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The Contexts and Dynamics of Science Communication and Language

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Abstract

This final contribution to this special *Journal of Language and Social Psychology* issue on "using the science of language to improve translation of the language of science" places the articles in the context and nature of the broader literature on science communication, particularly as it relates to the media. This framework is crafted with a view to identifying the complex factors and processes that create translation problems, highlighting models and approaches that can improve science communication. Throughout, we propose a parsimonious set of research agenda items. Scholars wishing to move between different models of science communication should take into consideration the processes of formative evaluation, intergroup accommodation, and message design logics.

Keywords

communication accommodation theory, deficit model, intergroup communication, knowledge brokers, media, message design logics, popularization, science communication, science translators, stakeholders

Organizations, institutions, policy makers, and citizens need to understand scientific information in order to make better decisions, develop reasoned attitudes toward or against developments, and enjoy a better life, making this a central concern for the social psychology of language. Yet science and technology are becoming increasingly complex and new, making it impossible for the public to keep up with or be aware of even a small array of significant advances and changes. Thus, media are the primary channel for conveying knowledge about science, innovation, and technology, shaping

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both the content and image of science and scientists (Schäfer, 2012; Weigold, 2001). Along with the rise of mass, and now digital and online, media is the growth of institutions for mediating or translating (some of) this information (Bucchi, 2008). At the same time, science, as a particular knowledge system, must compete with other kinds of knowledge, each with their own foundations, language, and communication styles (Peters, 2008).

The articles in this special issue provide a language-based lens into some of the details and contexts of science communication. We place articles of this special issue in the context and nature of the broader literature on science communication to identify factors and processes that create translation problems and some models and approaches to help improve science communication. This context frames 10 questions throughout that can direct future research.

The Nature of Science Communication

Bucchi (2008) describes four processes in the common model of science communication: *intraspecialist* (technical, scientific terms, data, references, and graphs that may be provisional and tentative); *interspecialist* (interdisciplinary articles and conference presentations that may be provisional and tentative); *pedagogic* (textbook science and the cumulative nature of knowledge that can be presented as facts); and *popular* news articles, TV documentaries, and metaphors that necessarily simplify ideas and facts, and blur distinctions, yet provide legitimizing contexts. In spite of the theoretical and practical presumption of a linear transmission of information through these increasingly broader audiences, many important scientific applications, understandings, interpretations, and implications come about through reciprocal interactions between scientists, policy makers, activists, and the popular media. That is, effective science communication is not a simple process transmiting comprehensible information and its potential implications.

Scientists also play various roles in communicating science, some of which correspond to Bucchi's four processes. The typical role involves communicating science *knowledge* per se, that is, both creating and disseminating "facts" or "findings" (here, intraspecialist and interspecialist). However, Peters (2008) describes three other roles that involve scientific *expertise*. The first is as public expert, engaging in media interviews, helping introduce and explain both basic and applied scientific knowledge (somewhat pedagogic). The second is as research popularizer from a scientific perspective (popular). The third is as participants in decision making and larger social discourses about relationships between science, technology, and society, engaging in issues such as values, risks, and conflicts. These distinctions expand science communication from transmission or translation to include policy advising, planning and consulting, public critique and opinions, and public and legislative debate. However, as all roles involve communication, they necessarily depend on, and are shaped by, language choices.

Weigold's (2001) overview describes the challenges media face in communicating science. Among others, these include decreasing coverage of science; fewer journalists trained or specializing in science; fewer journalists assigned to science topics; few editors with any science background; limited time and space; and central news attributes missing in most science stories. That said, academic journal publishers and science information professionals are doing a better job at disseminating intriguing or consequential studies, via feeds, free and promoted articles, news releases, and now social media (Weigold, 2001). And, similar to science knowledge brokers (Strekalova, Krieger, Neil, Caughlin, Kleinheksel, & Kotranza, this issue), or science translators (see this issue: Brooks; Howes & Kemp; Krieger & Gallois), information science professionals mediate between scientists and media. This then leads to the first three research agenda questions:

- Is there a negative correlation between the archetypal, conditional language of science (especially "uncertainty") found in many, particularly social, scientific studies, and those "stories" selected for media exposure?
- What are the core narrative structures, language choices, and framings of different topics of science communication, and how are those reflected in the public discourse of who talks to whom about these issues, when, how, and why?
- What are the major language practices and structures used in communicating science in academic journals and disciplinary magazines intended to popularize science and in mass media that can be identified so as to more successfully reach general audiences?

Condit, Lynch, and Winderman's (2012) review of 70 articles focuses on rhetorical studies from 1994 to 2011, identifying three main approaches. The first, and most frequent, rhetorical approach is to challenge science or its public representations. This occurs through opposing the legitimacy of science or particular science claims, emphasizing how discourse shapes and mediates science, or analyzing how scientific language can be used to dominate and obscure or ally science with oppressive perspectives. A paradox here is the use of rhetorical science communication to critique and oppose science communication. The second, nearly opposite, rhetorical focus of some articles is showing how scientific information can be embedded into familiar and valuable cultural narratives, to improve its effect. However, different metaphors and narratives may have beneficial as well as harmful implications, so there is no single simple rhetorical strategy (see Haslam, Holland, & Stratemeyer, 2016). The third main focus is on fostering public–science interactions and participation by both scientists and nonscientists.

Some argue that deficiencies in popular understanding of science issues could be solved by just more science communication. Indeed, academic and media interest in communicating science has been growing quickly. Searching online academic entries for "science communication" as of June 23, 2016, finds: from *ProQuest Social Sciences*, peer-reviewed scholarly articles in English (1970-2015): 884; from *ScienceDirect* (1970-2015; abstract, title, keywords): 102; from *Web of Science Core Collection* (topic): 1,050; from the *Department of Energy SciTech Conn*ect: 1,309; and *Google Scholar*: 202,000. Science communication also takes advantage of the multimodal and interactive nature of online and digital media (simulations, videos, virtual reality, 3-D display, and games). Carrying forward the search term "science communication" to the Web, we find 8,040,000 entries via a *Google* search, and 10,100 videos on *YouTube*. More surprisingly, there are 71,700 YouTube videos tagged as "Newton's laws," and even 271 videos involve rap versions of "Newton's laws." There are new environmental or science communication degree programs and research centers, new academic association interest groups, many conferences, and ongoing and new journals. Schäfer (2012) identified and reviewed 201 journal articles and 14 books dealing with the representation or coverage of science in mass media, from 1956 through 2009, though much of this has appeared only in the past decade. However, only from 0.001% to 0.005% of science papers outside of health/medicine obtain mass media coverage (Suleski & Ibaraki, 2010).

- What language forms or frames in media coverage of science communication increase perceptions of triviality or obviousness, and what forms increase perceptions or importance and novelty?

At the same time, another form of "science communication" is the ongoing and deep assaults on the fundamental validity of science (Brooks, this issue), including strategies such as "manufactured scientific controversy" (Ceccarelli, 2011), and heightening the focus on uncertainty (Lewandowsky, Gignac, & Vaughan, 2013; Neil, Krieger, Kalyanaraman, & George, this issue; Salmon, Dudley, Glanz, & Omer, 2015). Many note the growing public and political avoidance, misrepresentation, or even rejection of scientific information and reasoning (Gore, 2008; Jacoby, 2009; Peters, 2008; Pierce, 2010). Science communication, science, and scientists seen as challenging established interests (such as fossil fuel producers in the context of climate change) are rejected and reframed by a long-term and coordinated denial movement (Dunlap & McCright, 2011; Oreskes & Conway, 2010). So there are far deeper issues and problems than the choice of *le mot juste* in science communication.

An even darker side to science communication can be observed at two levels. First, media coverage that highlights errors and anomalies in reported scientific findings (Brown & Heathers, 2016), some with falsified data (Markowitz & Hancock, 2016) or irreproducible results (Baker, 2016) do little to assuage public concern about the validity of research findings and the research enterprise. Second, there is growing speculation that media reports on certain scientific issues (such as climate change) can harmfully affect subjective well-being. For instance, Weir (2016) claimed that "exposure to climate- and weather-related natural disasters can result in mental health consequences such as anxiety, depression and post-traumatic stress disorder" (p. 29).

- To what extent do media reports of apparent violations of the scientific norms of the importance of reproducibility and generality of findings influence how the public attends to and discusses science communication?
- Does fear arising from disaster-related science communication directly affect mental health or may it also more indirectly mediate interpersonal, family, and social network discourse devoted to communicatively managing such anxieties?

Language and Science Communication: Central Problems and Tensions

Language, Meaning, and Opposition

While "science" and "communication" are familiar and daily words, and we are immersed in the realities, developments, and implications of both every minute, there are no un-debated definitions of either (Weigold, 2001). After all, if the word "word" or specific medical terms do not have bounded definitions (Wray, this issue), how can principles of the universe and the quintessential nature of humans be more manageable? Thus, even before the need to help translate terms for general public use and understanding, interdisciplinary scientific collaborations themselves need to help identify boundaries and overlaps in the meanings of both existing and new terms. As Wray highlights, language is both a conduit and a barrier for communicating scientific and medical information, through both text and images (for the role of visual images in climate change communication, see Rebich-Hespanha & Rice, 2016; also http://www.climatevisuals.org/).

- When and why are linguistic and visual symbols differentially effective for communicating certain forms of science information?

Indeed, students' own language involves stereotypes and negative perceptions of science and scientists' training and work. These social constructions can contradict students' own identities, limiting their understanding of or interest in science (Brooks, this issue). Limited language about, and socialization away from, science, technology, engineering, and medicine (STEM) fields begins early, and is deeply integrated into gender, socioeconomic, and cultural norms (Kisselburgh, Berkelaar, & Buzzanell, 2009).

Specialist terminology is developed to foster shared, stable, and guiding meaning with a specialist group. Science often requires technical terms (pejoratively, "jargon"), and technical representations (e.g., logarithmic scales, graphs) to define and label factual and explicit information precisely to distinguish it from nonfactual and general information. Some topics are inherently complex and specialist (Howes & Kemp, this issue), or change, or make sense only in context (Wray, this issue). Yet, by definition, language is not self-explanatory or familiar to most people. Simply using nontechnical language to attempt to do so generates possibilities for misinterpretation (Weigold, 2001; Wray, this issue) and miscommunication (see Coupland, Wiemann, & Giles, 1991), as implied by Krieger and Gallois (this issue).

Applying communication accommodation (or, more generally, formative evaluation, discussed below) analyses is then necessary to construct a convergence between the intention and the meaning. But even accommodation can be interpreted differently (emphasizing common relations or conflicting group identities; over-, under-, and nonaccommodation) depending on perceptions, behavior, context, and actors (Gasiorek, 2016). Another crucial factor is trust and procedural fairness (Gallois, Ashworth, Leach, & Moffat, this issue) between the stakeholders, which moderates the perceived direction of accommodation.

Probably more troublesome—and more likely—is the case where the words used to represent a scientific concept are also those used in common language (including, ironically, terms meant specifically to describe scientific uncertainty, such as “significance” or methodological inability to “prove” a relationship; see Howes and Kemp, this issue, for forensic science examples). At least three kinds of uncertainty swirl within and around both scientific and general understanding: The inherent uncertainty of science (from a Popperian perspective of potential falsifiability), measured or bounded scientific uncertainty (e.g., sampling error and confidence intervals), and incomplete or unknown information (deficit uncertainty; Gustafson & Rice, 2016). Typically, the general public (and most journalists) do not know or understand the first two, so conflates them with the third. Furthermore, this general uncertainty fosters doubt, confusion, and even opposition to scientific information (Neil et al., this issue). A more common source of general uncertainty is the near-continuous changing of scientific uncertainty, such as frequent changes in health and nutrition guidelines, which can decrease confidence in the validity of science and scientific information (Neil et al., this issue).

Scientific developments and their related infrastructures are deeply interdependent with social, environmental, economic, cultural, and religious issues. Cases such as new energy developments (deVries, this issue; Gallois et al., this issue) require intense and negotiated communication among stakeholders. Hence, the language used and related interpretations can generate significant, negative and positive, intended and unintended, and expected and unexpected consequences. For example, one might think that a positive framing of science information about an issue (such as a new energy development) might foster more positive attitudes. However, deVries (this issue) shows that emphasis framing a message as only positive (or only negative) can foster a sense of manipulation and bias (especially if the source is not initially seen as biased), generating need for a sense of personal control, subsequent psychological reactance, and long-term opposition to the message (and, thus, the opposite effect expected from a simple deficit model). This boomerang relationship is moderated by both source and audience characteristics. While boomerang effects are familiar to the persuasion and attitude change literature, there are few other applications to science and environmental communication so far (for a notable exception, see Hart & Nisbet, 2012).

Digital Media

The Web and social media now provide many more opportunities due to freedom from space and medium limits, offering rich media, simulations, and interactivity (Weigold, 2001), as noted above. New media affect all three stages of science communication: conceptualization, documentation, and popularization. Yet Bucchi (2013) notes a “crisis of mediators,” whereby traditional mediators or guarantors of quality of science information (media, museums, science information professionals), and the traditional sequences of science coverage and dissemination, are being undermined by the proliferation of online/digital media and institutional public relations. There is now the danger of fragmentation of sources, information, audiences, opinions, viscerally engaging multi-media formatting, and the flattening of plausibility of information and their sources across a continuum, or even exploding it across *n*-dimensional space so that no source seems un-challengeable, yet none has the final say.

Lievrouw and Carley (1991) identified this transformation through online media early on, years before popular access to the Internet. Even the editor of a journal such as *Fertility and Sterility* (Roan, 2001) noted, 15 years ago, the increasing confusion of the public about nutrition practices caused by the constant, fragmented stream of news stories with contradictory and changing guidelines (e.g., Neil et al., this issue). Hence, another tension or challenge is just how much should scientists and media report what kinds of results, in what kinds of context, with what levels of consensus?

Although some scientists may embrace this popularization, others feel and contend that it degrades the objective scientific status of the issue and the researcher; the topics are then subject to issue cycles, manipulation, and trivialization. But research institutions engage in the popularization process themselves (e.g., *Communication Currents, Psychology Today, Pacific Standard*), trying to gain more control over the popularization process, via centers, open houses, and public relations. For an intriguing case example of the blurring of boundaries between science and popularization, scientists and corporations, and academic and digital media, see Williams's (2016) story on communication about hominid fossil discoveries.

Models of, and Ways to Improve, Science Communication

Models of Science Communication

Three primary models of communication of science with the public are deficit, dialogue, and participation (Bucchi, 2008; see also Krieger & Gallois, this issue). According to the *deficit model*, scientists and their translators only need to transmit or translate information, through more media, because lack of information, clearly communicated or translated, is the central cause of low science literacy or even support for science (see Howes and Kemp's analysis of using the deficit model in forensic communication, this issue).

The *dialogue model* emphasizes knowledge coproduction, citizen science, and citizen participation in discussions, involving discussion among the science source, mediators, and stakeholders. A powerful assumption here is that the general public also has valuable and relevant knowledge that complements scientific knowledge. The *participation model* acknowledges the importance and engagement of new science knowledge creators: corporations, military, environmentalists, activist and patient groups. A fundamental assumption here is that all stakeholders should have a voice in discussing scientific and technological actions and implications. Thus, it raises issues of involvement, conflict, and even possible diversion from initial goals.

Bucchi (2008) thoughtfully argues how each of these models might be more or less appropriate for different problems and contexts, projecting the need to be open to moving across the various models as appropriate (such as in different stages of forensic science communication; Howes & Kemp, this issue). Contexts may include science issue salience, public mobilization, credibility of science institutions and actors, the public's perceptions of controversy among scientists, institutionalization and boundaries in the science field, and social consensus (Bucchi, 2008).

Weigold (2001) provides two different models beyond the deficit model. *The rational choice model* focuses on finding out what knowledge people need to live in a society formed through science. The *context model* assumes that local, specific individual contexts shape what people want to know about and how to use scientific information. A rhetorical perspective on the contextual model emphasizes relationships to moral order and judgment, instead of just description, which are then bases for social action and the development of public understanding. This model emphasizes the role for both experts and publics, as well as convergence (Condit et al., 2012), and thus is similar to the participation model noted above. However, it also implicitly includes how "cultural tribes" use motivated reasoning to reframe or repudiate scientific information that is perceived to challenge one or more core values (Kahan, 2012).

Formative Evaluation

Science communication overlaps with public communication campaign theory and research. Indeed, many formal, large-scale science communication efforts, such as through health agencies (Centers for Disease Control, National Institutes of Health), are designed and implemented as communication campaigns (Rice & Atkin, 2012). Science communication programs, like other campaigns, should be evaluated with respect to their theoretical basis, design, implementation, and effects. However, evaluating public communication of science and technology is not straightforward, with many methodological and stakeholder tensions and challenges (Neresini & Pellegrini, 2008).

One of three kinds of campaign evaluation (formative, process, and summative or effects), formative evaluation, is a way of identifying stakeholders (i.e., community-based campaign design), issues, and communication meanings, opportunities, and needs. Atkin and Freimuth (2012) explain that a comprehensive formative evaluation process involves research both before and during a campaign to engage and analyze community resources and stakeholders, explore meanings and contexts of relevant goal behaviors, identify audience characteristics and media preferences, develop and test candidate messages, and help anticipate potential barriers to campaign effectiveness. Such formative evaluation may include a wide range of methodologies, such as focus group interviews, in-depth personal interviews, surveys, theater testing, day-after recall, media gatekeeper review, readability testing, eye- and attention-tracking, physiological responses, combinations of these, and so on. In the context of science communication, for example, Rebich-Hespanha and Rice (2016) propose that awareness and shaping of image frames in climate change news stories can help improve congruency between images and text, and intended framing effects (see also Neresini & Pellegrini, 2008).

Lurking beneath the surface of individual/group interests and meaning is the role of collective/social interests and meaning, including public goods or tragedy of the commons issues, and complex and subtle interdependencies (Wray, this issue). In-depth formative evaluation of these existing forces and relationships, motivated by a commitment to involving stakeholders, would improve the basis for science communication efforts. Theoretical understanding, allied with formative evaluation, would help science communicators understand the effect of audience attitudes, values, and existing knowledge on responses to science communication. For example, there is not necessarily a positive, linear relation between science knowledge and one's position about a scientific or technological issue (support or opposition; Gallois et al., this issue; Wray, this issue), due to a wide variety of personal, political, community, and cultural factors.

Communication Accommodation

As Krieger and Gallois (this issue) note, translating science is an exercise in communication accommodation (Giles, 2008, 2016). Applying communication accommodation theory, through both perceptions and behaviors, can help converge understanding between groups on the basis of both cognitive and affective communication motivations, but can also heighten different group identities, generating conflict (see Giles, 2012; Giles & Maass, 2016). Accommodation emphasizes common relations, while nonaccommodation emphasizes group identities, intergroup relations, and conflict (Gasiorek, 2016). Even sincere attempts at accommodation, such as explaining scientific terms and their implications based on a participation or context model, may be perceived as overaccommodating, through patronizing or ingratiating language. Each stakeholder group has its own language and meanings; one cannot presume a common jargon or interpretation; and even if it *is* the same, then it might expose deeper divisions.

As Gallois et al. (this issue) argue, the role, success, and valuation of scientific language varies by topic and stakeholder; even who qualifies as a stakeholder is shaped and framed through language. For example, they show that a reference to a scientific study in communicating about a social license to operate can be interpreted as accommodating (relevant) or nonaccommodating (distancing through scientific terminology and not human scale). Even empathic communication, a prototype of communication accommodation by nurses, can be differently valued by patients, and perceived as stigmatizing (Strekalova et al., this issue).

- What strategies of communication accommodation, together with what kinds of balanced foci on different sides of an issue, are more effective in improving the positive processing of science communication, by journalists and the public?

Message Design Logics

Message design logics theory (O'Keefe, 1988; Strekalova et al., this issue) also focuses on relational discourse. Positional discourses representing formal stakeholders can be assessed, and designed, with both accommodation and message design logics in mind (Gallois et al., this issue; Strekalova et al., this issue).

O'Keefe (1988) proposed three logics underlying an individual's approach toward achieving communication goals. *Expressive* logic is a one-way expression of the speaker, not considering message perception or receiver effects. Thus, such messages may be vague or repetitive, inappropriate and misunderstood, and assume a strict linear transmission perspective. This logic does not allow for feedback, message adjustment, or accommodation, or engagement in formative evaluation. It is thus similar to the basic knowledge deficit science communication model. *Conventional* logic involves the goal of showing the speaker's competence in acting appropriately in a given context, as the basis for communicating more relevant and effective messages. It is oriented toward social rules and effects, and uses apologies, compliments, hedges, and excuses, emphasizing obligations or expectations. Here, the context shapes what is considered relevant and appropriate, so can involve communication accommodation or, more generally, formative evaluation. Thus this is related to the contextual science communication model. *Rhetorical* logic involves the negotiation of social selves and situations. Discourse here is used to redefine problematic situations, and clarify intentions and perspectives, and highlights the importance, individuality, and beliefs of the receiver. Messages not only refer to contexts, but help create them, as well as offer participants both useful and salient perspectives. This is somewhat similar to the participation model. Strekalova et al. (this issue) show how such logics shape empathic responses to patients' discourse.

Conclusions

This special issue, and related work, shows that science communication is multidimensional, processual, intergroup, mediated, and even opposed or manipulated. Furthermore, and as highlighted by Gallois et al. (this issue), the intergroup dynamics in terms of identities, group loyalties, and stereotyping so integral to parties involved in the discourse of science communication have been conspicuous by their absence in science communication research. These articles a wide range of ways of thinking about the latter, from message design and framing, to accommodation and knowledge or language brokering, through science communication and message design models and linguistic meaning. They analyze such communication at all levels, from individual writing through multigroup interactions to audiences, communities, disciplines, and society. Methods range from conceptual to experimental, case study, discourse analysis, and media content analysis, identifying a wide range of approaches, as well as problems or challenges.

There are many contexts, opportunities, and challenges for studying and implementing successful science communication from an interdisciplinary language perspective. This special issue is an important step in the social psychology of language's foray into this arena. Ideally, it will trigger rigorous empirical, theoretical, and policy-oriented programs of work. Indeed, we hope that the contributions that make up this special issue will themselves be the topic of science communication.

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Author Biographies

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