the other side, global warming is a hypothesis lacking scientific validation, and reducing greenhouse gas emissions will have serious negative economic consequences.

In 1992, the United States, along with roughly 150 other nations, signed the United Nations Framework Convention on Climate Change (FCCC) at the Earth Summit in Rio de Janeiro. The FCCC was ratified by the US Senate in 1992 and has now been ratified by a total of 166 nations. The ultimate objective of this treaty is to "achieve . . . stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." In line with this objective, the most industrialized nations, including the U.S., agreed to the voluntarily aim of returning their greenhouse gas emissions back to 1990 levels by the year 2000. However, the U.S. and most other industrialized nations are not on course to meet this target. In fact, emissions in the U.S. are projected to be 13 percent higher in the year 2000 than they were in 1990.

Because these voluntary targets have proven inadequate in curbing emissions growth, there is now widespread agreement that legally-binding measures are necessary. The upcoming climate conference in Kyoto, Japan, is based on the premise that the participating nations should agree, for the first time, upon a legally-binding limit on emissions.

Questions:

1. Should the U.S. agree to legally-binding limits on greenhouse gas emissions? Why or why not?

2. Should the U.S. impose special taxes on carbon dioxide emission to encourage energy conservation, even if this increased monthly electricity and heating bills by $25 per month?

Why or why not?

3. Would you be willing to pay increased taxes in order to provide funding for research on alternative energy resources, such as solar power and fusion reactors? Why or why not?

4. Should the U.S. reduce automobile emissions by setting higher gas mileage standards, even if this increased the average cost of a new car by $500? Why or why not?

Scenario III

Researchers are just beginning to unravel the role of diet and nutrition in the development of cancer, or carcinogenesis. It is clear that carcinogenesis is a slow process, often taking 10 to 30 years. Diet may play an important role during the initiation of cancer whereby certain foods may serve to increase detoxifying enzymes that help stop the initial stimulation and growth of the cancer cells. At the same time, other nutrients and foods such as fat may serve as promoters for already initiated cancer cells.

Scientists have estimated that diet is responsible for 20 to 40 percent of all cancers, perhaps as high as 70 percent. Diets rich in fruits, vegetables, and fiber have consistently been shown to have a beneficial effect on cancer. On the other hand, heavy consumption of red meats, saturated fats, and salty foods have been linked to a variety of cancers. Other lifestyle factors related to nutrition also appear to be associated with cancer. Obesity has been linked to a variety of cancers, including endometrial, breast, colon, and ovarian. Alcohol consumption has been linked to cancers of the digestive tract and liver. Conversely, several studies have supported the beneficial aspects of physical activity, which may reduce the risk of several types of cancer, including colon, breast, and prostate.

Questions

1. How would you rate your overall awareness of the impact of diet and related factors on the development of cancer?

2. Has your awareness of the benefits of physical activity and a diet rich in fruits and vegetables impacted how you conduct your life? If not, why not? If so, in what way(s)?

3. Do you ever base decisions about what to eat on your understandings of current research into diet and cancer? If not, why not. If so, in what ways?

4. Do you regularly exercise? Why or why not?

5. Would you support increased legislation on foods associated with cancer, including removing high risk foods from the market?

Scenario IV

Many researchers believe that smoking accounts for a large proportion of all cancers and as much as 30 percent of all cancer deaths. Cigarette smoking has specifically been implicated as the cause of cancer of the lung, oral cavity, larynx, esophagus, bladder, kidney, and pancreas. Additionally, the risk of developing cancer is greater for people who smoke more and who start smoking at a younger age. Furthermore, researchers believe that smoking may be the cause of 25 to 30 percent of all heart disease. Exposure to passive tobacco smoke is very likely a significant cause of cancer in nonsmokers. Some scientists believe that the increased risk could be as high as 50 percent. It has been estimated that thousands of people die each year due to exposure to passive cigarette smoke.

Recently, nicotine in cigarette tobacco has been identified as a drug whose addictiveness exceeds that of opium and heroine. In addition to this, documents have come to light that indicate that some tobacco companies have used a variety of methods to increase the amount and potency of nicotine in cigarette tobacco. Finally, it has been shown that many people begin smoking as teenagers, and once started, have a very difficult time quitting.

In contrast to these claims, tobacco companies have consistently asserted that while tobacco may be associated with increased risk for various cancers and heart disease, it has never been *proven* to cause these diseases. Furthermore, to smoke or not is a free choice that should be up to the consumer, not government agencies.

Questions

1. Given the reported dangers of cigarette smoke and its addictiveness, should legislation be passed that would make cigarette smoking illegal? Why or why not?

2. Would you support legislation that makes it more difficult for minors to obtain cigarettes and/or penalizes tobacco companies who target minors in their advertising? Why or why not?

3. Do the alleged dangers of passive cigarette smoke justify banning smoking in public places such as restaurants and bars? Why or why not?

APPENDIX B
NATURE OF SCIENCE QUESTIONNAIRE

Last six digits of your social security number: xxx - ____ - _______

Instructions

Answer the following questions, using the back of the page if you need more space. Please note that there are no "right" or "wrong" answers to these questions. I am simply interested in your views of a number of issues about science.

1. After scientists have developed a theory (e.g., atomic theory, kinetic molecular theory, cell theory), does the theory ever change? If you believe that scientific theories do not change, explain why and defend your answer with examples. If you believe that theories do change: (a) Explain why. (b) Explain why we bother to teach and learn scientific theories. Defend your answer with examples.

Note: Parentheticals are not part of the questionnaire.

(This question aims to assess understandings of the tentative nature of scientific claims and why these claims change. It is common for respondents to attribute such change solely to the accumulation of new facts and technologies, rather than the inferential nature of scientific theories and/or paradigm shifts. The question also aims to assess respondents' understandings of the role of theories in science as well as the theory-laden nature of scientific observations).

2. Science textbooks often represent the atom as a central nucleus composed of positively charged particles (protons) and neutral particles (neutrons) with negatively charged particles (electrons) orbiting the nucleus. How certain are scientists about the structure of the atom? What specific evidence do you think scientists used to determine the structure of the atom?

(This question aims to assess understandings of the role of human inference and creativity in science, the role of models in science, and the notion that scientific models are not copies of reality.)

3. Is there a difference between a scientific theory and a scientific law? Give an example to illustrate your answer.

(This question aims to get at a common misconception about the relationship between the products of science. Many respondents believe in a hierarchical relationship between the two whereby theories become laws if and when enough evidence has been accumulated in their favor. Additionally, respondents express many ideas related to their understandings of the nature of science and science process as they attempt to delineate the difference between theories and laws.)

4. How are science and art similar? How are they different?

(This question aims to assess understandings of the role of creativity and imagination in science, the necessity of empirical evidence in generating scientific knowledge, and the cultural and social embeddedness of science.)

5. Scientists perform experiments/investigations when trying to solve problems. Other than in the stage of planning and design, do scientists use their creativity and imagination in the process of performing these experiments/investigations? Please explain your answer and provide appropriate examples.

(This question aims to assess respondents' understandings of the role of human creativity and imagination in science. While respondents generally recognize that experimental design involves creativity, they rarely say that creativity is used in data analysis in the sense that scientists are, for instance, "creating" patterns rather than "discovering" them.)

6. In the recent past, astronomers differed greatly in their predictions of the ultimate fate of the universe. Some astronomers believed that the universe is expanding while others believed that it is shrinking; still others believed that the universe is in a static state without any expansion or shrinkage. How were these different conclusions possible if the astronomers were all looking at the same experiments and data?

(By posing a scientific controversy and stressing the fact that scientists are using the same data but coming up with differing explanations, this question invites respondents to think about factors that affect scientists' work. The factors range from scientists' personal preferences and biases to differing theoretical commitments to social and cultural factors.)

Table 1

Description of Study Participants

	No. in Group A	No. in Group B
Field in which doctoral degree earned	Science education (4) Education (2) History of science (1) Forest science (1) Conceptual foundations of science (1)	Nuclear engineering (1) Mechanical engineering (1) Special education (1) English (1) Philosophy/history (2) Intercultural studies (1) Soil chemistry (1) Near Eastern studies (1)
Earned bachelor and/or masters degree in a science discipline	9 (biology, zoology, physical science, chemistry)	3 (soil chemistry, nuclear engineering, mechanical engineering)
Place of employment	University: School of Education (6) History dept. (1) Philosophy dept. (1) Forest science dept. (1)	University: School of Education (1) English dept. (1) School of Religion (1) History dept. (2) Information Management dept. (1) Engineering dept. (2) US Environmental Protection Agency (1)
Listed presentations, publications or courses taught on the nature, history or philosophy of science	9	0

Table 2

Comparison of Group A and Group B Responses for Each DMQ Question

		Yes		No		Undecided	
		Group		Group		Group	
	Question	**A**	**B**	**A**	**B**	**A**	**B**
Scenario 1 (Fetal Tissue Implantation)	**1**	8	9	1	0	0	0
	2	7	6	2	3	0	0
	3	5	5	3	4	1	0
	4	5	6	4	3	0	0
	5	8	9	0	0	1	0
Scenario 2 (Global Warming)	**1**	8	7	1	1	0	1
	2	6	5	2	4	1	0
	3	7	8	2	1	0	0
	4	7	8	2	1	0	0
Scenario 3 (Diet/Exercise & Cancer)	**1**	9	7	0	2	0	0
	2	7	8	2	1	0	0
	3	2	1	7	8	0	0
Scenario 4 (Smoking & Cancer)	**1**	0	2	8	7	1	0
	2	8	9	1	0	0	0
	3	8	9	1	0	0	0
Totals	**15**	95 (70%)	99 (73%)	36 (27%)	35 (26%)	4 (3%)	1 (1%)

Table 3

Categories of Decision Making Factors by Scenario

Group A Factors	No. of Respondents	Group B Factors	No. of Respondents
Scenario 1 – Fetal Tissue Implantation			
Nature of science*	0	Nature of science*	0
Other		Other	
Moral/ethical issues	9	Moral/ethical issues	9
Values	9	Values	7
Social/political issues	5	Social/political issues	2
Support of Science	3	Support of Science	1
Miscellaneous	5	Miscellaneous	1
Scenario 2 – Global Warming and Green House Gas Emissions			
Nature of science*	4	Nature of science*	3
Other		Other	
Social/political issues	7	Social/political issues	8
Pragmatism	5	Pragmatism	3
Personal issues/values	6	Personal issues/values	1
Personal philosophy	4	Personal philosophy	5
Economics (cost/benefit)	2	Economics (cost/benefit)	6
Miscellaneous	1	Miscellaneous	2
Scenario 3 – Diet, Exercise, and Cancer			
Nature of science*	5	Nature of science*	2
Other		Other	
Values	9	Values	9
Moderation	4	Moderation	5
Miscellaneous	4	Miscellaneous	3
Scenario 4 – Cigarette Smoking and Cancer			
Nature of science*	3	Nature of science*	1
Other		Other	
Values	9	Values	9
Pragmatism	7	Pragmatism	3
Miscellaneous	5	Miscellaneous	7

*The majority of the "Nature of science" factors consist of superficial references to evidence.

Table 4

Group A and B Decision Making Strategies

Strategy	No. of Group A Participants	No. of Group B Participants
Consider the Evidence	9	9
Conservatism	4	5
Risk Analysis	4	1
Cost/Benefit Analysis	3	2
Values-Based	3	3

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