Scientists' Public Communication Values

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Abstract

In this paper, we analyze the results of interviews with twelve scientists about their values in communicating with the public. We discuss various communication models, and we argue that caution is needed when inferring such models, and especially goals and motivations, from samples of scientists' speech. While scientists seem to view communication with the public in terms of what we call an asymmetric monologue, they value feedback from and understanding of their audiences more than a "just-the-facts" information-transfer view might suggest. We argue that some alterations in scientists' communication, including more "framing," might be compatible with the values scientists currently hold.

Keywords: values, deficit model, framing, cognitive biases

[1]Paper writing
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Introduction

While there has been much scholarship analyzing both scientists' communication with the public and the public's understanding of science, there has been relatively little research focusing on how scientists themselves talk about their own communication with the public (Davies, 2008a and 2008b). Furthermore, much of this research has focused on how scientists approach controversial issues (Burchell, 2007; Maranta et al., 2003). Recently, Sarah Davies has argued that "there remains…a need for detailed examination of scientists' talk about the public in a more *generalized* -- rather than controversy-focused -- context" (2008b, pg. 15).

We believe not only that more work needs to be done to understand scientists' talk about the public in a generalized context, but also that more needs to be done to uncover the norms and values scientists hold about their communication with the public. For some time, communication specialists have been arguing that scientists need to change the models of communication they use and to change the way they envision the public; in particular, there have been calls to move from a one-way to two-way form of communication, to replace the deficit model of the public's understanding of science with a contextual model, and to adopt strategies such as "framing" for improving communication (Irwin and Wynne, 1996; Nisbet and Mooney, 2007). Yet interviews with scientists show that the one-way and deficit models are still dominant, and the recent controversy in *Science* about framing shows that there is still a great deal of resistance to such strategies within the scientific community (Nisbet and Mooney, 2007; *Science* letters, 2007). It is possible that resistance to change is being motivated by core values scientists hold about their role in public communication.

Understanding scientists' values better will enable us to evaluate different models of public communication to see whether they fit with those values. It may be that scientists' resistance to certain changes in their communication practices stems from the misapprehension that these changes would be counter to their values. If so, then communication researchers can show that the changes are actually in line with scientists' values, and this will make their call for change more effective. For example, scientists may believe that engaging in framing would run counter to the norm of objectivity, but it might actually be the case that framing, when done properly, improves audience understanding of objectively established scientific data. On the other hand, it may be the case that some changes in communication would run counter to scientists' values, and then we will need to settle the question of whether the change is justified; if it is, then we will have to make an argument that scientists should change their values.

To make progress on this question, it is necessary to analyze scientists' speech to uncover both their norms of communication and the models of communication that they endorse. Unfortunately, this task is made difficult by two things. First, the models of communication that are often discussed in the literature are not defined consistently, and the definitions given sometimes lack the precision that is needed in order to determine whether a scientist's speech amounts to an endorsement of that model. This lack of precision can lead to views in the literature that may both oversimplify scientists' views and miscategorize them. Second, scientists' talk about communication underdetermines the norms and models that can be attributed to them, and previous studies of scientists' speech have not always been careful about the inferences drawn from samples of scientists' speech. Both of these problems will need to be dealt with before any conclusion about scientists' communication values can be justified. In this paper, we will address questions about what scientists' speech can tell us about their views regarding the flow of information in their communication, about their communication goals, about what they adjust their communication for, and about why they make those adjustments.

In this study, we interviewed twelve academic scientists about their views on public communication, using questions that would elicit their norms and values. We then analyzed their speech to identify implicit and explicit norms and to determine what models of communication best fit their talk about public communication. In order to carry out the analysis, we found it necessary to refine traditional definitions of communication models. We expected to find that scientists are most concerned with truth, objectivity, and accuracy in their communication with the public, and that they would only be willing to modify their communication in limited ways to adapt to their audience's interests and education. However, we found that scientists value the point of view of the public more than expected. Yet we found little evidence that they value a symmetric dialogue with the public; rather, their values indicated a preference for asymmetric, monologic communication with the public. Scientists' desire to learn from public feedback seemed primarily to serve the goal of making their own communication more effective in increasing audience understanding and interest. Yet the fact that scientists' words fit this model supports neither the hypothesis that scientists in general are wedded to strict norms restricting communication simply to the transfer of information, nor the hypothesis that when scientists do stray from the straightforward transfer of information that they are adopting drastically different communication models or norms. Still, within a framework of asymmetric, monologic communication, there is much room for variation in communication techniques and strategies, and choices between them will depend on the norms and motivations for that communication and for adopting that general model. We will argue that scientists committed to objectivity and engagement in asymmetric monologue should endorse more active framing methods for their communication, for this would be consistent with their current values.

We begin with a discussion of models of communication, arguing that these models need to be clarified and distinguished more carefully from each other than they have been so far in the literature. The requisite elaboration has two consequences of relevance here. First, a scientist's self-described emphasis on objectivity and his or her role as an expert does not of itself imply that the scientist is insensitive to the needs and involvement of the other parties, as would be implied by the attribution to the scientist of a simple "just-the-facts" model of communication. Second, the way in which one infers the motivations and normative commitments, and the way in which one models a scientist's communication practices, has significant implications for the kinds of suggestions one makes for improving communication practices.

In subsequent sections, we present our data on scientists' values, analyze the models of communication that fit them, and explore how the data and models collectively reveal some of the more specific properties of scientists' communication practices, such as how much they think they ought to adjust their communication for different audiences, and why. Finally, we will argue that some alterations in communication practice are compatible with the values scientists' currently hold.

Models of Communication

Previous research on models of scientific communication has identified a number of models that might apply, including one-way versus two-way, asymmetric versus symmetric, and deficit versus contextual models (Davies, 2008a; Sturgis and Allum, 2004; Grunig and Grunig, 1992; Grunig and Hunt, 1984). Unfortunately, the definitions of these models are not always precise, so it can be difficult to determine the model with which a given attitude expressed by a scientist is most compatible. In order to capture important features of the speech of the scientists we interviewed, we found it necessary to refine traditional models of communication. Our refinements are as follows.

The first axis on which models of communication can lie is *intended direction of information flow*. In other words, is information primarily meant to be disseminated from one party to another, or primarily meant to be exchanged between multiple parties? This distinction has traditionally been called “one-way” versus “two-way” communication, but researchers have been inconsistent about the criteria for each category. For example, Grunig and Grunig (1992) sometimes use ‘two-way’ to refer only to communication that involves speech from both parties, not a monologue, but sometimes they count communication as “two-way” if it involves a monologue, provided that the speaker collects information about the audience in order to make the communication more effective. We consider it important to distinguish between a model of scientific communication in which the scientist is the only one speaking, and one in which the scientist and lay public are meant to be speaking to each other. Thus, we will use the terms ‘monologic’ versus ‘dialogic’. Even if a scientist collects information about an audience in order to improve the effectiveness of the message, if the message itself is meant to be delivered in a monologue, this will count for us as a monologic model of communication.

The second axis we will use is *the balance of the intended effect of the communication*. Is the communication meant primarily to produce a certain effect in one party, or are both parties supposed to be influenced by the communication? This is often called “asymmetric” versus “symmetric” communication, but sometimes these terms are also used to distinguish monologic from dialogic communication. For our purposes, it was important to distinguish the direction of information flow from the intended effect of the communication, so we will use ‘asymmetric’ and ‘symmetric’ only to refer to the latter axis. Note that these two axes cut across each other. It is possible to have an asymmetric dialogue model (consider the Socratic method, which is meant to create understanding in one party, but via a genuine dialogue), and it is possible to have a symmetric monologue model (for example, delivering an inspiring sermon may be meant to redeem a pastor as much as to inspire a congregation).

Consider then Davies’ recent descriptive account of science communication (2008a). What she calls the “packet” model is a model of communication in which scientists consider their communication to consist in the transfer of pre-developed “packets” of information to the public. According to our characterization, this is an example of a monologic asymmetric communication model: the direction of communication is mostly one-way, and the intended effect is only on the public (increased information, knowledge, or understanding). We would consider such a model to be an asymmetric monologue even if information were collected about the audience to determine which “packets” are appropriate based on their background knowledge or interests; in such a case, there is no real dialogue, as the transfer of information to the speaker may be only one-time and is meant only to improve the one-way flow. Differences between a “packets” model and other equally asymmetric monologic models might be found in the degree to which scientists alter what they say for different audiences and what the intended goals are. There can be significant variation in how “pre-canned” and “one-size-fits-all” the content of the communication is to be, all within a context of delivering different, mostly asymmetric monologues, with directed information flow and intended effects.

Models of monologic communication that focus on information flow have been tagged with such disparate names as “information transmission model” (Shannon and Weaver, 1949), “cybernetics” (Wiener, 1948), and “general systems theory” (von Bertalanffy, 1962). These models share the following core characteristics. A communication source has the principal responsibility of encoding “bits of information” (Rapoport, 1953) to one or more receivers, whose principal task is to decode the message. The function of these models is to produce a decoded message at its destination that approximates the source’s message at encoding. Specifically, communicative success depends on the receiver knowing *what sentences the source sent*, but not the extent to which the receiver *believes or understands those sentences*. These models refer to disturbances called noise that may distort or mask the message, and feedback from receivers is restricted to responses about the fidelity of the source’s message. Receivers are not treated uniformly in the models, so the particular coding of the message can change depending on the context and receivers.

Scientists often do seem to discuss public communication in terms of information flow, but whether that in general is their main goal or an intermediate mechanism for reaching some other goal (e.g., the scientist really cares about creating understanding or knowledge) is not determined by either their focus on information or the directional nature of their communication.

One attempt to explain why scientists seem to focus on an asymmetric transfer of information has been to characterize their interest in terms of models of public attitudes towards science, particularly concerning negative attitudes about, or non-acceptance of, scientific findings. Two models that have received significant attention are the deficit model and the contextualist model. The deficit model states that negative attitudes about science are primarily due to a deficit of knowledge about the scientific method or the facts discovered by the use of that method. This model is associated with a corresponding view that increased education will lead to more positive attitudes: “to know science is to love it” (Turney, 1998). Contextualists, by contrast, hold that “other knowledge domains…influence attitudes toward science and technology in opposite or conflicting ways to factual scientific knowledge" (Sturgis and Allum, 2004, pg. 58), and that these other domains play at least as important a role in determining one's attitudes toward science as scientific knowledge itself does. While both deficit and contextual models are primarily about the causes of attitudes about science, they have sometimes been treated as corresponding views about communication norms or techniques.

However, views about attitude causation, while possibly correlated with views about communication norms and techniques, are not identical to them, and this makes it very difficult to infer a view about attitude causation from a scientists' avowed communication norms and techniques. For example, a holder of a deficit model of the causes of negative attitudes certainly might choose her primary immediate goal of science communication to be filling the knowledge deficit by helping the public increase their knowledge about a particular scientific theory or finding or their general understanding of scientific method. However, a holder of a contextualist model might also choose her primary immediate goal of science communication to be filling the knowledge gap, perhaps because she believes that her responsibility as a scientist requires her not to engage in advocacy for adopting a particular view, associated with particular non-empirical values. This might especially be the case if she feels an obligation to be as objective as possible.

Previous studies have indeed suggested there is a strong commitment to neutrality and objectivity amongst scientists regarding their communication with the public—a just-the-facts norm about communication with the public (Turney, 1998). Given this, we think that scientists might still maintain a traditional, asymmetric knowledge-transfer model of science education, independently of whether they hold a deficit or contextualist view about the causes of negative attitudes about science, and also independently of whether they rely on pre-packaged content or adjust content in audience-specific ways.

Davies has indicated that scientists do, at least under certain circumstances, seem to adopt alternative models of communication, models that, Davies suggests, are closer to what we would call genuine symmetric dialogue than the packets model she described (2008a, 424-426). We were interested in whether the scientists in our interviews indicated such a view. However, we believe it is important to be careful in assessing scientists' statements about how they pay attention to their audiences. Willingness to alter communication patterns is not necessarily a rejection of an asymmetric monologic or even a form of packet model. Regardless of what model of communication scientists have, they will still likely alter their communication according to at least some audience characteristics. Thus, we think the truly same-size-fits-all packet view Davies describes is unlikely to be held by many, and we include as monologic asymmetric even the change-depending-on-context view to which she alludes (2008a, 425). We are therefore particularly interested in not merely whether scientists are willing to adjust their communication, but rather *what* characteristics they will adjust for, and why. For instance, it seems likely the scientists would adjust their communication to account for the educational background of their audience—even a pure information transfer model allows for that, for example by choosing different "packets" of information, tailored to different education levels or interests. But what about adjusting for other audience characteristics, such as cognitive biases or values that pose potential impediments to that knowledge transfer? We will explore these below.

In summary, then, we wish to characterize the communication models characterizing our subjects' understanding of scientific communication along three polarized dimensions. The first is the intended direction of information flow, with the discrete poles 'one way' and 'two way'. The second is the balance of the intended effect of communication, with the poles 'asymmetric' and ‘symmetric’. The third is the degree to which communicators are willing to adjust content and or delivery methods to audiences, with the poles ‘deficit’ and ‘contextualist’. Insofar as subjects can be said to adopt a contextualist understanding, we are concerned to identify the contextual features in response to which scientists are willing to adjust content or communication strategy.

Methods and Results

The data for the discussion that follows were gathered from interviews of research scientists at a large mid-western university in the United States during the fall of 2007. During the academic year in which the interviews were conducted, 23,332 students were registered at the university (19,416 undergraduates and 3,916 postgraduates), and across all subject areas more than 1,260 faculty were employed at the institution. A high level of teaching and research activities is required of faculty at the university.

Twelve scientists were recruited from the departments of biology, physics, and psychology. Four scientists volunteered from each department for a face-to-face (i.e., one-on-one), one hour, semi-structured interview. Each interview was recorded and written transcripts were then produced of the interviews. The length of each transcript was approximately four single-spaced typewritten pages.

The interviews consisted of a six-question protocol and probing secondary questions. Secondary questions either probed for clarification or more information. The six primary questions included: (1) Have you ever had an opportunity to speak or write about scientific issues with the public? And if so, what did you discuss? (2) What are the most important concerns that must be addressed in communicating with the public? (3) What three or four duties or responsibilities do you believe are critically important in your communication with the public? (4) What role should a scientist play in talking about scientific issues with the public? (5) How would you prepare for communication with an audience you think might be hostile to the information you will be delivering? (6) In your professional education curriculum have you ever received training about how to communicate with the public on scientific issues?

Questions two through five addressed the values that scientists hold about public communication. Two coders (two of the paper's authors) independently culled values from each answer to each question. A third coder (a graduate student) independently examined the extent of agreement among the selected values of the first two coders. The inter-coder agreement on the selected values was .57. Then, each of the first two coders examined the selected values of the other coder. Each coder reviewed the values that s/he had not originally pulled from the transcripts, based on the values listed by the other coder, for inclusion in the final list of values. The inter-coder agreement on this second pass was .94. This indicates that each of the first two coders had overlooked values in the transcripts, rather than disagreed over whether a particular selection constituted a value.

A total of 301 values were listed over all questions and scientists, in which question 2 generated 100 values (M = 8.33, SD = 2.77); question 3, 49 (M = 4.08, SD = 2.39); question 4, 66, (M = 5.5, SD = 1.78); and question 4, 86 (M = 7.17, SD = 3.19). Since the values were produced in oral communication, each scientist repeated one or more values during the interview. Table 1 below represents the values that were common to at least two scientists.

Table 1: Values Important in Communicating with the Public*

<u>Question 2:</u> What are the most important concerns that must be addressed in communicating with the public?

- Plan the communication with an awareness of the public's educational background (.25).
- Describe the methods of science to the public (e.g., explain the methods, that scientists are held to a high standard, that the methods are objective) (.25).
- Build communication from something the public is already familiar and develop it with analogies and examples (.42).
- Communication, on the one hand, should be clear (e.g., avoid jargon), understandable (e.g., define terms), simple (e.g., avoid too much detail), well-organized (e.g., coherent and narrowed to a single topic) (.92). But, it cannot over-simplify the world-out-there (.42).
- Evidence should be presented factually and accurately (.25).
- Communication should offer a valid, rational construction of the world-out-there (.17).
- Communication should discuss the importance of science to the public (e.g., how science resolves everyday problems) (.17).
- Communication should be relevant and interesting to the public (.42).
- Avoid being superior (e.g., arrogant or condescending) or dogmatic to the public. Treat the public with respect (.25).

<u>Question 3:</u> What role should a scientist play in talking about scientific issues with the public?

- Scientists should be unbiased information providers in the sense of presenting factual information or multiple sides of a controversy, or avoiding personal prejudices (.50).
- Scientists should be very cautious about arguing public policy (.33).

- Scientists should participate in public communication because journalists often misrepresent the science, public funding obligates scientists to communicate, and/or scientific investigations can inform public policy (.67).

Questions 4: What three or four duties or responsibilities do you believe are critically important in your communication with the public?

- Talk to the public actively (.33).
- Convey information about science factually, accurately, and objectively (.58).
- Explain to the public how their money is used and that public funding of science is important (.25).
- Convey excitement about research (.25).
- Explain the importance of the research to the public (.33).
- Become more involved in education at the pre-college levels (.17).
- Don’t confuse the public (.25).

Questions 5: Suppose you are asked to describe some scientific research to an audience who you think might be hostile to the information; how would you prepare your communication for them?

- Understand why they are hostile and be sensitive to their point of view (.75).
- Be respectful, avoid language that is offensive, and find common ground (.67).
- Provide evidence for your point of view, ensure that your information is accurate, and explain the logic of your ideas (.58).
- Explain that scientific reasoning is different from religion (.25).
- Prepare answers to their possible questions in advance (.25).

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*The percentages shown in parentheses reflect the proportion of scientists who expressed the same or similar values.

Analysis regarding direction of communication and general communication models

Scientists in our sample view scientific communication with the public as a monologic and asymmetric activity, with the scientist as expert providing information. .

The scientists in our study talked about communication with the public in ways that suggests they viewed that communication more as a monologue (i.e., one-to-many lecture) than as a dialogue (i.e., interaction among interlocutors). Most scientists claim the role of an information source or knowledge provider to the public. Many values shown in Table 1 reveal scientists in the role of transmitting information to the public (e.g., 58% said they should convey information about science factually, accurately, and objectively; 50% said they should be unbiased information providers; 25% said they should explain how public money is being used; 25% said they should describe the methods of science to the public; and 17% said that they should offer a valid, rational construction of the world-out-there). The following text exposes the role succinctly:

> *Interviewee #6:* Unbiased information provider. . . .It's my job as a scientist to inform them [the public] about scientific findings in a way that they can grasp. So, it's not just a little bit of information.

Duties expressed in response to question #4 often indicated things the scientist is to convey *to* the public (e.g., talk to the public, explain to the public, convey information, convey importance). Little was mentioned about listening to the public, learning from them, or similar activities.

The message is the principal means of achieving various communication objectives. Messages are sharpened or re-worked to ensure that the public possesses the right "picture" of science, or perhaps to influence the public's predispositions toward some point of view on science in general. It is not surprising to find that scientists value the mechanics of message design: 92% mentioned striving for clarity and coherence; 42%, wanting messages to be relevant and interesting to the audience; 58%, making sure that information conveyed in the message about science is factual, accurate, and objective; and 58%, wanting to provide evidence for their point of view, ensure that their information is accurate, and explain the logic of their ideas.

Moreover, scientists show concern for problems that arise which function to distort their message about science to the public. The information transmission models have a concept of "noise," broadly conceived as anything that reduces the fidelity of the received message. Scientists mentioned three phenomena that interfere with message fidelity: a surfeit of scientific vocabulary (25%), the receiver's level of education (25%), and journalistic accounts of science to the public (17%).

Norbert Wiener (1948) described feedback as circular processes in the information transmission model that occur in response to the source's message. The scientists in our study expressed interest in receiving feedback in response to their message. In answering question five about coping with a hostile audience, 75% of the scientists said they should try to understand why the audience is hostile and be sensitive to their point of view. And, 67% advocated being respectful, finding a common ground, or at least, avoiding offensive language. Once the presentation has been completed, at least one scientist in our sample expected that public criticism would likely surface, and that they should expect it.

> *Interviewee #12*: You should expect that there will be criticism for any public statement that you make. Always find people who will not agree, for whatever reason. Sometimes religious, sometimes you make factual errors, and then in which case, that's something you definitely want to deal with. So yeah, you should listen to all negative feedback and

> try to learn from it. And not be surprised that it's there.

However, this is not to suggest that scientists are disposed to altering their point of view should they encounter negative feedback. In fact, 33% of the scientists overtly indicated that differences in opinion with the public would not necessarily alter their point of view.

> *Interviewee #5*: And you know people have different opinions. What you shouldn't do with them . . . you should not attack them. You shouldn't really go on the offense too much, but neither should you treat them necessarily in a collegial way. If someone's a crackpot, they're a crackpot; so you let them ask a question once, they get one answer and they are done.

It appears that scientists use feedback primarily to assess the fidelity of message reception or gauge the effects of their message. They may want to avoid triggering more hostility with the audience than necessary, but the main objective is to convey the scientific message regardless. This suggests that interest in audience characteristics and response may not in general reflect any real two-way dialogue—some information flow back to the scientists is consistent with what is primarily a one-way monologue where the speaker wants to be able to ensure and measure the fidelity of the message conveyance.

The other axis regarding communication direction analyzed in this study, symmetry versus asymmetry, refers to the intended effects of scientists' communication with the public. As we indicated above, there is little to suggest that scientists enter the public forum with the expectation that their own point of view is likely to change. In our sample, scientists only described asymmetric effects in their public communication, with the one exception of Interviewee #12 above, who mentioned that an audience member might point out factual errors in the presentation that need to be changed.

We can categorize possible effects as changes in belief, changes in feelings, or changes in behavior. Ostensibly, one objective of communicating with the public is to provide them with a clear and accurate account of some phenomenon through a presentation of scientific research. Our discussion above already highlights scientists' focus on conveying some particular message or information. But transfer of information might not be the main objective of scientific communication. There is some suggestion in our data that scientists are looking to generate specific effects from the creation of broader understanding and knowledge rather than simply generating receipt of information. The following scientist argues that scientists need to generate understanding of scientific methods as well as its results:

> *Interviewee #10*: [M]ost communications should contain some kind of description or a brief description of what science is. If not at least describe some of the methods in a way that they [the public] can understand. . . . Within the scientific community, we are held to a pretty high standard to make [sampling] designs unbiased and mathematically random and, if those kinds of technical details can be communicated to the public, I think it would communicate to them that we are trying to be objective above all in our pursuit of knowledge.

One scientist amplified his role through a comparison of the media's depiction of scientific research to the public. Too often the media, he believes, convey scientific research as if it were an isolated event, robbing the public of an enlarged view:

> *Interviewee #1*: They don't . . . people don't understand the history of the idea. Where it's been, what it is right now in the debate, and where it is going to. And I think that's bringing out the narrative for . . . research. You just hear about an idea that's been researched, you get some quick facts and, in and out, and it's done. I think it's very

> important that we get the narrative out; the history and the story of what the research is, so everyone understands.

Overall, 42% of the scientists in our study mentioned using analogies and examples; 25%, focusing on the evidence used to support a claim; 33%, making claims about the importance of science to the public. These figures suggest that scientists, even in their generally asymmetric monologic communication, sometimes aim to do more than provide "just the facts."

Some scientists mentioned particular feelings that they would like to engender in the public about science and scientific research. In Table 1, 25% of the scientists wanted the public to feel that science is interesting and exciting, 33% wanted to impress the public with the importance of science, and 25% wanted the public to feel secure about how their money was being spent. Overall, however, creating these feelings was overshadowed by the educational emphasis on generating knowledge or transferring information.

No scientist discussed specific behaviors that they wanted to influence. However, inasmuch as public policy initiatives could include actions or behaviors on the part of some members of the public, 33% of the scientists explicitly discussed whether they should influence public policy. One explicitly cautioned other scientists to be very careful about advocating for a particular public policy, while others were more open to engaging in such attempts at influence. The following scientist is representative of those willing to advocate on behalf of some public policy initiative, but also making clear the distinct roles of scientific expert and citizen-advocate.

> *Interview #7*: Well I think that there's no doubt that it's critical that we participate. I mean first of all, we are citizens; we are part of society. We happen to have an area of expertise that, if there is interest in those questions, we're in many ways best qualified to fill in, at least the critical portion of the discussion. I think that the problem that scientists

> play is that we also have opinions, just like everyone else about where society should go, and I think we need to be very clear when we're picking those kinds of arguments versus when we're trying to say here's the state of the art in terms of what we know. On the other hand, I also don't think that scientists should shy away from our willingness to participate in public debates just because we are afraid we will be losing our objectivity.

Overall, there was no particular effect or suggestion of an effect mentioned as an aim of scientific communication that was not directed towards the public.

The scientist as expert is another indicator of asymmetries in the communication. Expertise at least in one's area of research seems to be assumed by the scientists in the context of public communication. However, it can extend to other areas of science, the process of science itself, or even the application of science in public settings. One of the more bold scientists in our sample said the following:

> *Interviewee #8*: So I mean I think if they want to keep the general public, you know funding them and keep their children well educated, then they need to take the front line and say, "You know what? I'm an expert and I know exactly what's going on and I'm going to tell it to you." Well, I think I know exactly what's going on.

To sum up, the way the scientists in our study discussed communication with the public seems most consistent with an asymmetric monologic model of that communication. Information from the public seems to be valued, at least as it was discussed spontaneously amongst our scientists, primarily for ensuring accurate transmission of their message(s) via both appropriate design and possible feedback checks. Intended effects are all directed to the public.

We now turn to a more detailed examination of what we can infer about those intended effects, and the norms and motivations that govern them

Analysis regarding norms, goals, and motivations

Scientists in our study expressed various norms of objectivity more than any other norm about communication; however, they expressed more interest in various characteristics of their audiences than would be consistent with a purely packet-based information transfer model of objectivity. There was no evidence of specific deficit views about negative attitudes towards science.

As mentioned above, it can be easy to interpret a scientist's focus on conveying information as the main task at hand. But the motivations and end goals for that transfer of information can matter significantly for how it is done. Simply meeting an obligation to provide information about one's research might not motivate one to pay much attention to the mechanisms of the information transfer. An obligation not to interpret scientific results too much might lead a scientist to be as literal as possible in her description of those results. But a concern for fostering some understanding of the technical results and their meaning and import might lead a scientists to do more than merely provide information. Such a concern might also lead a scientist to consider more of the details of their audience's beliefs and knowledge than a view that the public generally has a common deficit of information that needs filling.

Davies (2008a, pp. 418-420; 2008b, pg. 21) suggests that filling information gaps is a major motivation for scientist's communication. Responses in our study often evoked filling-the-gap metaphors, as in these examples in response to question # 2:

> *Interviewee #1*: I think it is important to understand, you know, what the audience is probably familiar with…bring them in with what they know, but then help them understand that's just a small portion of the actual psychological research and that it goes

much more in depth than that…So I would make sure that I understand both. What they know and what they should know.

Interviewee #11: "One of the most important things that I see is that the further along that you get in science, the more jargon you use. And for me…one of the most important is just defining terms, what do the words we say actually mean. Then beyond that, it's explaining the concepts that we're trying to investigate or the tools that we're using in a way that the general public can understand without taking extensive amounts of schooling….So really its getting down to the level of basically no prior information is what I would basically try to do.

While the scientists certainly focused on their role of providing information and education, there was little explicit indication that they thought negative attitudes towards science are due primarily to lack of knowledge about science, and so nothing in our interviews that might differentiate the reason for that focus: a deficit view of the cause of negative attitudes, a normative guideline restricting scientific communication to objective information transfer and knowledge generation, or something else.

However, a notable percentage of the scientists interviewed did express several variations of emphases of objectivity, neutrality, and independent accuracy as apparent norms guiding their communication. In response to question two, 25% explicitly emphasized that evidence should be presented factually and accurately, and 17% said that communication should offer a valid, rational construction of the world. When asked about the role scientists should play, 50% mentioned being unbiased or avoiding personal prejudices. And when asked about their duties, 58% percent discussed the importance of communicating information factually, accurately, and objectively.

Such objectivity does not, however require a non-flexible one-size-fits all method of communication. It is true that information transmission models do not differentiate one set of receivers from another. However, as indicated above, scientists did want some information, though limited, about their audiences. In our sample, 25% of the scientists explicitly expressed a desire to know something about their audience prior to communication.

> *Interviewee #12*: I have to know who the audience is going to be. What is their background? What is the average age? Are there going to be any kids, or is it going to be a bunch of old people? And that may sound kind of goofy, but there are very different organizations that have invited us to give talks. And we want to know how long it's going to be. And that gives you a feeling for, to what depth, you might be expected to give a talk.

Such interest would be consistent with a goal of more than just a one-size-fits-all information transfer. Typically, knowledge of the audience permits scientists to discover a means of tailoring their presentation to the life experiences of the audience. In the quotation below, the scientist is developing an analogy that compares the invention of a lesson plan for students to a presentation with the public.

> *Interviewee #9*: So if a student plays basketball, I can work with that. I know what the physics of basketball is, and I think that if that's something they're interested in, I can use that as an application for teaching them about physics in terms of that interest. . . .you have to keep in mind what the public is actually interested in hearing about and the last thing you want to do is essentially throw a bunch of 'geek speak' at them because it makes them feel uncomfortable.

Many of these expressions of interest about the audience are focused on educational background and knowledge. While it is clear that scientists do not think that there is only one set of information to be provided equally to all, adjusting presentations according to knowledge and interests still may consider all audiences with similar interests to be able to climb the same "ladder" of knowledge, adjusted only according to how far along in scientific understanding the audience is.

However, some of the scientists interviewed expressed interest in knowing more about their audience than background knowledge and interests:

> *Interviewee #1*: You need to make sure that even, you know, the most rigorously done scientific research isn't just rushed out there and pushed into people. It's got to be accepted. A lot of things are hard to take the first couple of times you hear them. And if you are doing it in a way that isn't sensitive to others' feelings then they are just not going to accept it."
>
> *Interviewee #7*: I think you have to acknowledge the differences of opinion and why those differences might exist. And in doing so you might be able to point out where there in fact is common ground where the differences aren't as great or may even be not existent. Even though the sort of rhetoric of the time suggests there are huge gaps."

These quotations do indicate that the scientists believe they need to do more than just transfer pre-designed one-size-fits-all packets of information, chosen on the basis merely of educational background and interests. But there is nothing in the responses that indicates that the scientists rejected either a privileged position in the communication or a commitment to neutrality or objectivity on their part, by "keeping to the facts". Rather, the adjustments they consider seem consistent with the asymmetric monologic model of communication they expressed, if they have in mind, for perhaps a variety of reasons, goals that depend on the abilities and backgrounds of their audiences instead of goals that are independent of the characteristics of the audience.

From these quotations we can conclude neither that scientists are unconcerned with objectivity, nor that they believe that the main cause of disagreements is a lack of understanding. They may be inherently interested in learning about their audience's feelings, or desire to create positive attitude in the audience through other means than knowledge creation. However, there is at least some suggestion that their interest in norms and goals, such as being sensitive to feelings and creating common ground, are based on what they think following these norms and achieving these goals can accomplish in the way of reaching other goals such as generating scientific understanding. Such interest might be based on a recognition that conflicting views or values can be impediments to the communication process and subsequent generation of knowledge. If they do aim to be mostly providers of information and knowledge (as typically seems to be the case) engaging in monologic asymmetric communication, they can do so in more effective ways by taking into consideration not only the educational background but also other aspects of their audience. So here we have evidence for a contextualist model of communication, but a contextualism that is nonetheless deployed to asymmetric ends in monologic communication.

Suggestions

Our scientists' apparent commitment to remaining objective while generating understanding and considering non-knowledge-based characteristics of their audiences raises two interesting questions. The first is whether the asymmetric monologic model of communication is an appropriate one for the main tasks which scientists seem to set themselves. While we do believe that a dialogic and perhaps symmetric approach would be more appropriate for achieving certain communication goals (especially regarding public policies) and perhaps ought to be considered as an option more than it is, the adoption of such methods should be based on both the communication goals and various constraints on that communication. We will not question here whether scientists should be in the business of at least sometimes working toward particular policies or effecting changes of other sorts, such as specifically trying to adjust the values people hold rather than merely inform. We will take it as a given that there are at least some reasons scientists might refrain from engaging in such activities; for example, even if they would prefer less negative attitude about science and do not hold a deficit view about the cause of such attitude, they may nevertheless believe that they ought not engage in persuasion (except perhaps persuasion about whether evidence does or does not support a finding), and that they ought not go beyond providing information and improving knowledge about science and particular scientific findings. While dialogic methods are often better teaching methods, at least for one-on-one or small group communication, an asymmetric monologic model of communication is at least consistent with the goal of increasing knowledge and understanding in a broad audience when one party is an expert in the field.

The second question is whether adopting methods that are meant specifically to take into account a variety of audience characteristics, including non-empirical values and cognitive biases, is consistent with the apparent commitment to the transfer of information and generation of knowledge and understanding as the primary immediate goal of communication.

Audience values and other characteristics may play a role in scientific communication not merely via the contextualist model, according to which members of the public may perfectly well understand a theory, even in significant detail, but choose to reject it because they believe it conflicts with some of their pre-existing views. They may also play a role in the public's ability to gain and develop knowledge, so that even if it is a deficit of knowledge of a scientific theory that causes a negative attitude towards it, having values that seem to conflict with the theory tends to lead people not to lend appropriate credence to the evidence provided for it by a proponent of the theory. There is substantial evidence that non-empirically based motivations contribute to cognitive biases like confirmation bias and assimilation bias, and hence to subsequent effects like attitude polarization, wherein conflicting information actually leads audiences to become *more* confident of their prior beliefs (Lord et al., 1979).

Adjusting a message to take into account audience biases and values can be done in more or less conservative ways. A conservative method is to substitute one message for another, when the two messages are logically equivalent. Tversky and Kahneman (1981) have shown in a well-known study that an audience evaluates logically equivalent options very differently when they are stated in only slightly different terms (portrayed as "saving lives" rather than as "preventing deaths"). For a scientist to take this effect into account and substitute one message for another that is literally the same in meaning, is clearly consistent with the ideals of objectivity and accuracy. If there are several equally accurate ways of wording a message, avoiding wording that will trigger biases that interfere with understanding the message is not manipulative. In fact, such "framing" of a message can serve the purpose of conveying the message accurately. Of course, framing can also serve the purpose of trying to persuade or even manipulate the receiver, or to bias the receiver's decisions or inferences in various ways; adopting framing techniques for such purposes would arguably not be consistent with goals of objective communication of information, or transfer of knowledge. We intend only to suggest that attention to the frames elicited by certain word choices may sometimes be required to meet a commitment to objectivity.

A less conservative method would be to change one's message in more substantive ways in order to prevent an audience's values from interfering with their understanding of the message. It has been shown that when an audience will view some information or the presentation of such as potentially challenging to some aspect of their self-identity, the attitude polarization that would result can be reduced by providing a path of self-affirmation via some alternative mode of self-identity (Cohen et al., 2000; Cohen et al., 2007). Affirming audience identity in ways unassociated with the scientific topic may therefore allow the audience to examine evidence and arguments with less bias. There are also strategies shown to be effective in prompting audiences to examine potential cognitive dissonance in non-defensive ways, for example by merely inviting them to consider the "opposite" viewpoint (Lord et al., 1984). Framing in stronger ways than suggested above, for example, by describing certain scientific findings via a first-person discovery adventure, may serve similar purposes. Such purposes would arguably not be manipulative if used not to convince audiences to accept beliefs without examination, but rather only to help alleviate universal and systematic biases to which we are all subject, in order to enable more open evaluation of evidence and arguments.

To be willing to adopt these methods, scientists would need to recognize that failures of scientific communication to convey knowledge are not entirely due to deficits of vocabulary and scientific training on the public's part, but are at least partly due to universal cognitive biases and to particular value systems members of the public may have that greatly affect how they understand a scientist's message. To address this problem, scientists need to focus on more than the mechanics of message design; tailoring a message to suit an audience's interests and vocabulary level may not be sufficient. Thus, scientists may need training in more sophisticated methods of communication, including training in how to frame messages, even if their goal is not to persuade. Training in and adoption of such techniques is arguably consistent with many scientists' current models and norms of communication. However, ethicists need to address the issue of what sorts of framing are morally appropriate, and their discussion needs to be integrated into research ethics training for scientists.

In conclusion, analysis of the norms that scientists hold regarding their communication with the public indicates that there are several core values many of them hold, including objectivity, accuracy, and lack of bias. It is plausible that these norms influence scientists' choice of communication strategies. Thus, any argument that scientists ought to adopt different models of communication or employ different strategies will need to show that these changes are consistent with these core values. By making the argument in this way, communication specialists will be more able to persuade scientists to alter their communication practices.

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