172. Understanding the Roles of Value Predispositions, Mass Media, and Cognitive Processing in Public Attitudes toward Nanotechnology

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Abstract. This study examines how value predispositions, communication variables, and perceptions of risks and benefits are associated with public support for federal funding of nanotechnology. Our findings show that highly religious individuals were less supportive of funding of nanotech than the less religious individuals, whereas individuals who held a high deference for scientific authority were more supportive of funding of the emerging technology than those low in deference. Mass media use and elaborative processing of scientific news were positively associated with public support for funding, whereas factual scientific knowledge had no significant association with policy choices. We conclude with policy implications that will be useful for policymakers and science communication practitioners.
Keywords: Mass media; Elaborative processing; Interpersonal discussion; Risk; Nanotechnology

Introduction

Nanotechnology is projected by the federal government to be the defining technology of the twenty-first century, with the potential to drive our next industrial revolution (National Science and Technology Council 2000). According to the 2006 State of the Union Speech by President George W. Bush, nanotech is among the emerging technologies for which funding will be doubled over the next ten years in the United States. With wide applications cutting across important sectors such as medicine and healthcare, environment, and national defense, nanotech promises to overcome many of the challenges that the world faces today (National Science and Technology Council 2000). In 2007 alone, $147 billion worth of nanotech-enabled products were produced in the market and the annual global revenue of nanotech-based products is expected to reach $3.1 trillion by 2015 (Lux Research 2008). Despite this, there are fears that the novel technology could lead to various health and environmental problems, and other negative social, moral, and ethical consequences (Bainbridge 2003; Sententia 2004; PCAST 2005).

Currently, the American public is unaware of the potential risks and benefits of this emerging technology (Scheufele and Lewenstein 2005). Public opinion about nanotech is likely to have a bearing on future funding-related policies (Roco and Bainbridge 2003). Although the U.S. is currently leading the “nano race” in terms of public and private funding (European Commission 2005), this technological supremacy may be threatened if public attitudes toward nanotech were to turn negative. For example, if funding and infrastructure support for nano-scientists in the U.S. were insufficient, they may choose to relocate their research base to other countries with more attractive funding opportunities. Ensuring constant funding initiatives for nanotech will enable the U.S. to remain competitive in the international arena and to sustain a positive climate for science and technology in the country. Since the public is primarily unfamiliar with nanotech at this early stage, examining the mechanism behind how public form attitude toward support for federal funding of nanotech is pertinent.

Thus far, there are two lines of assertions that explain how the public form attitudes toward nanotech. First, the "familiarity hypothesis" asserts that public support for nanotech will likely grow as awareness or knowledge of it expands. Using meta-analyses of public opinion studies of nanotech, Satterfield et al (2009) have demonstrated that familiarity with nanotech is correlated with positive attitudes toward it, in which members of the public who claim to know a lot about nanotech were substantially more likely to believe its benefits outweigh its risks. Conversely, the predisposition argument asserts that personal values and heuristics could play a bigger part in shaping public attitudes toward nanotech. For example, individuals who hold a pro-science and technology orientation are predisposed to seek out scientific information from the mass media, to discuss science with others, which in turn, produces positive attitudes toward nanotech (Vandermoere et al. 2009).

Since these arguments are far from conclusive, this study aims to use a holistic approach to examine how both cognitive and heuristic factors can potentially shape public level of support for federal funding of nanotech. Previous research have shown that public attitudes toward emerging technologies are associated with value predispositions such as religious beliefs and deference to scientific authority, and other heuristic cues such as risk and benefit perceptions (e.g., Ho et al. 2008; Nisbet et al. 2002; Priest 2001; Priest et al. 2003). Scholars have also shown that the public often rely on positive frames and/or information in the media to form favorable attitudes toward nanotech (e.g., Brossard et al. 2009; Lee et al. 2005; Scheufele and Lewenstein 2005).

In addition, individuals' use of cognitive processing strategies to reflect upon and absorb the scientific information that they gathered from the mass media can also be associated with their acceptance of the new technology. Scientific knowledge has been demonstrated to have a small association with public acceptance of emerging technologies (e.g., Miller et al. 1997; Miller and Kimmel 2001). We will therefore examine how these factors are associated with public support for funding of nanotech in this study.

Value predispositions

Religious guidance is a likely heuristic cue in which the public will depend on to form judgments about nanotechnology. Recent research has shown that religious guidance is one of the major factors associated with public resistance to emerging science and technologies (Brossard et al. 2009; Gaskell et al. 2005; Ho et al. 2008; Nisbet 2005). This is hardly surprising given the historical intransigence and normative inconsistencies between religion and science (Brooke 1998; Miller et al. 1997). One explanation for this tension has to do with the perception that science tampers with nature or is akin to playing God, putting it at odds with religious beliefs (Sjoberg 2004; Sjoberg and Winroth 1986).

Nanotech is not spared from the potential friction between religion and science. The U.S. Food and Drug Administration officially defined nanotech as part of the Nano-Bio-Info-Cogno (NBIC) technologies that highlight the unity of nature at the nanoscale, and the intelligible processes of evolution that have constructed life and intelligence, from the nanoscale, without divine intervention (Bainbridge 2003; Sententia 2004). Bainbridge (2003) argued that this all-inclusive approach to nanotech may go against people's religious beliefs and reduce their support for the emerging technology.

Brossard et al. (2009) found a negative relationship between the strength of religious beliefs and support for funding of nanotech among the U.S. public. They concluded that people use religiosity as an attitudinal filter when it comes to forming opinions about the new technology. Religious people may lump nanotech, biotech, and stem cell research together and perceive them as means to enhance human qualities. In short, some people may believe that researchers are "playing God" when they create materials that do not occur in nature, especially where nanotech and biotech intertwine. Based on these considerations, we therefore hypothesize that religious beliefs will be negatively associated with public support for federal funding of nanotech (Hypothesis 1).

Deference to scientific authority is another value predisposition that can be associated with attitudes toward science and technology (Brossard and Nisbet 2007; Ho et al. 2008). Deference to scientific authority is defined as "a long-term socialized trait that guides citizens' responses to a range of technical controversies" (Brossard and Nisbet 2007, p. 10). Studies have demonstrated that the more individuals defer to scientific authority, the more likely they were to hold positive views on controversial scientific issues (e.g., Brossard and Nisbet 2007; Ho et al. 2008). The American educational system has instilled a strong sense of respect for scientists and scientific institutions among the citizens, and this has fostered a culture of deference to scientific authority in the U.S. These have been reflected in education that involved teaching people to view scientific research as solitary activities that are kept away from external social and political pressures (Bimber and Guston 1995), and to perceive science as a pure and unbiased pursuit that increases our knowledge about the world (Irwin 2001). Hence, we posit that deference for scientific authority will be positively associated with public support for federal funding of nanotech (Hypothesis 2).

Mass media

The mass media is the main source of information about science and technology for majority of the public (Pew Internet and American Life Project 2006), and media coverage have been shown to play an important role in shaping public attitude toward science and technology (Ho et al. 2007, 2008; Nisbet et al. 2003; Nisbet and Lewenstein 2002). In a content analysis of the New York Times from 2000 to 2003, Gaskell et al. (2004) found an overwhelming coverage of benefits than risks for nanotech, and concluded that “media coverage is more slanted towards a supportive culture of science and technology in the U.S.” (p. 496)

Likewise, by examining nanotech coverage in major U.S. and non-U.S. newspapers published from 1988 through 2004, Stephens (2005) found that the proportion of articles in which benefits outweighing risks (versus risks outweighing benefits) is three to one. Friedman and Egolf (2005) shown that even when health and environmental risks were covered in the U.S. newspapers, most of the articles published were balanced and described risks with both positive and negative information. The researchers concluded that news coverage in the U.S. would positively influence public opinion about nanotech (see also, Scheufele and Lewenstein 2005).

Besides this, some scholars have argued that the tone of media coverage of nanotech can serve as a simple decision rule in influencing the risks and benefits considerations among the public (Nisbet and Scheufele 2007; Scheufele and Lewenstein 2005). This is manifested in the form of media frames in which audiences use these heuristic cues as shortcuts for processing new information in a short time (Scheufele 1999). Studies have shown that framing of nanotech has an effect on how audience perceived risks and benefits of the technology (e.g., Cacciatore, Scheufele and Corley, 2009; Cobb 2005; Schutz and Wiedemann 2008).

In essence, the mass media has a dual function. On one hand, the media are information providers that offer a source of informal learning about emerging science for most Americans. On the other hand, media frames such as the positive tone of coverage about nanotech offer audience the heuristic cues to make quick decisions about the technology (Scheufele and Lewenstein 2005). Given the overall positive content and valence of the news media on nanotech over the past few years, we postulate that mass media use will be positively associated with public support for federal funding of nanotech (Hypothesis 3).

Elaborative processing and interpersonal discussion

Going beyond mass media use, individuals’ cognitive processing in the form of reflective integration (i.e., news elaboration and interpersonal discussion about scientific issues) can be associated with public attitude towards nanotech. Cognitive information-processing strategies are defined (Kosicki and McLeod 1990) as “tactics that individuals use to try to cope with the amount and kind of mass media information that they encounter in their everyday lives” (p. 73). Most people are cognitive misers who tend to engage in reflective integration to sift out media messages that are useful to them. Specifically, reflective integration consist of thinking about a specific issue covered in the mass media (i.e., news elaboration) and talking about it with others by connecting it with preexisting knowledge (i.e., interpersonal discussion) (Eveland 2001, 2002; Eveland and Thomson 2006).

Elaboration is a behavioral style that people use to associate new ideas and information with what is already known, look for similarities with past experiences, and find ways to apply the information (Eveland 2002). Any new information incorporated into a pre-existing knowledge structure through the process of news elaboration will promote a deeper understanding of the scientific world. Likewise, interpersonal discussion (Kosicki and McLeod 1990; Scheufele 2001, 2002) involves talking to other people about mass-mediated issues, discussing the pros and cons, and weighing alternatives to reach a conclusion. Discussions with family, friends, neighbors, and co-workers are likely to reinforce mass media effects (Johnson 1993). Since the media has on the most part portrayed nanotech and science in general favorably, interpersonal discussion about science and nanotech should reinforce this perspective.

Reflective integration can promote a deeper understanding of the scientific world and provide a stronger cognitive base and sophisticated knowledge structure for opinion formation about scientific issues than simple factual, textbook-style scientific knowledge. By sophisticated knowledge, we are referring to the ability of individuals to associate, integrate, and relate various news issues or topics, which will also include the knowledge of how concepts within a specific domain are interrelated. We therefore hypothesize that elaborative processing will be positively associated with public support for federal funding of nanotech (Hypothesis 4) and that science discussion will be positively associated with public support for funding (Hypothesis 5).

Factual scientific knowledge

Scientists and policymakers have assumed that greater scientific literacy enables individuals to sort through the misinformation and extraordinary claims that emerge during scientific disagreements (Bodmer 1985). Scholars also assume that highly knowledgeable public would be more supportive of scientific research (Miller 1998, 2004). Scientific knowledge has been shown to have direct positive relation with public perceptions of scientific issues

(Brossard et al. 2005; Nisbet et al. 2002; Sturgis et al. 2005), and to have contingent associations with public attitudes toward science and technology (e.g., Brossard et al. 2009; Ho et al. 2008; Sturgis and Allum 2004). However, some studies have shown that factual scientific knowledge had little or no relationships with public acceptance of new technologies (e.g., Allum et al. 2005; Priest 2001).We therefore pose the following research question: How will scientific knowledge be associated with public support for federal funding of nanotech? (Research Question 1)

Trust in scientists

Trust refers to citizens' willingness to rely on the endorsements of experts, such as scientists and regulators, as well as institutions such as the federal government, to manage risks associated with emerging technologies (Earle and Cvetkovich 1995; Giddens 1991; Luhmann 1979; Sztompka 1999). Giddens (1991) pointed out that trust in a variety of abstract systems is a necessary part of everyday life, and the characteristics of abstract systems imply constant interaction with "absent others" – people we have never met but whose actions directly affect our lives. Irwin and Wynne (1996) demonstrated that people were much more concerned with whom to trust than with the scientific aspects of an issue itself. Trust is a state-like disposition which acts as an uncertainty reduction mechanism, driving down citizens' concerns over the unforeseen risks and costs of emerging science and technologies (Freudenburg 1992,
1993; Slovic 1999), thereby enabling citizens to form judgments about emerging technology without understanding the risks involved.

Numerous studies found trust in relevant actors to be positively associated with support for emerging science such as biotech (Brossard and Nisbet 2007; Brossard and Shanahan 2003; Priest 2001; Priest et al. 2003; Sinclair and Irani 2005), gene technology (Siegrist 2000), stem cell research (Ho et al. 2008), and nanotech (Ho et al. forthcoming; Lee et al. 2005). Trust as a tool in decision-making is efficient when individuals have limited knowledge and personal experience, and when they have little chance to anticipate the future consequences of a particular technology (Olofsson et al. 2006). This is highly applicable to the emerging nanotech field with which most people are unfamiliar with. Therefore, it is likely that trust in scientists will be positively associated with public support for funding of nanotech (Hypothesis 6).

Perceptions of risks and benefits

Public perceptions of risks and benefits can be related to their decision-making about funding for nanotech. Coming from the psychometric approach, Slovic (1987) defines risk perceptions as "the judgments people make when they are asked to characterize and evaluate hazardous activities and technologies" (p. 280). Research have shown that the public tend to perceive hazards as risky if they are not within their control (Starr 1969), seem "dreadful" and "novel" (Fischhoff et al. 1978), and interfere with nature (Sjoberg 2002). The more individuals perceive a hazard or a technology as risky, the less likely they are to accept it.

Numerous studies have found that perceived risks and benefits are associated with levels of acceptance of technology (Frewer et al. 1998; Siegrist 2000; Siegrist et al. 2000; Sjoberg 2002, 2004). For example, Siegrist (2000) demonstrated that while perceived benefits was positively associated with acceptance of gene technology, perceived risks was negatively associated with support for the technology. Sjoberg (2004) opined that outright rejection of an emerging technology is often a function of perceived high risks in the technology per se. Given the fact that the "real" risks are not apparent for nanotech at the current stage of its development, and media coverage of this emerging technology is overwhelmingly positive, simply examining risks perception without consideration for the perceived benefits of the technology would preclude us from gaining a full understanding of public opinion. Hence, it is worthwhile to examine the relationship between perceptions of risks and benefits and public support for funding of nanotech. We hypothesize the following: Perceived risks will be negatively associated with public support for federal funding of nanotech (Hypothesis 7) and perceived benefits will be positively associated with public support for federal funding of nanotech (Hypothesis 8).

Methods

Our data came from a nationally representative random-digit-dial telephone survey of U.S. adult respondents aged 18 years and over (N = 1,015). The University of XXX Survey Center conducted the fieldwork between May and July 2007 with an average length of 21.47 minutes per interview. The margin of error was approximately +/ 3%. A significant amount of time and effort were put into call-backs and refusal conversions to minimize systematic non- response. The overall response rate for this survey was 30.6% (based on AAPOR response rate formula 3).

Hierarchical OLS regression analysis was used to investigate the relationships between the independent variables and public support for funding of nanotech. The variables were entered into the regression model based on their assumed order: the control variables (i.e., age, gender, and SES) were entered in the first block, followed by value predispositions (i.e., religious beliefs and deference to scientific authority), mass media use, reflective integration (i.e., elaborative processing and science discussion), factual scientific knowledge, and finally, other perceptions (i.e., trust in scientists and risks and benefits perceptions of nanotech).

Results

Table 1 shows the hierarchical OLS regression analysis for support for federal funding of nanotech. The results show that all the control and independent variables were significantly correlated with public support for funding of nanotech at the zero-order level, indicating potential multivariate relationships between them.

The first block of final standardized beta coefficients indicates the role of the demographic variables. Age, gender, and SES were initially correlated with support for funding at the zero-order level, but the significant associations were fully explained away by the independent variables that were subsequently entered into the regression model. The demographic block accounted for 6.80% of the variance in the model.

Table 1. Hierarchical OLS Regression Analysis for Public Support for Federal Funding of Nanotechnology

Variables	Zero-Order Correlations	Final Standardized Beta
Block 1: Demographics		
Age	-.15***	-.05
Gender	-.10***	-.01
SES	.23***	.04
Incremental R2 (%)		6.80***
Block 2: Value Predispositions		
Religious beliefs	-.21***	-.09***
Deference to scientific authority	.29***	.12***
Incremental R2 (%)		9.30***
Block 3: Mass Media		
Mass media use	.33***	.07*
Incremental R2 (%)		5.70***
Block 4: Reflective Integration		
Elaborative processing	.31***	.06*
Science discussion	.28***	.05
Incremental R2 (%)		2.80***
Block 5: Knowledge		
Factual scientific knowledge	.22***	.00
Incremental R2 (%)		.00
Block 6: Other Perceptions		
Trust in scientists	.43***	.13***
Perceived risks	.06*	

-.10** Perceived

benefits .54***

.40*** Incremental R^2 (%)

14.50*** Total R^2 (%)

39.30***

*p<.05. **p<.01. ***p<.001.

When it comes to value predispositions, the negative final standardized beta coefficient shows that highly religious individuals were significantly less supportive of nanotech funding than the less religious individuals. Conversely, the positive beta coefficient indicates that individuals who had a high deference for scientific authority were significantly more supportive of funding of the emerging technology than those low in deference. Hence, both H1 and H2 were supported. The value predispositions block explained 9.30% of the variance in our model.

After controlling for the demographics and value predispositions, our results show that mass media use and elaborative processing were positively associated with public support for funding. However, interpersonal discussion of scientific issues had no significant association with the dependent variable. Therefore, H3 and H4 were supported, but not H5. The science media use and reflective integration blocks accounted for a combined 8.50% of the variance in public support for funding. With respect to RQ1, our results indicate that factual scientific knowledge had no significant association with policy choices.

Finally, the positive beta coefficients indicate that individuals who had a lot of trust in scientists were more supportive of nanotech funding than those who had a low trust in scientists. Perceptions of risks were negatively, while perceptions of benefits were positively associated with public support for funding of nanotech. This supported H6, H7, and H8. The final block accounted for 14.50% of the variance in our dependent variable. In total, the factors explained 39.30% of the variance in our model.

Discussion

This study examined the associations of value predispositions, mass media use, reflective integration, factual scientific knowledge, trust in scientists, and risks and benefits perception with public support for federal funding of nanotech. Overall, our findings provide support for the hypothesis that mass media use had a positive association with public support for federal funding of nanotech. Notably, the results support the hypothesis that elaborative processing was positively associated with public attitude towards nanotech. Heuristics in the form of value predispositions, trust, and risks and benefits perceptions were also shown to have bearings on public support for funding. Taken together, these findings underscore the important roles of cognitive and heuristic cues when it comes to understanding how the public form attitude towards emerging technologies. Using this holistic approach, the findings are useful for designing more effective science communication and public outreach efforts.

Consistent with results from previous studies (e.g., Brossard et al. 2009; Ho et al. 2008; Nisbet 2005), this study showed that religious belief was negatively related to public support for federal funding of the emerging technology. The normative contradictions between science and religion (Brooke 1998; Miller et al. 1997) may be an explanation for the relationships found between religious guidance and acceptance of nanotech. In addition, the fact that religious people may perceive nanotech, biotech, and stem cell research together as means to enhance human qualities, hence tampering with nature by playing God (Sjoberg 2004; Sjoberg and Winroth 1986) may plausibly explain the negative relationship.

On the other hand, individuals' deference for scientific authority and trust in scientists are two positive factors associated with public acceptance of nanotech, consistent with findings from previous research (Brossard and Nisbet 2007; Ho et al. 2008; Lee et al. 2005). Again, these findings are not surprising because, as tools in decision-making, deference for scientific authority and trust in scientists are efficient when knowledge and personal experience are limited, especially when it comes to nanotech. In addition, the independent effects of deference to scientific authority and trust in scientist on public attitudes toward nanotech suggest that researchers should adopt a fine-grained approach to examine these concepts separately in future studies as they are essentially different entities.

Next, this study shows that the public utilize positive frames derived from the mass media as heuristic cues to make decision about acceptance of the emerging technology, which is congruent to results of previous studies (Brossard and Nisbet 2007; Lee and Scheufele 2006; Lee et al. 2005; Scheufele and Lewenstein 2005) and consistent with framing effects of the media (Kahneman and Tversky 1979; Scheufele 1999). This could plausibly be explained by the fact that media outlets are the major gateway to nanotech for most Americans (Castellini et al. 2007) and that the tone of media coverage of nanotech has been overwhelmingly optimistic in the past few years (Bainbridge 2002; Gaskell et al. 2004).

Besides this, elaborative processing plays an important role in shaping public support for federal funding of the new technology. This could be explained by the fact that people who actively process and synthesize information from the mass media build a larger knowledge structure about science generally, and nanotech specifically, in their memory. This new scientific information could be easily accessed for people to formulate judgments about nanotech acceptance. Nanotech has been covered in overwhelmingly positive light in the mass media and it is therefore, not surprising that these positive information become part of the audience memory when audiences reflect and integrate the materials they attended to in the news.

Contrary to our expectation, scientific discussion was not found to be significantly associated with public support for federal funding of nanotech. Interpersonal discussion with others about scientific issues was initially correlated with support for funding at the zero-order level, but the relationship was explained away by other variables (e.g., perceived risks and benefits) that were subsequently entered into the regression model. Another plausible explanation may be that people may not be talking about nanotech per se in their discussions about scientific issues, and therefore the association with attitude towards the emerging technology is not strong.

Consistent with results of previous studies (e.g., Brossard et al 2009), individuals who perceived greater risks of nanotech were less supportive of nanotech funding, while those who perceived greater benefits were more supportive of funding for nanotech. This suggests that the public rely on risks and benefits perceptions as heuristic cues to form judgment about nanotech.

This study has important policy implications that will be useful for policymakers and science communication practitioners. Given that there are various groups that have different opinions about nanotech (such as the highly religious public), science communication practitioners should adopt the target segmentation strategy, in which communication messages are tailored to fit with publics from different social backgrounds for maximum effect. For example, to reach out to the religious public, scientific institutions should strengthen partnerships with religious institutions by arranging scientists to speak on topics related to nanotech and inviting religious leaders to address scientists on issues of concern.

At the same time, policymakers and the relevant scientific institutions should find ways to promote and instill trust in scientists and deference to scientific authority among the public (e.g., arranging eminent scientists to conduct seminars for high-school students) so as to counter the opposing force that religious guidance could potentially play in shaping opinion about nanotech. In addition, trust in nano-scientists both in academia and industry is crucial to sustain public support for nanotech. Therefore, government regulatory bodies should ensure that the necessary guidelines are in place (e.g., guidelines to manage toxicity related to nanotech and health standards for creating commercial products) so that public confidence and trust is maintained.

Given the findings that the mass media play a key role in shaping public perceptions of nanotech by providing heuristic cues and/or information, policymakers and scientists should learn to focus on framing their messages in ways that connect with diverse audience. For example, when scientists are speaking to a group of businessmen, they should emphasize the economic relevance of science by pointing out that expanded government funding would make the U.S. more economically competitive. It is important for public officials, scientists, and science communicators to pay attention to new developments in media coverage of nanotech to monitor public opinion movements, especially when the issue of nanotech enters into a different stage of the issue-attention cycle. The mass media could also be a point of intervention for public officials as they could provide accurate and up-to-date information about nanotech to the public so as to sustain positive public opinion. For example, public officials could use the mass media as an avenue, such as running campaigns and sponsoring science programs on PBS channels, to offer accurate and up-to-date information about nanotech to the public.

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