THE INFLUENCE OF KNOWLEDGE AND DEFERENCE TOWARD SCIENTIFIC AUTHORITY: A MEDIA EFFECTS MODEL FOR PUBLIC ATTITUDES TOWARD NANOTECHNOLOGY

By Chul-joo Lee and Dietram A. Scheufele

Previous research suggests both cognitive and affective variables can impact how the public thinks about new scientific developments such as nanotechnology. Most studies have not explored the origins of these variables or their simultaneous, interactive influences on public opinion. Using national telephone survey data (N=706), we examine the pathways between different types of media use and attitudes toward nanotechnology, particularly potential mediating roles of nanotechnology knowledge and deference toward scientific authority. People relying on newspapers and the Internet for science information report higher levels of nanotechnology knowledge, while respondents using science TV showed higher levels of deference toward scientific authority.

Previous studies have reported that public attitudes toward nanotechnology are positive or neutral at this point,[1] which is consistent with general attitudes toward science and technology in the United States.[2] Moreover, some studies on public opinion toward nanotechnology have also found that both cognitive and affective variables have important impacts on how the public thinks about this new scientific development.[3]

These studies, however, have paid little attention to the interplay of cognitive and affective factors and their potential interactive influences on public opinion about nanotechnology. Even though a few researchers[4] examined basic pathways to public attitudes toward emerging technologies, their studies are limited in two respects. First, Scheufele and Lewenstein[5] did not explore the specific roles that different types of science media play in this process. To address this limitation, we disaggregate media use for science into three categories: television science use, newspaper science use, and Web science use.

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Second, Scheufele and Lewenstein[6] found that a "heuristic/framing model" is more relevant to people's decision-making process with regard to nanotechnology than a "science literacy model." Although they helped reveal the underlying mechanisms by which people with lower levels of knowledge form attitudes about new technologies, they were less concerned with the specific factors that may be at work within a heuristic/framing model. By specifying the heuristics the public uses when making decisions about nanotechnology, we aim to clarify the linkages from science media use to public attitudes toward nanotechnology.

Our study examines the distinct pathways from different types of science media use to public attitudes toward nanotechnology. More important is our examination of the potential mediating roles that knowledge about nanotechnology and deference toward scientific authority play in shaping public attitudes toward nanotechnology.

Two Pathways to Public Attitudes toward Nanotechnology

The traditional explanation of public attitudes toward science involves a "civic science literacy" approach,[7] based on the assumption that people with higher levels of science knowledge are more likely to be appreciative of and supportive of scientific issues. With few exceptions,[8] when the relationship has been tested the positive links between science knowledge and support for science and technology have been empirically supported by a majority of studies, at least in the United States.[9] For example, Miller and his colleagues[10] reported that civic science literacy is positively associated with public support for scientific research and for federal funding for science and technology. Therefore, we hypothesize:

> **H1:** Knowledge about nanotechnology will be positively associated with public attitudes toward nanotechnology.

Given recent emphasis in social psychology and related fields on the role of non-cognitive factors in shaping attitudes,[11] a number of researchers have focused on affective processes in explaining public attitudes toward scientific issues.[12] These researchers contend that (1) the general public tends not to have much science- and technology-related knowledge and therefore often relies more on affective factors when making judgments about these issues, and (2) that such affect is so immediate and automatic that it can be quite influential in determining people's attitudes or behaviors.

When examining affective pathways, researchers have focused primarily on the influences of different types of trust.[13] And trust is, without a doubt, an important influence on public attitudes toward science and technology. Friedman, Dunwoody, and Rogers[14] and Irwin and Wynne[15] illustrated that people were much more concerned with whom to trust than with the scientific aspects of an issue itself.

Brossard and Nisbet explored this issue further and introduced the construct of "deference toward scientific authority."[16] This construct captures the idea that citizens should not develop their own ideas about what is good or bad relative to a scientific controversy because legitimate authorities have already laid down the rules. They showed that deference toward scientific authority, as a broader construct, predicted people's attitudes toward emerging technologies such as agricultural biotechnology. This relationship was both direct and indirect, mediated by trust in scientists. On the basis of these considerations, we hypothesize:

> **H2:** Deference toward scientific authority will be positively associated with public attitudes toward nanotechnology.

Brossard and Nisbet also found that the impact of deference toward scientific authority operated largely independent of people's knowledge of the issue.[17] These findings parallel the large body of research on the relative importance of literacy about scientific issues and trust in scientists. Priest, for example, compared the influence of genetics-related knowledge with diverse kinds of trust in institutional actors when explaining public attitudes toward genetic engineering, concluding that trust in institutional actors is a stronger predictor of support for genetic technology than genetic knowledge.[18] Priest[19] and Siegrist[20] also found that a more important factor in judgments of risks and benefits is trust in industry and scientists rather than beliefs about specific technological developments, which ultimately leads to public support for gene technology.

However, these studies have focused mainly on highly visible controversial technologies (e.g., bioengineered technology and nuclear energy) where people had potentially already formed strong attitudes in favor of or against the technology. Emerging technologies such as nanotechnology remain an under-researched field. Nanotechnology is still in the early stage of the issue cycle.[21] Knowledge levels among the public, thus, are still relatively low.[22] When individuals make judgments and decisions about issues that they are not well aware of, they rely on trust in order to make up for the lack of information.[23] This literature, in combination with the recent findings by Brossard and Nisbet,[24] leads us to expect that people will depend more on deference toward scientific authority than knowledge about nanotechnology in making decisions on support for nanotechnology.

Science Media Use and Science Knowledge

Mass media are often the most easily available and sometimes the *only* information source for the public to acquire information about scientific practices and advancements. Newspapers and magazines—especially in their science sections—function as information sources for those who are neither scientists nor university students.[25] Given its wide reach, science programming on television plays an important role in

shaping public understanding of science and scientists above and beyond newspapers and magazines.[26]

However, cultivation researchers contend that the effects of television viewing on science literacy may be negative, especially for heavy viewers.[27] Shanahan, Morgan, and Stenbjerre, for example, showed that those respondents who watched television more than others were less knowledgeable about scientific issues because television viewing displaced other opportunities to learn about science.[28]

Cultivation studies in this area, however, often ask respondents about the time they spend viewing television without considering the genres of television programs and audience characteristics. Also, given the conceptual framework underlying them, it is not too surprising that they focused more on entertainment programs, such as scientific television dramas and science-fiction movies, than informational science programs.

With these limitations in mind, our study focuses explicitly on science media use, given that informational use of mass media contributes to knowledge gain.[29] Previous research in this area[30] showed that newspaper use and television use for science information increase individuals' levels of science knowledge, thereby decreasing public reservations about science.

LaFollette[31] and Nelkin[32] also reported various types of science news use were positively related to the levels of knowledge about science and scientists. In this vein, it is reasonable to assume that people's consumption of mass media for science information leads to higher levels of nanotechnology knowledge.

H3: Television science use will be positively associated with knowledge about nanotechnology.

H4: Newspaper science use will be positively associated with knowledge about nanotechnology.

Finally, previous research in this area has paid little attention to the potential influence of Internet use for science and its potential relationship with public perceptions and understanding of science and technology. The Internet may play an important role in promoting public understanding of new technologies because it can provide cutting-edge information that has not found its way into traditional mass media yet. In the 2001 NSF Science Indicators survey, for instance, respondents reported that the Internet was more helpful than other mass media for additional information about specific scientific issues.[33]

Even though the relationship between Web science use and science knowledge has yet to be empirically tested, the educating roles of mass media use for science information may be applied to the Internet as well. Therefore, we hypothesize:

H5: Web science use will be positively associated with knowledge about nanotechnology.

Science Media Use and Deference toward Scientific Authority

In addition to informing the public, science media can cultivate images of science and scientists in our minds and therefore influence our perceptions of whether they can be trusted or not.[34] Media also directly influence deference toward scientific authority.[35]

Although a group of cultivation studies focusing on entertainment media[36] has reported that science, technology, and scientists are depicted as dangerous or out of touch with the mainstream, a growing number of studies have found that scientists are often described as important authority figures in science-specific programs, which highlights the importance and benefits of science.[37] In turn, these positive descriptions can also influence people's willingness to defer to scientific authority when forming attitudes about scientific issues.[38]

In the case of nanotechnology, it may be reasonable to assume that the positive nature of coverage so far and the novelty of the technology also help to increase levels of deference toward the authority of scientists currently working in this area. Gaskell, Ten Eyck, Jackson, and Veltri,[39] for example, indicated that U.S. mass media tend to frame nanotechnology in more positive terms than the U.K. mass media, focusing on its economic and commercial benefits. These results suggest that it is possible for the public to have relatively positive images about scientists and the science community associated with nanotechnology at this point. In their early study, Gorss and Lewenstein[40] found that in contrast to issues such as biotechnology "public accountability" was a dominant frame during the early stages of news coverage. They also suggested that this frame could also raise concerns about the credibility of scientists. Friedman and Egolf's initial analyses of nanotech coverage showed that "overall only mild concern about potential health and environmental nanotech risks was expressed between 2000 and 2004."[41]

However, no prior research, to our knowledge, has examined the differential effects of science media channels on deference toward scientific authority. Therefore, these differential effects are left as open-ended research questions.

RQ1: What is the link between television science use and deference toward scientific authority?

RQ2: What is the link between newspaper science use and deference toward scientific authority?

RQ3: What is the link between Web science use and deference toward scientific authority?

Methods

In the fall of 2004 we conducted a national telephone survey (N = 706). The cooperation rate (based on definition CR-1 of the American Association for Public Opinion Research) was 43%. The survey was based on a probability sample that minimizes sampling and non-

response biases. We were particularly concerned about systematic non-response as a result of the scientific nature and novelty of the topic (i.e., people who chose to respond are more interested in nanotechnology and related issues and people less aware or less interested refused to participate). This would skew our descriptive statistics and potentially introduce biases in the reported multivariate relationships. We therefore invested significant resources in multiple call-backs for non-contacts and initial refusals in order to minimize non-response.

Dependent Measures. We measured *public attitudes toward nanotechnology* by asking respondents to rate themselves on two ten-point scales (1 = "not at all," 10 = "very much") tapping respondents' agreement with the statements: "Overall, I support the use of nanotechnology" and "Overall, I support federal funding for nanotechnology" (Cronbach's α= .82, M = 11.38, sd = 5.13). We used the negative association with people's *judgments about risks of nanotechnology compared to its benefits* (r = -.45, $p < .001$) as a criterion to judge the validity of our measure of public attitudes toward nanotechnology on the assumption that a valid measure of public attitudes toward nanotechnology would be expected to negatively relate to judgments about risks of nanotechnology compared to benefits.[42]

Antecedent Variables. Our regression path model includes three communication variables. The first is *television science use,* which includes self-ratings on two ten-point exposure items (1 = "not very often," 10 = "all the time") and two ten-point attention items (1 = "little attention," 10 = "very close attention"): (1) exposure to TV stories related to science and technology and (2) exposure to TV stories about specific scientific developments, such as nanotechnology; (3) attention to TV stories related to science and technology and (4) attention to TV stories about specific scientific developments, such as nanotechnology (α= .94, M = 16.66, sd = 10.61).

Second, *newspaper science use* includes the following six items: (1) exposure to newspaper stories related to science and technology; (2) exposure to newspaper stories about specific scientific developments, such as nanotechnology; (3) exposure to stories about the investment and market potential of specific technologies; (4) attention to newspaper stories related to science and technology; (5) attention to newspaper stories about specific scientific developments, such as nanotechnology; and (6) attention to stories about the investment and market potential of specific technologies (α= .95, M = 24.34, sd = 16.96).

Web science use includes four items: frequency of Web use for (1) information related to science and technology, (2) information about specific scientific developments, such as nanotechnology, (3) information about scientific studies in new areas of research, such as nanotechnology, and (4) information about the investment and market potential of specific technologies (α= .93, M = 8.70, sd = 9.46).

Mediating Variables. We measured two mediating variables: *knowledge about nanotechnology* and *deference toward scientific authority.* First, knowledge about nanotechnology was operationalized as an additive index of six dichotomous items, asking respondents to indicate if the following statements were correct: (1) Nanotechnology involves materials

TABLE 1

Predicting Public Attitudes toward Nanotechnology

	Zero-order Correlation	Before-Entry Beta	Final Beta
Block 1: Demographics			
Age	-.09*		-.02
Gender (Female Coded High)	-.23***		-.14***
Education	.19***		.06
Income	.18***		.04
Incremental R^2 (%)		9.00***	
Block 2: Science Media Uses			
TV Science Use	.36***	.31***	.19***
Newspaper Science Use	.33***	.28***	.11**
Web Science Use	.28***	.20***	.05
Incremental R^2 (%)		11.50***	
Block 3			
Knowledge about Nanotechnology	.21***	.10*	.07*
Deference toward Scientific Authority	.41***	.31***	.31***
Incremental R^2 (%)		9.50***	
Total R^2 (%)			30.00***

Note:
* $p < .05$; ** $p < .01$; *** $p < .001$

that are not visible to the naked eye; (2) U.S. corporations are not using nanotechnology yet to make products sold today; (3) experts consider nanotechnology to be the next industrial revolution of the U.S. economy; (4) a nanometer is a billionth of a meter; (5) nanotechnology allows scientists to arrange molecules in a way that does NOT occur in nature; and (6) a nanometer is about the same size as an atom (KR-20 = .56, M = 3.90, sd = 1.55). Given the dichotomous nature of these scaled items, the moderate reliability for these two variables is not surprising.

Second, deference toward scientific authority was an additive index of three ten-point items that measured agreement with the following statements: "Scientists know best what is good for the public," "It is important for scientists to get research done even if they upset people by doing it," and "Scientists should do what they think is best, even if they have to persuade people that it is right" (α= .65, M = 14.67, sd = 6.13).

Analysis Procedures. In order to test our hypotheses and research questions, we conducted ordinary least squares (OLS) regression analysis as a first step. Then, a path model was specified that incorporated the links discussed in the literature review and presented in Figure 1 with the influence of four relevant exogenous demographic variables controlled. Specifically, we included age (M = 50.02, sd = 17.72), gender (58.5% females), education (median: some college education), and

income (median household income between $30,000 and $50,000). As Asher[43] and Cohen and Cohen[44] described, our path model—a graphic representation of the links among the key variables in this study—was tested using simultaneous regression path modeling.

Results

Our first regression model examined public attitudes toward nanotechnology as the criterion variable (see Table 1). Demographic controls such as age, gender, education, and income accounted for about 9% of the variance. Even after these controls, the significant before entry betas indicated that television science use and newspaper science use along with Web science use were positively associated with public attitudes toward nanotechnology. As expected, both knowledge about nanotechnology and deference toward scientific authority showed positive links to public attitudes toward nanotechnology, supporting **H1** and **H2**.

Figure 1 presents a graphic display of the results of the full path model. Among science media use variables, newspaper science use and Web science use were found to have a significant link to knowledge about nanotechnology even after adjustment for demographics, indicating support for **H4** and **H5**. In contrast, our data did not support **H3**, which predicted that television science use would be positively related to knowledge about nanotechnology.

Television science use showed a significant positive link to deference toward scientific authority. However, the links between newspaper science use and Web science use and deference toward scientific authority were not statistically significant.

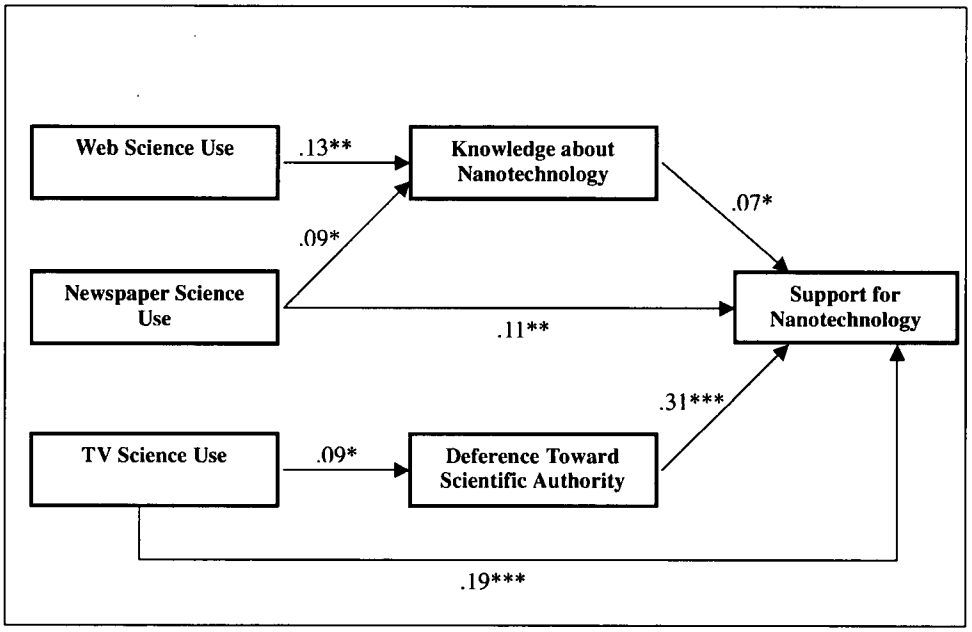
In terms of mediating relations, we found that television science use was indirectly associated with public attitudes toward nanotechnology through deference toward scientific authority. However, the direct relationship between television science use and public attitudes toward nanotechnology (ß = .19) was also significant, providing evidence that deference toward scientific authority partially mediated the relationship between television science use and public attitudes toward nanotechnology. Notably, this indirect pathway suggests that television science use seems to exert *affective* influences on people in terms of their attitudes toward emerging science and technology.

The relationship between newspaper science use and public attitudes toward nanotechnology, in contrast, was based more on cognitive pathways. That is, the significant indirect relationship between newspaper science use and public attitudes toward nanotechnology showed that newspaper science use seems to have positive influences on public attitudes toward nanotechnology by increasing knowledge about nanotechnology. However, this mediation hypothesis was also partially supported because the direct relationship between newspaper science use and public attitudes toward nanotechnology (ß = .11) was statistically significant.

Interestingly, we found that Web science use was indirectly related to public attitudes toward nanotechnology through knowledge about nanotechnology. However, the direct relationship between Web science

FIGURE 1

Mapping the Pathways to Public Attitudes toward Nanotechnology



Notes:
(1) The coefficients of demographics are not shown.
(2) * $p < .05$; ** $p < .01$; *** $p < .001$
(3) All coefficients are based on OLS regression path analyses.

use and attitudes toward nanotechnology was not statistically significant, indicating complete mediation.

Overall, about 11% of the variance in knowledge about nanotechnology was accounted for by four demographic variables and three science media use variables. Also, 6% of the variance in deference toward scientific authority was accounted for by these seven variables, and 30% of the variance in public attitudes toward nanotechnology was accounted for by just nine variables.

Discussion

Our study demonstrated the mechanisms by which people form their attitudes toward nanotechnology. Of course, these findings need to be interpreted within the constraints of the data we used in this study. A few issues, in particular, need to be addressed.

First, it is possible that people's knowledge about nanotechnology and their deference toward scientific authority promote their use of certain media channels for science information acquisition, rather than the reverse. In a cross-sectional dataset, however, it is problematic to test reciprocal or a two-way relationships using two-stage least squares

regression (2SLS) or similar analytic techniques, since such tests show a static snap-shot of "only one half of the loop"[45] and require fairly narrow assumptions about instrumental variables that differentially predict the two reciprocally-linked variables. Based on our theoretical model, we are therefore emphasizing the one-way impact of media use on nanotechnology knowledge and deference toward scientific authority in this study. In order to confirm the causal order, additional analyses using panel data or experimental designs will be needed in the future. Cross-sectional data do not allow us to answer this question conclusively.

Second, one could argue that our models do not explore all potential antecedents of science media use and that our analyses therefore do not paint a comprehensive picture of the pathways leading to attitudes toward nanotechnology. This is accurate. People may use the media for information about topics that are relevant to them or that fit their interests.[46] Previous research in this area[47] has also established that there is a science active or attentive public and this science issue public may be more likely to seek science information from newspapers and the Internet, whereas the passive public is more likely to get science information from television if it gets it at all. In the present study, we were faced with a trade-off between parsimony and a granular focus on specific aspects of our model, on the one hand, and an all-encompassing model, on the other hand, that would have provided a broader and less fine-grained overview of the different factors shaping public attitudes. Both are important for understanding the process of opinion formation about scientific issues, but we opted for the former in this particular study.

Third, the media's role as an important influence on attitudes toward science is, at least in part, due to long-term, cumulative effects, such as cultivation. One-shot cross-sectional models like the one presented in this study fail to adequately capture these dynamic media effects.

Nonetheless, most studies testing these theories have assessed exposure only at one point in time but use it as if it were an estimate of longer term exposure. This is partly because of practical reasons, such as panel survey cost, etc. All of these cross-sectional designs, of course, are based on the assumption that their one-shot measures represent likely exposure before and after the moment of measurement. And, in fact, Lee and Hornik[48] found that general media exposure measures are highly stable, i.e., that they provide an estimate of consistent exposure over time. Even though their measures are somewhat different from the media use variables used in this study, their results further strengthen our confidence in the stability of our media use measures.

Despite these limitations, our study provided very important insights into the distinct pathways to public attitudes toward emerging technologies. Two findings deserve highlighting.

First, science media use had *direct* links with public attitudes toward nanotechnology as well as indirect effects through knowledge and deference toward scientific authority. The significant coefficients between television science use, newspaper science use, and public attitudes toward nanotechnology survived even after knowledge about nanotechnology

and deference toward scientific authority were entered in the model. Only the effects of Web science use on public attitudes toward nanotechnology were completely mediated by nanotechnology knowledge. These findings can be explained by the possibility that there was another important mediating variable not included in our study. Therefore, future research in this area should consider other potential mediating variables across cognitive and affective factors in order to clearly understand how people form their attitudes toward emerging technologies. These direct influences of science media use, however, are not surprising in that they are consistent with the previous findings that mass media directly affect public acceptance of science and technology through use of interpretative narratives or frames.[49]

Second, the coefficient between knowledge about nanotechnology and public attitudes toward nanotechnology is statistically significant but quite weak. As discussed earlier, this is partly due to the fact that nanotechnology remains within the early stage of the issue cycle, and, therefore, mass media tend to focus only on a narrow range of the aspects associated with nanotechnology.[50] However, if nanotechnology evolves through the issue cycle, mass media will use more frames through which nanotechnology is covered and accordingly convey more aspects of nanotechnology to the public. Therefore, people will be also exposed to more and more negative or complex information about nanotechnology. Given that our study focused only on the early stage when nanotechnology is located within the administrative policy arena, before moving into the political policy arena, modeling and testing the process of how people's knowledge, deference toward scientific authority, and attitudes toward emerging technologies change over time might be worthwhile.

The most important contribution of our study is the examination of the different pathways that specific media take in explaining public attitudes toward nanotechnology. We found that television science use is associated with public attitudes toward nanotechnology through deference toward scientific authority, whereas the influences of newspaper science use are at least partly mediated by nanotechnology knowledge. It should be noted that despite the concern over sensational journalistic practices,[51] newspaper science use positively affects people's science knowledge. In contrast, television science use was not significantly linked to nanotechnology knowledge.

Why is that? One explanation is based on certain characteristics of television news production. Iyengar[52] showed that television news tends to take an episodic approach, focusing on individual cases and events while newspaper articles tend to frame stories more thematically. Even when reporting public issues, television usually frames them in terms of personal and human interest. Also, the issues that need more systematic examination (e.g., controversial or emerging science and technology) are likely to be excluded from television news programs. In this sense, the episodic frames may prevent audiences from learning scientific issues by causing confusion and uncertainty among the public.

In contrast, newspapers present considerably more contextual information than television news at least because the former has much more news space.[53] Graber[54] further insisted that newspapers' inverted pyramid format is conducive to readers' learning by making important information more prominent in a news text. Therefore, the newspaper enjoys an advantage in its informational role while television exerts its primary impact on public attitudes toward science and technology through affective pathways.

With regard to the role of Web science use, our expectation that people would use the Internet as a complementary tool for gathering additional information about emerging technologies was supported. At this point, mass media coverage of nanotechnology is minimal, and, therefore, people seem to rely upon alternative media (i.e., the Internet), through which they can actively search for additional and in-depth information regarding nanotechnology.

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