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How scientists view the public, the media and the political process

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Abstract

We review past studies on how scientists view the public, the goals of communication, the performance and impacts of the media, and the role of the public in policy decision-making. We add to these past findings by analyzing two recent large-scale surveys of scientists in the UK and US. These analyses show that scientists believe the public is uninformed about science and therefore prone to errors in judgment and policy preferences. Scientists are critical of media coverage generally, yet they also tend to rate favorably their own experience dealing with journalists, believing that such interactions are important both for promoting science literacy and for career advancement. Scientists believe strongly that they should have a role in public debates and view policy-makers as the most important group with which to engage. Few scientists view their role as an enabler of direct public participation in decision-making through formats such as deliberative meetings, and do not believe there are personal benefits for investing in these activities. Implications for future research are discussed, in particular the need to examine how ideology and selective information sources shape scientists' views.

Keywords

deficit model, media, public participation, scientists' attitudes

1. Introduction

The first issue of *Public Understanding of Science* in 1992 included a suggestion that science communication scholars "supplement our studies and activities on the understanding of science by the public, with studies and activities on the understanding of the public by scientists" (Levy-Leblond, 1992: 20). In the last decade, a number of scholars have taken up this call using in-depth interviews,

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case studies and surveys with small samples to highlight common elements of scientists' views about the public. Bauer, Allum and Miller (2007) argue that this phase of research largely began in the mid-1990s as a critique of "scientific institutions and experts who harbor prejudices about an ignorant public" (p. 85).

In this article we review previous studies and combine our synthesis with an analysis of two large-sample surveys of scientists – one from the United Kingdom and another from the United States. Our review is intended to provide an integrated understanding of how scientists view different dimensions of the public sphere and to constructively broaden discussion beyond the mid-1990s critiques.

We believe it is increasingly important to understand how scientists form judgments about the public sphere. With strong levels of societal trust and admiration, scientists remain among the leading authorities called upon in policy debates to give media interviews, testify before political bodies or address public forums. In addition, as decision-makers at their organizations, many scientists are responsible for setting strategy, allocating resources and establishing communication priorities. Many scientists also contribute to the framing of controversies over topics such as climate change and stem cell research through blogging, political activism and other forms of public commentary, shaping societal interpretations about why an issue might be a problem, who or what is to blame and what should be done (Nisbet and Mooney, 2007; Nisbet and Scheufele, 2009). In this article, we therefore focus on connecting past scholarship with recent surveys examining (1) scientists' views of the general public, (2) scientists' views of the news media, and (3) scientists' views of the role of the public in the policy process. Based on previous studies, we use the term "scientist" as encompassing a broad array of individuals from across science-, medical- and engineering-related fields, working in research and non-research positions, holding varied levels of post-graduate degrees, and employed across the university, government, non-governmental or industry sectors.

In writing a synthesis article, we take a descriptive approach to each of the three outlined areas. This is done by first highlighting major past work, most of which is qualitative, and then integrating, where possible, the available data from the UK and US surveys of scientists. In the conclusion, we discuss several likely factors influencing scientists' views. These include social background, discipline, gender, worldviews, ideology, information sources, perceived group norms and other communication-related processes. Previous studies have identified these factors as shaping how scientists perceive risks related to technologies such as nuclear energy or nanotechnology and how such technologies should be managed and/or regulated (e.g., Barke and Jenkins-Smith, 1993; Corley, Scheufele and Hu, 2009; Jenkins-Smith, Silva and Murray, 2009; Slovic, 1999). Given that most scientists lack substantial expertise in research related to public opinion, the media or policy, these same factors are likely to play a key role in how scientists make sense of the complexities of public communication and engagement.

Background on the survey data

The first data set was collected by People Science and Policy with funding from the Royal Society, Research Councils UK, and the Wellcome Trust (Royal Society, 2006) on behalf of a study group seeking to better understand and promote science engagement. Data collection was conducted online during the fall of 2005 using a representative sample of scientists and engineers from 50 higher education institutions. The survey reported a response rate of 52% and the final data set included 1,377 scientists (sampling margin of error of about 2.6% at the 95% confidence level).

Table 1. "How much of a problem, if at all, do you think each of the following are for science in general?" (US AAAS/Pew data).

		%	Age (r^2)	Male (r^2)	Subfield	(r^2)
The public expects solutions to problems too quickly	Major	49.1	–	−.07*	Social Sci.	−.05**
					Bioscientist	.06**
	Minor	44.6	–	.07*		
	Not	6.1			Bioscientist	−.08**
					Social Sci.	.07**
The public does not know very much about science	Major	84.9	.06*	–	–	
	Minor	14.0	−.06*	–	–	
	Not	1.1	–	–	–	

*$p > .05$, **$p > .01$ (n = approximately 1,400 for age and male and 2,500 for subfield, weighted).
Source: Pew (2009).

The data were weighted to ensure that the demographics of the sample reflected the underlying population of scientists.

In addition to frequencies our analyses focus on mean comparisons for key variables as well as correlations between key variables and age ($M = 39.33$, $SD = 9.65$), gender (65% male), and self-reported subfield. The fields included are medicine (including dentistry, $n = 384$ or 26% of the sample), biological science ($n = 414$ or 28% of the sample), engineering ($n = 307$ or 21% of the sample), chemistry (including chemical engineering, $n = 79$ or 5% of the sample), physics ($n = 123$ or 8% of the sample), mathematics ($n = 59$ or 4% of the sample), and environmental sciences ($n = 113$ or 8% of the sample). Only 7 respondents (less than 1% of the sample) failed to provide disciplinary information. While data are treated as continuous when tools such as five-point scales are used, the algorithm used by SPSS to calculate correlations automatically adjusts for continuous-dichotomous (point-biserial) and dichotomous-dichotomous (*phi*) correlations.

The second data set was collected by the Pew Research Center for the People and the Press in collaboration with the American Association for the Advancement of Science (AAAS) (Pew, 2009). Online interviews were completed in early summer 2009 with randomly selected AAAS members and these data were also weighted to ensure that the sample reflected the AAAS membership (weighed $n = 2{,}535$ for sampling margin of error of about 2% at the 95% confidence level). Online and traditional mail contacts were used to achieve a response rate of 25%. One of the current authors contributed to the survey design and was provided with access to the data (Pew, 2009).

The AAAS/Pew data were analyzed in a manner similar to that of the Royal Society data. Available subfields included biological and medical sciences ($n = 1{,}293$ or 51% of the sample), chemistry ($n = 346$ or 14% of the sample), physics and astrophysics ($n = 211$ or 8% of the sample), social scientists ($n = 211$ or 8% of the sample), engineering ($n = 153$ or 6% of the sample), and geosciences ($n = 152$ or 6% of the sample). A small proportion chose not to respond, said they were not a scientist or gave "other" as their field ($n = 127$). The Pew survey includes substantial ordinal measurement (e.g., the questions in Table 1) and the correlations provided are therefore often based on dichotomous relationships.

There are several limitations with the available data. One limitation of the use of the AAAS membership as the baseline population for this survey is that the organization is specifically aimed at the "advancement" of science, increasing the likelihood that those who belong may have a different set of political views than the overall population of scientists. With an annual $70 million budget, AAAS publishes *Science* magazine and educates policy-makers, the media, the public and its members on a range of policy debates such as those over climate change and stem cell research. Many scientists may, however, forgo membership in AAAS because the chief benefit – a *Science* magazine subscription – can be read online at their workplace. Still others may disagree with some of the policy positions taken by AAAS.

While the Royal Society and AAAS/Pew surveys have been used by the organizations to inform descriptive reports, we build on these reports by analyzing the survey data in the context of previous academic research and by examining differences by background factors such as gender and discipline. By drawing on and comparing results from both surveys, we also provide a cross-national comparison of scientists' views. Findings from a 2001 survey of 1,540 scientists in Great Britain sponsored by the Wellcome Trust (MORI/Wellcome Trust, 2001) will also be cited where appropriate. We did not independently analyze these data.

2. Scientists' views of the public

What does the public know?

Of the three areas discussed here, the most common focus has been on what scientists think the public knows. Almost universally, the answer has been that scientists believe the public is inadequately informed about science topics, including food risks (De Boer, McCarthy, Brennan, Kelly and Ritson, 2005; Krystallis et al., 2007), genetic modification, (Burchell, 2007), chemicals (Burningham, Barnett, Carr, Clift and Wehrmeyer, 2007), and even aquaculture (Young and Matthews, 2007). Further, scientists believe that, except for a small minority (Blok, Jensen and Kaltoft, 2008), the public is uninterested in becoming more knowledgeable (Burningham et al., 2007). As Davies (2008) notes, these findings reflect a traditional "deficit model" of science communication that sees scientific illiteracy at the root of opposition to new technologies, environmental action and adequate science funding (for a review, see: Sturgis and Allum, 2004).

The consequence, and cause, of the public's limited scientific sophistication has also been the subject of speculation by scientists. Several studies find that scientists view the public as non-rational and unsystematic in their thinking such that they rely on anecdotes (Moore and Stilgoe, 2009; Young and Matthews, 2007) and then overreact to minor risks (Cook, Pieri and Robbins, 2004; De Boer et al., 2005; Krystallis et al., 2007). Others have found that scientists see the public as emotional (Michael and Brown, 2000), fear prone (Davies, 2008), overly focused on the sensational (Petersen, Anderson, Allan and Wilkinson, 2009), self-interested (Burningham et al., 2007; Young and Matthews, 2007) and stubborn in the face of new evidence (Burchell, 2007; Cook et al., 2004). Because of these perceived limits, scientists argue that scientific information needs to be simple, carefully worded (Cook et al., 2004), visual and entertaining (Davies, 2008; De Boer et al., 2005).

Turning to the results of the surveys, the 2001 Wellcome Trust study found that 53% of scientists said the main barrier to "greater understanding of science" among the public was lack of education. Another 35% said the problem was the media, 26% said the problem was lack of understanding about scientific processes, and 22% suggested that the problem was the lack of interest. Less than a third suggested that the problem was with scientists. Among those that reflected on their own faults, 20% argued for lack of communication skills by scientists and 11% pointed to scientists' limited interest in public communication (MORI/Wellcome Trust, 2001).

The more recent data from AAAS/Pew show that scientists agree the public knows too little about science but disagree on whether this presents a problem. As Table 1 indicates, men and social scientists were somewhat less likely to view the public's expectation of short-term solutions as a "major problem," whereas those involved in the biosciences were more likely to view such expectations as problematic. Older scientists are slightly more likely to see the problem as major.

Scientists name the public's limited capacity when describing their rationale for public engagement. The Royal Society data suggest that scientists are evenly divided on whether their work is too complicated for the public to understand. When asked to respond on the degree to which their "research is too specialized to make much sense to the non-specialist public" on a five-point scale anchored by "strongly agree" (1) and "strongly disagree" the mean response was 3.54 (SD = 1.11). Younger respondents ($r = -.10$, $p > .01$), men ($r = -.09$, $p > .01$), and those in engineering ($r = -.12$, $p > .01$), physics ($r = -.09$, $p > .01$) and math ($r = -.18$, $p > .01$) were more likely to view their research as too specialized. Those in medicine ($r = .19$, $p > .01$) and environmental science ($r = .07$, $p > .05$) appeared to view their work as more accessible to the general public (approximate n = 1,475, weighted).

In addition to concerns over the public's level of knowledge, some studies also suggest that scientists do not believe the public trusts scientists (Burchell, 2007; Young and Matthews, 2007) and can be outright hostile (Michael and Birke, 1994; Michael and Brown, 2000). The prevalence of this impression is supported by the 2001 Mori/Wellcome Trust survey that found that 44% of scientists thought the public viewed scientists as uncommunicative, 46% thought scientists were seen as secretive, and 58% said scientists were seen as detached.

Similarly, an open-ended question in the 2006 Royal Society survey showed that 10% of scientists said the "main drawback" to engaging the public was becoming a potential "target" (weighted n = 1,456). Another 14% named "becoming a target" as a "second main drawback" (weighted n = 938). A related concern was that the public would misunderstand any attempt at communication and either make the scientists look bad or misuse their work (Davies, 2008; Stilgoe, 2007). The same 2006 open-ended question saw 19% say that engaging the public can result in sending out "the wrong message" (another 16% gave this as a "second main drawback").

Pearson et al. (1997) is unique in focusing on scientists who had recently participated in public engagement, finding that these scientists often come to see the public as moderately informed, keen to learn, and not very confrontational.

Who is the public?

Several studies have also found that scientists see the public as homogeneous. One such study of scientists involved in genetically modified food research suggested that experts view the public as a uniform group of non-experts with little allowance for "any relevant expertise outside of the scientific community, or for any intermediate degrees of scientific knowledge or understanding" (Cook et al., 2004: 437). In contrast, other studies emphasize a range of specific homogeneous groups of lay-persons (e.g., farmers, consumers, etc.), though these were often simplified using dichotomies that asked respondents to differentiate between a dominant public that does not understand science and a minority, pro-science public (Blok et al., 2008). Another study of scientists in the chemical industry suggests a view of the public either as chemical plant neighbors or as consumers of chemical products (Burningham et al., 2007). One group scientists may differentiate from the public is opponents of science such as environmental or animal rights group members (Cook et al., 2004; Michael and Brown, 2000). Limited work notes that actual experience interacting with the public tends to give scientists a more nuanced view, encouraging scientists to view the public as diverse in background, orientation and views (Blok et al., 2008).

3. Scientists' view of the media

Scientists do not exclusively blame the public for its failings; they also blame the news media. The public is misguided, according to this argument, because it is inordinately swayed by biased or sensational news coverage (Blok et al., 2008; Burchell, 2007; Burningham et al., 2007; De Boer et al., 2005; Krystallis et al., 2007; Young and Matthews, 2007). Such coverage is often critiqued for emphasizing the views of interest groups, industry and other vocal minorities rather than those of scientists and other experts perceived as impartial and authoritative (Burchell, 2007; Cook et al., 2004; Michael and Birke, 1994; Michael and Brown, 2000; Young and Matthews, 2007). Journalists' lack of specialist training is also seen as the cause of poor scientific coverage (Burchell, 2007; Petersen et al., 2009). Some scientists appear to recognize that different types of journalists can produce different types of content, that scientists sometimes lack the ability to communicate effectively to reporters, and that science can be difficult to adequately report (Petersen et al., 2009). Scientists also appear to rely on a simple sender-receiver model of media effects that fits poorly with contemporary media effects research (Davies, 2008; Petersen et al., 2009). Despite the frequency with which the media is mentioned, most of the qualitative studies focus only tangentially on views about the media (see, however: Petersen et al., 2009; Young and Matthews, 2007). The available survey data, however, speak to scientists' concerns in some detail.

The 2001 Mori/Wellcome Trust data show that a greater percentage of scientists believe the public trusts television documentaries (67%), television news (68%) and national newspaper journalists (49%) more than university scientists (39%). Scientists further believe that media coverage has influenced public opinion on bovine spongiform encephalopathy (BSE), genetically modified foods (GMOs) and human genetics, making the public more confused (59%, 58% and 43%, respectively) and more wary (59%, 69% and 68%, respectively).

Nevertheless, when asked about effective methods for communicating with the public about social and ethical implications of research, 48% said that being on television or the radio was the "most effective" means of communication. Another 26% said talking to television or radio journalists, and a further 26% said talking to national newspapers was the most effective communication method. Some 30% said writing for the national press themselves was the most effective method while smaller percentages mentioned writing for the popular science press (19%) or talking to local newspaper reporters (5%) (MORI/Wellcome Trust, 2001).

The more recent Royal Society data suggest that scientists see some limited value in being in contact with journalists, with popular science journalists viewed as more important than other types of writers and documentarians (Table 2).

Data from AAAS/Pew show that scientists are equally split between those who view the media's tendency to oversimplify as a "major" or "minor" problem but are in near unanimity in their negative opinion of science coverage (Table 3). In contrast, a third of respondents in the UK (34%) strongly agreed or agreed that "engagement with the non-specialist public is best done by trained professionals and journalists" (44% disagreed or strongly disagreed) ($n = 1{,}476$, weighted). About a third of UK scientists also indicate that talking to various types of specialty and non-specialty reporters is important to their current position (based on choosing a "4" or "5" on a five-point scale anchored by "not important" and "very important"). Science journalists focused on "popular" topics are seen as particularly key. Some 21% of scientists in the Royal Society data identify general journalists as the "hardest [group] to talk with" about research and another 6% feel popular science journalists are the most difficult to communicate with. Some 10% said they saw other media writers and documentarians as being the most difficult group to talk to about their work ($n = 1{,}413$, weighted).

Table 2. "How important do you feel it is that you personally, in your current post, directly engage with each of the following groups about your research?" (1 = not important to 5 = very important) (UK Royal Society data).

	M	*SD*	Age (r^2)	Male (r^2)	Subfield	(r^2)
General journalists (i.e., in the press, TV and radio)	2.69	1.32	.18**	.09**	Engineering	−.06*
					Math	−.10**
					Environment	.06*
Others in the media such as writers, documentary and other programme makers	2.82	1.26	.16**	.05*	Medicine	−.06*
					Math	−.07*
					Environment	.05*
Popular science journalists (e.g. on *New Scientist*)	3.23	1.27	.05*	–	Medicine	−.08**
					Chemistry	−.06*
					Math	−.09**

*$p > .05$, **$p > .01$ (n = approximately 1,475, weighted).
Source: Royal Society (2006).

Table 3. Views about the news media (US AAAS/Pew data).

		%	Age (r^2)	Male (r^2)	Subfield	(r^2)
"How much of a problem, if at all, do you think each of the following are for science in general?"						
The news media oversimplify scientific findings	Major	49%	–	–	Social Sci.	−.07**
	Minor	45%	–	–	Social Sci.	.05**
	Not	62%	−.06*	.06*	Social Sci.	.05**
News reports don't distinguish between well-founded and not well-founded scientific findings	Major	76%	–	−.07*	–	
	Minor	22%	–	.06*	–	
	Not	2%	–	–	–	
"All things considered, how would you rate …"						
Television news coverage of science	Excellent	1%	–	–	–	
	Good	15%	.08**	–	Chemistry	−.05*
					Math	.05*
	Only fair	48%	–	−.07*	–	
	Poor	34%	−.10**	.07*	–	
Newspaper news coverage of science	Excellent	2%		–	Math	.05**
	Good	35%	.05*	–	Chemistry	−.07**
	Only fair	48%	–	–	Chemistry	.05*
	Poor	15%	−.05**	.06*	–	

*$p > .05$, **$p > .01$ (n = approximately 1,400 for male and 2,500 for gender and subfield, weighted).
Source: Pew (2009).

The AAAS/Pew data further suggest that respondents see television as particularly problematic, with nearly 85% of scientists' describing television news coverage as "only fair" or "poor." Newspaper coverage does somewhat better, but still barely a third of scientists view the coverage as "good" or "excellent." Indeed, almost no scientists described either newspapers or television coverage as "excellent" (Table 3).

However, a 2005–2006 survey study of epidemiologists and stem cell researchers in France, Germany, Japan, the UK, and the US counters the assumption that scientists feel ill at ease in dealing with journalists (Peters et al., 2008a, 2008b). In this study, representative samples of scientists from each country reported considerable media experience with 30% indicating that they had more than 5 media contacts over the past three years and 39% reporting between 1 to 5 media contacts. Contact was associated with leadership positions and research productivity and a plurality rated their interactions with journalists as having a positive impact on their careers (Peters et al., 2008b).[1] Many scientists (57%) indicated they were "mostly pleased" with their most recent appearance in the media and generally agreed that journalists asked good questions, used information accurately, explained research well, and included important information. Respondents were more ambivalent, however, about the media's overall accuracy, use of credible sources, tone, and comprehensiveness (Peters et al., 2008b).

The survey also asked about 16 motives for engaging with the media with more than 9 out of 10 respondents indicating the goal of "achieving a more positive attitude towards research" and more than 9 out of 10 scientists indicating the goal of "a better educated public." In terms of factors weighing against interaction, 9 out of 10 respondents indicated the "risk of incorrect quotation" and 8 out of 10 cited the "unpredictability of journalists" (Peters et al., 2008b).

4. Scientists' view of the public and the political process

Research on scientists' views of the public relative to political decision-making has focused on two main themes: (1) the appropriate role of the public and (2) how the public should be engaged in public decision-making.

Role of various actors in public decision-making processes

Scientists seem to walk a difficult line both in recognizing the right of citizens to play a role in decision-making while having reservations about the public's capacity to do so. One study spoke of a scientist's need to have the public provide "legitimacy and validation" (Young and Matthews, 2007: 140). This position appeared to be operationalized as a duty to empower citizens to make good decisions. However, a good decision was understood as one that was consistent with scientists' point of view, and empowerment was understood as education (Davies, 2008). In the end, scientists report feeling frustrated when they believe their views receive inadequate attention (Gamble and Kassardjian, 2008; Stilgoe, 2007).

A study dealing with aboriginal knowledge also focused on the need to empower non-scientists to contribute to science, but the goal was to facilitate better quality data, rather than to give non-scientists a voice. The value of citizens in providing anecdotal evidence as potential areas for research was similarly discussed (Moore and Stilgoe, 2009; Stilgoe, 2007). A more limited perspective was the view that the public needs to be provided opportunities to speak but that it is unrealistic to expect scientists to receive substantive input. This viewpoint was elaborated as a sense that (industry) scientists viewed it as their job to work directly with regulators to protect the public because the public is incapable of and uninterested in doing so (Burningham et al., 2007; see also: De Boer et al., 2005). In contrast, Michie and colleagues found that, whereas the public wanted their right to decide about prenatal genetic tests, scientists said decisions should be made by panels of both scientists and the public (Michie, Drake, Marteau and Bobrow, 1995). These results suggest that, when asked about the role of the public, scientists may opt for some type of co-decision-making but also suggest a desire by scientists to differentiate themselves from the public (Cook et al., 2004).

Table 4. "How important do you feel it is that you personally, in your current post, directly engage with each of the following groups about your research?" (1 = not important to 5 = important) (UK Royal Society data).

	M	*SD*	Age (r^2)	Male (r^2)	Subfield	(r^2)
Non-governmental organizations	2.96[a]	1.21	.13	−.07	Math	−.10**
					Physics	−.06*
					Environment	.09*
Young people outside of school	2.99[a]	1.30	.09**	–	Medicine	−.05*
					Engineering	−.05*
					Physics	.05**
					Chemistry	.06*
The non-specialist public	3.11[b]	1.18	.07**	−.13*	Engineering	−.20**
					Math	−.07*
					Environment	.07*
					Medicine	.12**
Schools and school teachers	3.27[c]	1.33	.11**	.06*	Medicine	−.14**
					Math	.06*
					Physics	.09**
					Chemistry	.11**
Industry/business community	3.29[c]	1.31	–	.10**	Medicine	−.13**
					Math	.08*
					Bioscience	.07**
					Chemistry	.11**
					Engineering	.18*
Policy-makers	3.65[d]	1.30	.20*	.06*	Math	−.10**
					Engineering	−.06*
					Environment	.06*

*$p > .05$, **$p > .01$ (n = approximately 1,475, weighted).
[a–d] represent significantly different subsets based on t-tests (two-tailed, $p > .05$).
Source: Royal Society (2006).

The available survey data are limited on the question of the public's role in political decision-making. The AAAS/Pew survey shows that 97% of scientists believe they should be "actively involved in political debates about issues such as nuclear power or stem cell research." Those involved in mathematics were less likely to hold this view ($r = .05$, $p > .05$). There was less agreement on the degree to which scientists believe that others have "too much influence" over scientific decision-making within their own specialty. Only 41% of respondents held this view and it was most common in older respondents ($r = .07$, $p > .05$) and those involved in chemistry ($r = .05$, $p > .05$) (n = approximately 1,400 for age and 2,500 for gender and subfield, weighted).

The Royal Society data further show that scientists perceive policy-makers as the most important group with which to engage. The general public are perceived in the mid-range of importance, somewhat more important than young people or non-governmental organizations (NGOs), but less important than the private sector and educators (Table 4). Correlations show that those in the medical field are most likely to see the public as important while engineers are less likely to hold this view. Age is related to seeing more value in engagement while men are less likely to see engagement with NGOs and the public as important and more likely to see value in engaging with the private sector and policy-makers.

5. Views about engagement

Public engagement includes a host of activities wherein citizens are asked to play a role in decision-making. It can take the form of one-way attempts to provide content through the news media, advertising, Internet sites, or presentations, to more interactive activities where participants are invited to participate in two-way dialogue (Rowe and Frewer, 2005). While education may be a part of public engagement, scholars have argued it should not generally be seen as the sole goal unless education is aimed specifically at enabling the public to participate in decision-making (Besley, Kramer, Yao and Toumey, 2008b). The news media can play an important secondary role by covering engagement initiatives such as public meetings, providing information about the participants, the arguments made, the process and the results (Besley and Roberts, 2010).

Previous studies, however, suggest that scientists tend to favor one-way communication with the public via the media, viewing engagement as chiefly about dissemination rather than dialogue. Petersen et al. (2009), for example, notes many scientists view it as their responsibility to inform the public via the media about the benefits of nanotechnology because of the public money that goes towards research. This finding is consistent with those from the cross-national survey of researchers who reported that achieving "a more positive attitude towards research" and a "better educated public" as chief motivations for engaging with journalists (Peters et al., 2008b).

As with Table 1, above, several studies found scientists believe that some research might be too complicated for engagement purposes (Petersen et al., 2009; Poliakoff and Webb, 2007) or that the public is more interested in criticizing science than engaging in dialogue (Burningham et al., 2007). However, the primary argument that scientists give for public engagement is the need to increase citizen knowledge (Davies, 2008) or allay unfounded fears (Burningham et al., 2007). Several studies also emphasize that scientists are willing to engage directly with citizens (De Boer et al., 2005) but that such engagement is usually still framed in terms of providing information (Kurath and Gisler, 2009). The key difficulty may be that scientists often believe public debates should turn on logic and cost-benefit-analysis accounting whereas the public wants consideration of factors such as fairness, ethics and accountability (Cook et al., 2004).

A small quantitative study by Poliakoff and Webb (2007) showed that scientists' intention to engage with the public is predicted by attitudes about the process or activity (e.g., would it be enjoyable), social norm perceptions about what other scientists in the peer group are doing, and feelings of efficacy based on the belief that one has the skill and tools necessary to succeed (Poliakoff and Webb, 2007).

The data from the UK and Great Britain include extensive information about scientists' engagement views. The 2001 Wellcome Trust data showed that 91% of scientists agreed or strongly agreed that "scientists have a responsibility to communicate the social and ethical implications of their research to policy-makers." A further 84% agreed or strongly agreed that scientists had the same obligation to the "non-specialist public."

The more recent Royal Society data showed that, when asked what engagement means, however, only 12% indicated it meant listening to or attempting to understand the views of the public (n = 1,358, weighted). Another 7% said it meant being accountable for public funding. Most of the remainder gave a response that focused on either informing the public about science or the

Table 5. Scientists indicating a "main reason" and "second most important reason" for engaging with the public as well correlations with age, gender and subfield (UK Royal Society Data).

	%	Age (r^2)	Male (r^2)	Subfield	(r^2)
To ensure the public is better informed about science and technology OR To raise awareness about science generally OR To raise awareness about your subject	80%	–	–	Engineering	−.06*
To ensure the public is better informed about science and technology	52%	.07*	–	Medicine	−.07**
				Engineering	−.06*
				Chemistry	.05*
				Environment	.05*
				Bioscience	.06*
To contribute to public debate about science and scientific issues OR To contribute to discussions about social and ethical issues science can raise	38%	–	–	Engineering	−.13**
				Bioscience	.12**
To contribute to public debate about science and scientific issues	26%	–	–	Engineering	−.11**
				Environment	.07**
				Bioscience	.08*
To raise awareness about science generally	25%	–	.08*	Medicine	−.07**
				Physics	.08**
To be accountable for the use of public funds	24%	–	–	Medicine	.06**
To raise awareness about your subject	24%	–	–	Bioscience	−.10**
				Physics	−.07**
				Chemistry	−.06*
				Medicine	.17*
To generate/stimulate additional funds for universities and colleges	17%	–	–	Environment	−.08**
				Engineering	.13**
To contribute to discussions about social and ethical issues science can raise	14%	–	−.10*	Physics	−.06*
				Bioscience	.11**
To recruit students to your subject	10%	–	.08*	Medicine	−.10**
				Bioscience	−.10**
				Environment	.08**
				Chemistry	.06*
				Physics	.09**
				Engineering	.14**
There are no reasons to engage [the non-specialist public]	1%	–	–	Engineering	.06**

*$p > .05$, **$p > .01$ (n = approximately 1,475 weighted).
Source: Royal Society (2006).

scientific process, or working with the media. When given a list with 10 potential reasons to engage, fully 80% chose informing or raising awareness as their first or second reason (Table 5). In contrast, only about one third said that contributing to public debates or discussions about social and ethical issues is a key reason for engagement. Engineers appear to be somewhat less likely to choose a statement that reflects concern about public involvement (and were more likely to focus on recruitment and funding). Those involved in bioscience appear to be the most likely to see a public role for themselves. Most of the other correlations between specific arguments and either demographics or subfield were relatively small.

When Royal Society respondents were asked whether getting support for science was the "main reason" for public engagement, the mean fell nearly in the mid-point ($M = 2.97$, $SD = 1.08$) of a five-point scale with respondents in engineering ($r = -.14$, $p > .01$) and chemistry ($r = -.06$, $p > .01$) slightly more likely to agree with this position and environmental scientists ($r = .08$, $p > .01$) more likely to disagree.

In addition to the data above, the AAAS/Pew data highlight that only about a quarter of the respondents from the AAAS, an organization that works to get scientists involved in public debates, have heard about activities such as town hall meetings to discuss science. Within that smaller group, respondents are evenly divided on the usefulness of such meetings for the public and policy-makers and more cautious about the value to journalists and scientists themselves. Some 44% of respondents said town halls are "very" useful for the public and 42% said these were valuable for the policy-makers. Only 36% said such meetings were very useful for journalists and 33% said they were very useful for scientists. Respondents could also indicate if they saw these as "fairly" or "not" useful. Younger respondents (age) were more likely to view town halls as "very" valuable to the public (r = -10, $p > .05$) and older respondents were more likely to see such meetings as "fairly" useful ($r = .11$, $p > .05$). Those involved in physics were more likely to see meetings as "fairly" useful to the public ($r = .09$, $p > .05$) and less likely to see them as "very" useful to policy-makers ($r = .08$, $p > .05$). Social scientists were more likely to perceive town hall meetings as "not" useful to the public ($r = .08$, $p > .05$). Demographics and subfield did not generally predict views about town hall meetings (n = approximately 575, except age where $n = 368$, weighted).

6. Discussion and future research

Past studies provide clear evidence that scientists believe the public knows little about a range of scientific issues and that they see this knowledge deficit as shaping risk perceptions, policy preferences and decisions. Scientists further tend to blame science media content for many of the public's failings. Scientists' negative views about the media, however, are matched by a positive impression of their own interactions and a belief that the media remain an effective means of public communication. When it comes to policy debates, scientists recognize that they have a role to play in supporting public debate but emphasize a need to educate the public so that non-experts will make policy choices in line with the preferences of scientists. It also appears that scientists believe direct engagement with policy-makers is the most effective route for affecting policy outcomes. Only a small proportion of scientists appear to view their role as an enabler of public participation through formats such as deliberative meetings, and see few personal benefits for such engagement. There were few differences in views between scientists in the UK and the US, though subfields appeared to matter more in the UK data.

There are a number of topics, however, that the analyzed survey data and past research do not address. While several of the qualitative studies note that scientists recognize the public's diversity of background and views, the quantitative data do not speak to this belief. A failure to ask scientists in surveys about different subsets of the public may result in over-emphasizing scientists' dissatisfaction with the public as a whole. Second, whereas commentators still tend to describe the relationship between scientists and journalists in negative terms, the available survey data suggest that most scientists have positive personal interactions with journalists. As the authors of this study suggest, a number of reasons likely account for the continued narrative asserting a "gulf" between scientists and journalists (Peters et al., 2008a, 2008b).

The fact that the surveys emphasized either general engagement or engagement in a respondent's specific specialty could also limit the degree, type, or importance of reported outreach activities. For researchers involved in non-controversial science, for example, an emphasis on school-based outreach and specialty beats within the media may be effective. In contrast, for scientists involved in issues such as climate change, other forms of engagement may be more desirable. To get at these questions, scientist surveys may need to avoid generalities and either focus on views about communication on specific topics or focus on sampling scientists in specific fields (e.g., Besley, Kramer and Priest, 2008a; Scheufele et al., 2007).

As we mentioned at the outset of this article, future research should also more carefully examine how factors such as personal experience, gender, ideology, worldview, selective information sources and other communication processes shape how scientists perceive the public and the media. In this regard, it is noteworthy that a few of the studies reviewed (Blok et al., 2008; Pearson et al., 1997) emphasized that respondents who had participated in engagement activities had more positive and more nuanced views of the public. This question could be the subject of additional analyses of the existing quantitative data but the cross-sectional nature of the data will make it difficult to determine whether views about the public lead to engagement or whether participating in engagement activities changes views about the public. Future work therefore needs to include studies aimed at assessing individual scientists over time, perhaps in conjunction with sustained leadership or training initiatives such as Stanford University's Leopold Institute or the ESCOnet communication trainings. Our hope is that scientists will continue to participate in such programs and that funding can be found to support their development and evaluation.

Several well-established areas of communication research should also be applied to the understanding of scientists' perceptions and behavior.[2] Research on pluralistic ignorance and false consensus – a failure to realize when one's own opinion is in the majority or minority, respectively – has long demonstrated that individuals will often inadvertently misperceive the views of others, especially when there is a self-interested reason to do so and when those others are perceived as socially distant or lacking competence (Glynn, Ostman and McDonald, 1995). While we are unaware of work in this area that has specifically focused on scientists, there is no reason to believe that scientists are immune to such effects. For example, despite opinion polling that contradicts such fears, the consistent claims by some scientists that the public is "hostile to science" and that there is a growing "anti-science sentiment," are likely a result of these processes (Nisbet and Scheufele, 2009).

Scientists are also likely to be strongly prone to faulty estimates of media coverage. Known as the "hostile media effect," this means individuals with a strong commitment to an issue – such as action on climate change, funding for stem cell research and/or a strong political identity – tend to view even favorable coverage as slanted against their goals and point of view. This process is particularly likely to be found in the US setting, as the AAAS/Pew survey results reveal that more than half of members surveyed self-identify as either "strongly liberal" or "liberal," indicating a strongly one-sided political composition for the organization.

"Third person effect" research may also prove useful. This widely used theory suggests that a member of one social group will perceive media coverage (or a message) as not affecting them but will think the media coverage has influenced those socially distant from their group (Davison, 1983, 1996). It seems particularly relevant to scientists who, as we have reviewed, tend to view the wider public as mostly ill-informed about science if not often lacking competence. Such views seem likely to magnify concerns about slanted and biased media coverage that may lead to misplaced communication strategy on the part of scientists and their organizations.

Choices relative to communication and public engagement strategy also connect to how the perceived majority views and opinions among scientists shape an individual scientist's willingness to express (or censor) their own political views and preferences (Hayes, Shanahan and Glynn, 2001). In the US data, for example, given the strong left-leaning political identity of scientists in the AAAS sample, moderates and conservatives among their ranks may feel reluctant to express political views, policy proposals or preferred public engagement approaches that are perceived as different from the preferences of their liberal counterparts. With an ever-increasing reliance on blogs, Facebook and personalized news, the tendency among scientists to consume, discuss and refer to self-confirming information sources is only likely to intensify, as will in turn the criticism directed at those who dissent from conventional views on policy or public engagement strategy. Moreover, if perceptions of bias and political identity do indeed strongly influence the participation of scientists in communication outreach via blogs, the media or public forums, there is the likelihood that the most visible scientists across these contexts are also likely to be among the most partisan and ideological. These are all questions and hypotheses that deserve considerably more attention and research, moving beyond Levy-Leblond's focus on whether or not scientists understand the public, and examining how the same processes that influence the lay public, also influence the judgments and perceptions of scientists.

Notes

1. *Science* reports much of this information as an online-only supplement to the journal article.
2. Additional material from science and technology studies could also provide guidance but is beyond the ability of the current review to summarize in the available space. A fruitful path for future research might include developing a multi-disciplinary synthesis of key theories and concepts that could support the type of empirical research described here.

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