

**SCIENCE COMMUNICATION RESEARCH:
BRIDGING THEORY AND PRACTICE**

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PREFACE

AAAS describes public engagement with science as intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public. Through the Alan I. Leshner Leadership Institute for Public Engagement with Science, AAAS empowers scientists and engineers to practice high-impact public engagement by fostering leaders who advocate for critical dialogue between scientists and the public and lead change to enable their communities, institutions, and others to support public engagement.

This white paper, with additional work on understanding mechanisms for institutional change, as well as practical experience in public engagement with science, will guide the work of the Leshner Leadership Institute and its Public Engagement Fellows, as well as other programs of the AAAS Center for Public Engagement with Science. The Center, which manages the Leshner Leadership Institute, offers this paper as a resource for the broader community of public engagement practitioners, researchers, and scientists doing public engagement.

SCIENCE COMMUNICATION RESEARCH: BRIDGING THEORY AND PRACTICE

A growing number of researchers across fields are investigating the factors that influence public perceptions of science and technology and the implications for effective communication. As described in a previously published AAAS white paper, much of the research has conceptualized communication as a two-way iterative dialogue involving experts, the public, and stakeholders. By way of formal contexts such as public meetings and other consultation exercises, the public and stakeholders are invited to be active participants in deciding what is discussed, contributing to the production of expert knowledge and/or the formulation of policy options and decisions.¹ A related but distinct area of research has examined effective approaches to communication within informal learning contexts such as science museums, science centers, zoos, and aquariums.²

In a third line of research, as issues such as climate change and food biotechnology have become politically controversial, social scientists and polling experts have studied the factors influencing public opinion and policy preferences. As reviewed in a previous AAAS report, this research illuminates the social context within which science communication and outreach takes place, but typically lacks direct recommendations for scientists and practitioners.³

Yet over the past decade, out of this mostly theoretical and descriptive research on public opinion formation, there has emerged a more applied and practical focus. In this line of work dubbed the "science of science communication" by the U.S. National Academies, social scientists develop and empirically test specific communication strategies, principles, and practices. In contrast to some of the more traditional research on public engagement mentioned earlier, much of this research focuses on more strategic goals such as gaining public attention and generating concern about a problem; responding to or correcting false information; encouraging specific policy preferences or outcomes; or recruiting members of the public to become involved civically or politically.

¹ Nisbet, M.C. & Markowitz, E. (2015, Nov.) Public Engagement Research and Major Approaches. Literature review and annotated bibliography prepared support of the AAAS Leshner Leadership Institute. Washington, DC: American Association for the Advancement of Science. Available at: <http://goo.gl/gRCg8M>.

² See for example Feder, M. A., Shouse, A. W., Lewenstein, B., & Bell, P. (Eds.). (2009). Learning Science in Informal Environments: People, Places, and Pursuits. National Academies Press.

³ Nisbet, M.C. & Markowitz, E. (2016, Feb). American Attitudes about Science and Technology: The Social Context for Communication. Commissioned report prepared for the Alan Leshner Leadership Institute of the American Association for the Advancement of Science, Washington, DC. Available at: <http://goo.gl/k6UEtW>

In this annotated bibliography and review, we synthesize recent research on the science of science communication, highlighting seven areas of work that are particularly relevant to scientists, and that have been the subject of considerable attention and interest. These areas of research include:

- Strategies that scientists can adopt for establishing and maintaining trust among members of the public and policymakers.
- Strategies for identifying and recruiting everyday opinion-leaders who are highly skilled at recommending information to others and influencing decisions. This includes how scientists themselves can serve as opinion-leaders and the ways in which they can talk about their work so that it is more likely to be shared by way of social media.
- Strategies for developing communication materials such as presentations, web sites, brochures, and reports that are tailored to the mental models, concerns, and information needs of targeted audiences.
- Strategies for re-framing how Americans perceive climate change, broadening concern and motivating public participation.
- Strategies involving storytelling and narrative to influence how audiences come to understand complex science subjects such as climate change.
- Strategies that scientists and their partners can use to counter misperceptions and false beliefs about complex science-related topics.
- Strategies involving "consensus" messaging in which scientists and their partners emphasize simple messages that correct false perceptions about the level of expert agreement on issues like climate change and childhood vaccination.

We devote a section of the annotated bibliography to each of these subjects. Each section opens with a brief overview of research in the area followed by detailed summaries of peer-reviewed studies or synthesis articles. We chose the combined 27 peer-reviewed articles based on the strength of the empirical evidence they provide; their direct relevance to practice, and their accessibility to an interdisciplinary readership. We also prioritized research that had appeared over the past five years, and that has been influential as indicated by citations and visibility. In the introduction to each section, we also draw on additional works not included in the bibliography, including references to further reading in the footnotes.

MAINTAINING TRUST AND CREDIBILITY

In order to form opinions or make decisions about complex science-related issues, the public often relies heavily on how much they trust or defer to the authority of scientists. Above and beyond knowledge, studies show that trust in scientists is one of the strongest predictors not only of general attitudes about science, but also of opinions about contested scientific topics such as climate change. Trust involves a relationship between scientists and the public that facilitates ongoing interactions that

involve uncertainty and risk-taking about future interactions and outcomes. Trust is considered to have at least three key dimensions including "integrity," the belief that a person or organization is fair and just; "dependability," a belief that an individual or organization will do what they say; and "confidence," a belief that an individual or organization can or will deliver on their promises.⁴ Given these elements, establishing and maintaining trust is an essential component of effective public communication.

The good news for the scientific community is that among U.S. institutions, scientific leaders tend to hold very high levels of trust. In 2012, 90 percent of the public expressed either "a great deal of confidence" (41%) or "some confidence" (49%) in leaders of the scientific community. In comparison, since the 1970s, as public confidence in Congress, the presidency, industry, religious institutions, and the news media have plummeted; public faith in the scientific community has remained virtually unchanged.⁵ Some evidence suggests that trust in the scientific community has declined among conservatives, though other research indicates that conservatives tend to be more skeptical of so-called "impact scientists," researchers such as climate scientists or health scientists who examine the environmental and health impacts of economic development and technology. In contrast, conservatives tend to hold greater trust in so-called "production scientists," researchers such as engineers or chemists producing new technologies and marketable products.⁶

Specific to climate change, polling shows that the public holds strong overall trust in scientists as a source of information, though levels of trust have shifted slightly downward in recent years. Yet still, compared to other possible sources of information, scientists and expert government agencies enjoy widespread trust, especially in comparison to the oil and gas industry. Other research shows that on topics like climate change and stem cell research, scientists hold unrivaled cultural authority and credibility. On these topics and others, scientists in comparison to other groups such as elected officials and business leaders are believed by the public to have a substantially greater role to play in policy decisions, to have greater levels of expertise, and to be more likely to support what is best for the country.⁷

⁴ National Academies (2015). Trust and Confidence at the Interfaces of the Life Sciences and Society: Does the Public Trust Science? A Workshop Summary. Washington, DC.

⁵ Nisbet, M.C. & Markowitz, E. (2016, Feb). American Attitudes about Science and Technology: The Social Context for Communication. Commissioned report prepared for the Alan Leshner Leadership Institute of the American Association for the Advancement of Science, Washington, DC.

⁶ McCright, A. M., & Dunlap, R. E. (2010). Anti-reflexivity the American conservative movement's success in undermining climate science and policy. *Theory, Culture & Society*, 27(2-3), 100-133.

⁷ Nisbet, M.C. & Markowitz, E. (2016, Feb). American Attitudes about Science and Technology: The Social Context for Communication. Commissioned report prepared for

Still as Druckman (2015) reviews, on highly contested issues like climate change or genetically modified food, motivated reasoning and politicization can undermine perceptions of expert credibility and feelings of trust. Fisk and Dupree (2014) suggest that scientists as a group tend to score high in perceived expertise and competence, but are perceived as less "warm" and therefore less trustworthy than some other professions. Still other research they present contradicts this finding, suggesting that the public when asked offer few reasons to distrust climate scientists and many reasons to trust them. A potential "Achilles heel," for climate scientists, however, is the perception that they are motivated by research money.

In reviewing research, Jamieson and Hardy (2014) and Druckman (2015) warn that scientists when speaking in a professional capacity are likely to lose credibility and trust when they present their research findings or recommendations in a way that clearly favors one political group over another, that conveys an explicit value preference, or preferred policy outcome. This is not to say that as private citizens, scientists should not participate like other Americans in a variety of political activities, but when speaking in a professional capacity on areas related to their expertise, these authors warn that trust and credibility is put at risk by advocating on behalf a particular political group or specific policy outcome.

To overcome doubts on issues like climate change or genetically modified food, Jamieson and Hardy evaluate a "leveraging, involving, visualizing, and analogizing (LIVA)" message strategy in which a scientist avoids partisan or ideological side taking, and conveys that they are "faithful to a valuable way of knowing, dedicated to sharing what she knows within the methods available to her community, and committed to subjecting what she knows and how she knows it to scrutiny and hence, correction by her peers, journalists, and the public."

Druckman (2015) echoes similar recommendations for overcoming motivated reasoning and politicization as threats to credibility. A key strategy is to communicate when possible about consensus evidence endorsed by a diversity of experts, make transparent how scientific results were derived; and avoid conflating scientific information with values that may vary among the public. He emphasizes the importance of "values diversity," in which scientists avoid offering value-laden scientific information, defining for the public a "good" or "competent" decision or policy outcome. Rather than arguing on behalf of a specific outcome, scientists should work to ensure relevant science is used or at least consulted in making a policy decision. These are principles that individual scientists can adopt, but more importantly, Druckman (2015) argues they are principles that need to be promoted and invested in by scientific organizations, universities, and similar institutions.

Drawing on their research findings, Fiske and Dupree (2014) recommend that climate scientists can maintain and build trust by emphasizing in communication those motives that the public rates them highly for; which include a desire to educate the public, save humanity, and save the environment. By doing so, climate scientists may be able to balance already high perceptions of expertise with greater perceptions of warmth. They also warn against scientists clearly identifying with liberal causes or candidates, or engaging in other overt forms of political advocacy.

Research by Kahan (2010) suggests that a possible effective strategy for overcoming biased information processing on a controversial science-related topic is to "present information in a manner that affirms rather than threatens people's values." People tend to doubt or reject expert information that could lead to restrictions on social activities that they value, but research by Kahan and colleagues shows that if they are provided with information that upholds those values, they react more open-mindedly. For example, among right leaning individuals who often doubt expert advice about climate change because they see it as aligned with policy actions that restrict commerce and industry, they tend to look at the same evidence more favorably when they are made aware that "the possible responses to climate change include nuclear power and geo-engineering, enterprises that to them symbolize human resourcefulness." In this sense, the technological and policy options presented as solutions to climate change provide much of the contextual framing by which the public evaluates the issue. Like Druckman (2015), this line of research also suggests that polarization is likely to be reduced when people encounter experts and communicators from a diversity of backgrounds who are emphasizing the same scientific advice.

Fiske, S. T., & Dupree, C. (2014). Gaining trust as well as respect in communicating to motivated audiences about science topics. *Proceedings of the National Academy of Sciences*, 111 (Supplement 4), 13593-13597.

Fiske and Dupree review research demonstrating that credibility in science communication likely turns on the key dimensions of perceived expertise (competence) and warmth (trustworthiness). In a series of studies evaluating how Americans view a range of professions, scientists along with accountants, lawyers, CEOs, and engineers score high in terms of perceived expertise but relatively low in terms of warmth. Scientists along with these other "envied" professions earn respect from the public but not trust as conveyed by warmth, they conclude. Interestingly, professors and teachers' were perceived as substantially warmer as scientists, and almost as competent. Scientists whose job involves teaching and communicating may seem warmer and more trustworthy than scientists who focus exclusively on research, suggests Fiske and Dupree.

Yet other data they present directly contradict low scores for scientists in terms of trust. Asking specifically about climate scientists and posing a series of questions

about credibility and trust, Fiske and Dupree find that distrust of climate scientists is remarkably low and trust relatively high. In terms of assessing reasons to distrust climate scientists, subjects were asked seven items about climate scientists' alleged motives to lie with statistics, complicate a simple story, show superiority, gain research money, pursue a liberal agenda, provoke the public, and hurt big corporations. Only one of these items -- gain research money -- scored on average above the midpoint in terms of distrust, suggesting that this might be an "Achilles heel" to address in outreach efforts. In terms of three questions asking about reasons to trust climate scientists, they scored high on motives to educate the public, save humanity, and save the environment. By emphasizing these goals or characteristics in communication efforts, climate scientists may be able to balance already high perceptions of expertise with greater perceptions of warmth. They also warn against scientists clearly identifying with liberal causes or candidates, or engaging in other over forms of political advocacy.

Kahan, D. (2010). Fixing the communications failure. *Nature*, 463(7279), 296-297.

Kahan reviews research he has conducted with colleagues finding consistently that right-leaning Americans with individualistic values who prize personal initiative and freedom and those with hierarchical values who prioritize respect for authority and the status quo tend to dismiss expert advice and evidence about climate change and other environmental risks. The reason is that they view such evidence as aligned with or supporting policies that would restrict commerce and industry, activities that following from their worldviews they deeply admire. In contrast, more left-leaning individuals who tend to hold more egalitarian and communitarian values are suspicious of commerce and industry, since they view corporations and markets as promoting unjust social and environmental disparities. As a consequence left-leaning individuals are much more inclined to believe scientific advice and evidence that commerce and industry pose environmental and climate change risks since such evidence is viewed as supporting policies that would restrict commerce and industry.

For example, in one study examining risk perceptions of nanotechnology, when subjects were presented with neutral, balanced information about the risks, they split in their views about the technology into two opposing factions consistent with their pre-existing views about towards more familiar technologies like nuclear energy and genetically modified food. Across studies, differences in individualist, hierarchical, egalitarian, and communitarian worldviews explain disagreements in environmental-risk perceptions more completely than differences in gender, race, income, education level, political ideology, personality type or any other individual characteristic.

Kahan's research also suggests that the perceived values of expert communicating about a controversial topic also matters to their credibility and to acceptance of that advice. In a study examining public perceptions of the HPV vaccine, when an expert who was perceived as exhibiting hierarchical and individualistic values criticized the CDC recommendation to mandate the vaccine, people who shared those

values and who were already predisposed to see the vaccine as risky became even more intensely opposed to it. Similarly, when an expert perceived as egalitarian and communitarian defended the vaccine as safe, people with egalitarian values became even more supportive of it. Yet when the hierarchical expert was presented as unexpectedly offering support for mandatory vaccination and the egalitarian expert opposing vaccination, subjects shifted their positions to be in line with the like-minded expert, reducing polarization on the issue.

One strategy for overcoming this type of biased information processing is to "present information a manner that affirms rather than threatens people's values." People tend to doubt or reject expert information that could lead to restrictions on social activities that they value, but if they are provided with information that upholds those values, they react more open-mindedly. For individualistic and hierarchical individuals who tend to resist expert advice about climate change because they see it as aligned with actions that restrict commerce and industry, they tend to look at the same evidence more favorably when they are made aware that "the possible responses to climate change include nuclear power and geo-engineering, enterprises that to them symbolize human resourcefulness." Similarly individuals with strong egalitarian and communitarian values tend to doubt expert advice on the safety of nanotechnology or genetically modified food because they see the technology as favoring corporations and industry. But if they are made aware of the possible environmental benefits of the technologies, they are less likely to reflexively dismiss expert evidence.

A second strategy is to make sure that scientific evidence is vouched for and communicated by a diverse set of experts and social authorities. Polarization is likely to be reduced when people encounter experts and communicators from multiple backgrounds who are emphasizing the same scientific advice. For example, by working with military or religious leaders as partners in communicating about climate change, may promote a more open-minded consideration of scientific evidence about climate change among right-leaning Americans.

In all, Kahan's research suggests that on a polarized topic like climate change, scientific organizations and universities can maintain credibility and soften disagreement by investing in communication activities and initiatives that emphasize a broad menu of policy actions and low carbon energy technologies. In this case, experts and their institutions can serve in the role of "honest brokers," expanding and evaluating the range of known solutions to a problem rather than narrowing them to a few choices that might reflect a particular preferred set of values or political goals.⁸ In doing so, in outreach efforts and in convening public discussion, a diversity of trusted

⁸ For discussion of the honest broker model of engagement, see Pielke, R. A. (2007). *The honest broker: making sense of science in policy and politics* (p. 188). Cambridge: Cambridge University Press.

societal leaders should be involved, communicators who discuss a complex issue in a manner that resonates with the identity and cultural background of multiple audiences.⁹

Jamieson, K. H., & Hardy, B. W. (2014). Leveraging scientific credibility about Arctic sea ice trends in a polarized political environment. *Proceedings of the National Academy of Sciences*, 111(Supplement 4), 13598-13605.

Reviewing research in the area, Jamieson and Hardy warn that no matter how effectively translated or simplified, members of the public are likely to dismiss scientific evidence and advice if it is perceived as hostile or antagonistic to members of their own political or social group. To avoid and counter such perceptions on issues like climate change or genetically modified food, scientists in their outreach efforts should employ a leveraging, involving, visualizing, and analogizing (LIVA) message strategy. This strategy involves not only eschewing advocacy but also conveying that scientists are sharers of knowledge faithful to science's way of knowing and respectful of the audience's intelligence; that the sources on which they rely are well-regarded by both conservatives and liberals; and that the message explains how the scientist arrived at the offered conclusion, is conveyed in a visual form that involves the audience in drawing its own conclusions, and capsulizes key inferences in an illustrative analogy.

A scientist's credibility, write Jamieson and Hardy, depends on communicating that she is "faithful to a valuable way of knowing, dedicated to sharing what she knows within the methods available to her community, and committed to subjecting what she knows and how she knows it to scrutiny and hence, correction by her peers, journalists, and the public." In contrast, a "scientist who can be construed as either self-interested or partisan risks the credibility carried by the scientific role." One way to avoid appearing self-interested or partisan is to offer recommendations that are policy relevant, but not policy prescriptive.

They use an example and test case the 2013 increase in Arctic sea ice extent, an event that was highlighted in conservative media to argue against the reality of climate change, but left unaddressed by three major climate science reports (and the related communication efforts) that appeared the same year. In testing an effective counter-message to conservative efforts to use the event to cast doubt on climate science, Jamieson and Hardy created a message design incorporating their LIVA principles. To counter-act "identity protecting" interpretations, the message opened by emphasizing NASA as well-known, valued source of accurate information that for decades has benefited national defense and the economy with satellite tracking of arctic sea ice a

⁹ For discussion of how the honest broker model relates to communication and outreach strategies employed by expert organizations and universities, see Nisbet, M.C. (2014). Engaging in Science Policy Controversies: Insights from the U.S. Debate Over Climate Change. *Handbook of the Public Communication of Science and Technology*, 2nd Edition. London: Routledge (pp. 173-185). Available at: <http://goo.gl/xtlY81>.

longstanding part of this mission and service. Next, the presentation sought to show that NASA scientists are dedicated to weighing the best available evidence, explaining how NASA knows what it knows about sea ice, incorporating a graphic that shows a multi-decade decline in sea ice extent. To aid with audience reasoning, the presentation also incorporated the following analogy: "expecting sea ice extent to return to its 1979 level based on the improvement in 2013 is like earning a C on a first examination, a D on a second examination, an F on a third examination, and a D on a fourth examination and as a result of that recent D, anticipating an A on the final."

To test the efficacy of the presentation in countering false statements and impressions about the increase in Arctic sea ice, 305 U.S. adults were assigned to an experimental condition in which they read a misleading Fox News story about the sea ice, and 326 subjects were assigned to a second condition in which they read both the Fox News story and the LIVA designed message (just reviewed). A similar number of subjects were also assigned to a control condition. According to their analysis, among conservative subjects who were most prone to identity protecting biases and false beliefs, the LIVA designed presentation significantly increased sea ice extent knowledge levels over those in both the Fox and control conditions and also blunted the Fox effect on beliefs that ran counter to scientific consensus. The study and LIVA principles outlined offer a promising counter-strategy to false claims and perceptions about politically contentious science-related issues. More research is needed testing the efficacy of the method and more work on how to translate the method and insights into direct practice.

Druckman, J. N. (2015). Communicating Policy-Relevant Science. PS: Political Science & Politics, 48(S1), 58-69.

A major challenge in science communication is that people make decisions primarily based on their social, political, moral, and/or religious values and not based on new information or knowledge. This explains why the public is consistently shown to score low on knowledge of science and politics, but often can hold very strong opinions on these subjects. It also explains why the most knowledgeable individuals are often the most divided on issues like climate change and become "over confident" in their opinions, leading them to reject scientifically accurate information. It is not the amount of information that matters, writes Druckman, but rather which information individuals use "to (1) identify which values are most relevant for a given decision (e.g., is the decision framed in terms of the most relevant values?), and (2) connect the given value to the decision."

As Druckman explains, drawing on research in the area of "motivated reasoning," even the most effective translation of scientific evidence will not lead to a single point of view among the public "because the scientific information will have distinct meanings to people with varying values, and this must be recognized: singular scientific findings may have distinct implications for individuals that are contingent on

their values." The tendency towards motivated reasoning is amplified under conditions of politicization by various political actors which involves "introducing doubt and/or challenging scientific findings with a political purpose in mind." To counter motivated reasoning and politicization, among recommendations, Druckman emphasizes the following general principles and strategies, drawing on relevant areas of past research.

Seek to maintain credibility: Research suggests strategies for maintaining credibility include ensuring consensus evidence that differing political sides endorse to minimize perceived bias; ensuring transparent evidence in terms of how the results were derived; and avoiding conflating scientific information with values that may vary among the public.

Actively engage the public and policymakers: Moving forward, though the actions of individual scientists and experts are important, scientific organizations, universities, and similar institutions must take the lead in promoting sustained, well resourced efforts to identify areas of scientific consensus. When these areas do not exist, they can organize groups of researchers to assess the work that may be needed to move toward a consensus. When a consensus does exist, organizations should not hesitate about engaging mass-media outlets to publicize research.

Recognize value diversity: Do not offer value-laden scientific information, and do not impute what defines a "good" or "competent" public decision or policy outcome. Rather, work to ensure relevant science comes into play in making that decision. Ensure the recognition of distinct value priorities, representation of different perspectives on expert committees or convening, and recognize that scientific findings may offer distinct implications depending on values.

Emphasize uncertainty, relevance, localization, and deliberation: To compete and gain public or policymaker attention, seek to frame scientific advice and findings in terms of their personal or social relevance and to localize an issue such as climate change. Explicitly state the uncertainty in research and present them in probabilistic terms, since this helps build credibility and promotes dramatic tension and interest in an unfolding story or mystery about discovery and understanding complexity.

Anticipate and counter motivated reasoning: Emphasize relevance, providing information from varied sources, or engaging in conversations and engagement in social networks. Connect scientific issues to individuals' lives, ensure representation of distinct ideologies on research endeavors, and stimulate interpersonal interactions.

IDENTIFYING AND CULTIVATING OPINION-LEADERS

For more than seventy years, marketers, advertisers, and campaign strategists have recruited informal, everyday opinion-leaders as promoters of issues, candidates, or products. Yet until recently, opinion-leaders have received little to no attention among

science communication researchers and practitioners. Research suggests several key traits that make opinion-leaders key go-betweens and influencers, offering strategies for identifying them as part of outreach efforts. With the quickly changing nature of today's digital and social media, recent studies have also examined the role of opinion-leaders in online contexts as well as the qualities of messages that are likely to be shared and recommended online.

Opinion-leaders are everyday individuals who have a stronger motivation for public affairs content or information specific to an issue like climate change, and who have a special ability as a trusted source to share that information with others. Opinion-leaders rarely hold formal positions of authority and instead prove influential by way of their greater attention to a topic, their knowledge, their strength of personality, and their experience in serving as a trusted go-between among their large network of friends, colleagues, neighbors, and acquaintances. As a combination of these traits and behaviors, opinion-leaders not only help draw the attention of others to a particular issue like climate change or consumer choice like installing solar panels, but perhaps most importantly, signal how others should in turn respond or act. This influence may occur by giving advice and recommendations, by serving as a role model that others can imitate, by persuading or convincing others, or by way of contagion, a process where ideas or behaviors are spread with the initiator and the recipient unaware of any intentional attempt at influence (Nisbet & Kotcher, 2009).

Opinion-leaders are a key resource for scientists attempting to effectively communicate with the public. If scientists focus their efforts on identifying and working with opinion-leaders, these individuals can then pass on science-related information to their broader network of peers, talking about the topic in a way that is trusted, persuasive, and personally relevant. In their everyday interactions and via social media, scientists themselves can also serve as trusted opinion-leaders, sparking conversations and sharing information among co-workers, friends, neighbors, and acquaintances.

Generating a greater number of conversations about science-related topics can have many civic benefits. Studies show that interpersonal conversations about science are closely linked to more effortful processing of the information that people might encounter in the news media, online, or by way of other sources. This greater level of elaboration in turn can lead to a deeper and more sophisticated understanding of a complex issue, along with a greater ability to apply this knowledge when making decisions or offering an opinion.¹⁰

Research also suggests that discussion of science amplifies concern about problems like climate change. In a study tracking the discussion patterns of a nationally

¹⁰ Eveland, W. P., & Cooper, K. E. (2013). An integrated model of communication influence on beliefs. *Proceedings of the National Academy of Sciences*, 110(Supplement 3), 14088-14095.

representative sample of Americans across two years, attention to science-related news coverage was found to promote more frequent conversations about science, which in turn helped boost overall concern about climate change. This heightened concern not only promoted subsequent attention to news coverage of science but also intensified the frequency of science-related conversations, which resulted in even greater levels of worry about climate change.¹¹

Interpersonal conversations are also a key mechanism by which individuals are recruited into taking action to address a problem. For example, two-thirds of Americans say they trust "family and friends" as a source of information about global warming, a proportion higher than any other group except for climate scientists.¹² Given this level of trust, when the public is asked who could convince them to take action to reduce climate change, rather than naming a political leader, expert, or organization, they are most likely to say a person close to them, including their significant other (27%), child (21%), close friend (17%), parent (11%), or sibling (7%).¹³ Similarly, if asked by someone they "like and respect," a third or more of Americans say they would sign a petition about global warming, attend a neighborhood meeting to discuss actions to address the problem, or take a pledge to support a candidate that shared their views on the issue.¹⁴

Specifically targeting opinion-leaders as part of a social media initiative can help spread and diffuse science-related information, building greater engagement with an issue like climate change, even potentially cultivating new opinion leaders on the issue. In this sense, social media campaigns and outreach efforts should be conceived of as more than generating "likes" or re-tweets. Instead, these forms of information consumption and expression may actually socialize individuals into thinking of their role as a communicator on a topic like climate change, imparting a sense of efficacy and the skills needed to take part in various forms of civic engagement and political activism (Roser-Renouf et al, 2014; Vraga et al., 2015).

¹¹ Binder, A. R. (2010). Routes to attention or shortcuts to apathy? Exploring domain-specific communication pathways and their implications for public perceptions of controversial science. *Science Communication*, 32, 383-411.

¹² Leiserowitz, A., Maibach, E., Roser-Renouf, C., Feinberg, G., & Rosenthal, S. (2014). *Climate change in the American mind: April, 2014*. Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change Communication.

¹³ Leiserowitz, A., Maibach, E., Roser-Renouf, C., & Feinberg, G. (2013) *How Americans communicate about global warming in April 2013*. Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change Communication.

¹⁴ Leiserowitz, A., Maibach, E., Roser-Renouf, C., Feinberg, G., & Rosenthal, S. (2014a) *Americans' actions to limit global warming, November 2013*. Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change Communication.

Other research suggests that to make information about a complex topic like climate change more likely to be shared and recommended via social media, scientists and their partners should present information in ways that are perceived as directly relevant to people, that provoke emotions, that are directly useful or solutions focused, and that are intrinsically interesting (Milkman & Berger, 2014).

Nisbet, M. C., & Kotcher, J. E. (2009). A two-step flow of influence? Opinion-leader campaigns on climate change. *Science Communication*, 3, 328-354.

Research across several different disciplines has consistently shown that individuals frequently monitor their social environment and conform their opinions and decisions to the perceived majority opinion. Importantly, what individuals often pay closest attention to is the perceived opinion among people like them, in other words their direct reference group. Given this reality, the authors argue that on climate change and similarly complex environmental issues, the identification and recruitment of opinion-leaders across reference groups is needed. Opinion-leaders are everyday individuals who have a stronger interest in public affairs content or information specific to an issue like climate change, and who have a special ability as a trusted source to share that information with others. Opinion-leaders rarely hold formal positions of authority and instead prove influential by way of their greater attention to a topic, their knowledge, and their strength of personality and experience in serving as a trusted go-between for information among their large network of friends, colleagues, neighbors, and acquaintances.

As a combination of these traits and behaviors, opinion-leaders not only help draw the attention of others to a particular issue, action, or consumer choice, but perhaps most importantly, signal how others should in turn respond or act. This influence may occur by giving advice and recommendations, by serving as a role model that others can imitate, by persuading or convincing others, or by way of contagion, a process where ideas or behaviors are spread with the initiator and the recipient unaware of any intentional attempt at influence. The authors review research suggesting three types of opinion-leaders that are likely to be important to engaging the public on climate change, depending on the goal and focus of a communication campaign.

- *Climate change-specific opinion leaders.* These individuals are unique in that they pay very close attention to news and information about climate change and energy. These types of opinion-leaders are best suited to recruiting individuals from among segments of the public already predisposed to be alarmed or strongly concerned by the issue of climate change. Many activists in past and current climate change campaigns exhibit strong issue-specific opinion-leader traits.

- *Influentials or public affairs generalists.* To widen the appeal and recruitment potential of a climate change campaign, so-called “influentials” should also be a strong focus of recruitment. These opinion-leading generalists track public affairs news and issues more closely, have overall higher levels of civic involvement, social capital, and political participation as measured by group membership and involvement, and tend to score higher in terms of strength of personality. These types of opinion-leaders are ideally suited to recruiting people to participate politically or civically from among audience segments normally less disengaged or doubtful about the importance of climate change, and less trusting of environmental groups.
- *Market mavens and communicative adopters.* Consumer behavior research has identified “market mavens” as a special class of consumers who take pleasure in shopping, follow closely the release of new products as well as sales and discounts, and enjoy sharing this information with others. Communicative adopters are not only generally first generation purchasers of new products and technologies, but they also evangelize and recommend the product to others. Across segments of the public, these opinion-leaders are likely to be especially important for promoting forms of political consumerism, rewarding and punishing companies.

Survey scales have been developed to reliably and validly identify these categories of opinion-leaders, and shortened versions can be included in surveys of members of organizations, or to email lists and social media followers. Scores on these questions can then quickly identify those individuals who have strong opinion-leader like traits. The authors, however, caution against over-relying on social media and online connections and recruitment. Such strategies are appealing because of the relative ease in which organizers can develop metrics to measure success. Yet ease in tracking data does not equate to effectiveness. There are several trade-offs and weaknesses to relying too heavily on social media forms of opinion-leadership, namely that Americans still say that they prefer their recommendations about complex issues or consumer choices by way of “face-to-face” friends and contacts. The goal for both researchers and practitioners is to figure out under what conditions or with which demographic segments digital opinion-leaders can be effectively used on climate change, and in which ways online interactions can build on real-world ties. Combining digital organizing with face-to-face interaction by using hand held devices such as the iPhone, as was done in the 2012 Obama campaign, is a strategy that future climate change efforts should explore, argue the authors.

Roser-Renouf, C., Maibach, E. W., Leiserowitz, A., & Zhao, X. (2014). The genesis of climate change activism: from key beliefs to political action. *Climatic change*, 125(2), 163-178.

Analyzing a representative 2009 survey of Americans, the authors examined the influence of opinion-leader along with other factors in predicting different forms of climate change activism which included contacting elected officials on the issue; donating their time or money to the issue; and/or attending rallies or meetings. Overall, about 17 of Americans said they had engaged in one or more of the three activities over the past year.

Among factors assessed, issue-specific opinion-leadership on climate change was the strongest predictor of climate change activism. Opinion-leadership was measured by a combination of questions asking if an individual liked to discuss global warming; if other people came to them for advice on the issue; if they believed that others perceived them to be a good source of information; if they gave more information on global warming than they received in discussions; and how often they had discussed the issue over the past 2 weeks. Each item was scored so that negative scores indicated opinion-leaders who were against mitigation-related actions and positive scores reflecting those in favor of actions to address climate change.

Opinion-leaders favoring action to address climate change were more likely to participate in forms of climate change activism both directly and indirectly by way of other beliefs and attitudes. First, opinion-leaders were more likely to be personally and emotionally engaged with the issue saying that they were worried about climate change and that the issue was very important to them. Second, climate change-specific opinion-leaders were also more likely to participate in more general forms of civic engagement such as attending local meetings. Civic engagement itself was predictive of climate change-related activism. Third, and perhaps most importantly, opinion-leaders were more likely to believe that forms of activism would make a difference, and these feelings of efficacy in turn were strongly predictive of having contacted elected officials on the issue; donated their time or money to the issue; and/or having attended a climate change-related rally or meeting.

As the authors conclude, activities and initiatives that cultivate and recruit opinion-leaders on the issue by encouraging people who are concerned about climate change to actively discuss the issue with others may be among the most effective methods for increasing overall levels of public engagement, participation, and activism.

Turcotte, J., York, C., Irving, J., Scholl, R. M., & Pingree, R. J. (2015). News recommendations from social media opinion leaders: effects on media trust and information seeking. *Journal of Computer - Mediated Communication*, 20(5), 520-535.

As of 2014, half of Facebook users -- or about a 1/3 of Americans -- say they receive news from the social media platform either by way of subscribing to a news organization or similar outlet's feed or by way of recommendations from friends. In comparison to a world of traditional news media distribution, Facebook enables both journalists and friends to serve as "information gatekeepers, vetting the significance and relevance of news content, and raising the possibility of new opinion leader-follower dynamics," argue the authors. For scientists and others seeking to build greater public engagement with quality sources of news and information about science or an issue like climate change, understanding the role of Facebook friends in cultivating attention to news stories and growing the audience for quality sources of information is therefore important.

Facing a relentless torrent of information and recommendations by way of their news feed, Facebook users likely rely on easy shortcuts and cues for deciding which news stories to click on and read. The most influential cue is the perceived trustworthiness of friend. Greater trustworthiness is likely to predict that an individual will read a story and possibly be more likely to follow news by way of that source in the future. To test these expectations, the authors recruited a sample of 364 undergraduate students, gaining with their permission access to their Facebook friend networks and usage patterns.

In the experimental condition, participants received a notification of a news story about a local news issue and were told that it was recommended by one of their real-life Facebook friends. The story included a picture of their friend and their comment saying: "People should pay more attention to this kind of thing." The friend was chosen from among those who had a frequent interaction with the subject. Participants in the control condition only saw a link to the story with no recommendation. Subjects were asked a series of questions rating the trustworthiness and credibility of the news source and whether they intended to follow coverage by that local news source in the future. They also assessed the opinion-leading qualities of the recommending friend asking them to rate whether "This person is well informed about politics and current events" and "This person is honest about politics and current events."

In line with their expectations, in comparison to the control group, those subjects receiving a recommendation from a friend they perceived as an opinion-leader were more likely to rate the news organization as trustworthy and credible; and they were more likely to say that they would follow that news source in the future. However, if the subject rated the recommending friend as not well informed or honest, the impact of the recommendation had the opposite effect: the news organization was rated as less credible and they were less likely to follow the news source in the future.

"News professionals and opinion leaders shoulder the burden of informing and educating the public in the age of digital journalism," conclude the authors. "Our findings suggest that individuals may learn to trust certain media outlets through opinion leaders, but then may directly use those outlets in the future, potentially when acting as opinion leaders themselves." By way of Facebook, Twitter, and other social media platforms, scientists can serve as trusted recommenders of quality news sources related to science, health, and environmental issues. They can similarly identify, recruit, and encourage non-scientists to serve as trusted recommenders and endorsers of quality news sources at Facebook and other social media.

Vraga, E. K., Anderson, A. A., Kotcher, J. E., & Maibach, E. W. (2015). Issue-Specific Engagement: How Facebook Contributes to Opinion Leadership and Efficacy on Energy and Climate Issues. *Journal of Information Technology & Politics*, 12(2), 200-218.

Analyzing data from a 2013 U.S. survey of Republican and Republican-identifying independents, the authors evaluated how liking energy-related pages and following energy news on Facebook may differentially influence climate change attitudes and behavior compared to more general forms of Facebook use or news consumption.

In terms of predicting energy-related Facebook engagement, their analysis showed that relatively more moderate Republican men of minority background and lower income levels were more likely to say they follow and share energy related topics. Those Republicans who were heavier consumers of conservative media and national newspapers were also more engaged with and expressive about energy topics on Facebook. In turn, those Republicans more engaged with energy topics on Facebook were more likely to score higher on opinion-leader traits related to climate change and were more efficacious about their ability to impact decisions on the issue. Yet this relationship held about Republicans who were both more dismissive of climate change as a problem and those who were more concerned about the possible threats.

The authors reason that energy-related engagement on Facebook among Republicans may help cultivate opinion-leaders on climate change by boosting an individual's self-perceptions of their role in the political process, benefiting their knowledge, vocabulary, and communication skills on the complex topic; and encouraging greater amounts of news consumption and information seeking. As a result, social media campaigns and activities that pursue various strategies at boosting the prevalence and visibility of content about energy and climate change on climate change have important impacts beyond what can be accounted for by tracking clicks, readers, or "likes." Yet given that Facebook engagement builds opinion-leader skills and traits among both those who are doubtful and alarmed about climate change, "advocacy groups must use caution in promoting climate change and energy activity on Facebook, as it may not only spur those people who agree with their position but also those who disagree."

Milkman, K. L., & Berger, J. (2014). The science of sharing and the sharing of science. *Proceedings of the National Academy of Sciences*, 111 (Supplement 4), 13642-13649.

Much of the research in science communication has examined the features of a message or communication effort that make them more understandable or persuasive, but few studies have considered what makes content more sharable or transmissible. Such characteristics have always been important to the "word of mouth" effect of science news coverage, but in today's world of social media, generating "buzz," attention, and readers to content online often depends strongly on its "sharability" or "pass around" impact.

In this study, the authors examined "(i) how attributes of a discovery and the way it is described impact sharing, (ii) who generates discoveries that are likely to be shared, and (iii) which types of people are most likely to share scientific discoveries," emphasizing the implications for how scientists and others can more effectively frame or describe studies and research in ways that boost its transmissibility. Past research suggests two main motivations for sharing online information or news content:

- *Self-enhancement*: A key motivation for people to share content by way of Facebook, Twitter, or email is "self-enhancement," or to generate impressions that make them look good and to signal a particular desired identity. This means they are more likely to share science-related information that is surprising or novel, that is useful since it makes them look smart or in-the-know, and that is positive, making people feel good rather than bad.
- *Social bonding*: People also share content as a form of social bonding, a strategy to deepen connections with others. Research suggests that sharing emotionally gripping news stories or video clips about science is a common form of generating social bonds, since they create common emotions of sadness, anger, hope, guilt, or other sentiments.

To test these expectations, the researchers recruited 800 scientists to describe in brief summaries their own studies and a sample of 7,000 non-scientists were then randomly exposed to a scientific summary and asked to rate their likelihood of sharing the finding, and to judge the summaries level of interest, emotion, and other characteristics. In a series of regressions, those summaries that were more positive, emotional, interesting, and useful were all more likely to be shared. Importantly, these ratings were not a function of the study's content itself, but depended on how the authors described them. Their results showed that small differences in how co-authors of the same study summarized their study led to higher ratings and sharability. They also found that studies by business academics, psychologists, and economists were more likely to be shared than articles by physicists, geneticists, and biochemists. Part of the reason is that studies referencing people are significantly more likely to be shared than

those that do not involve people. To conclude, the authors recommend that "When describing one's work to a lay audience, framing findings in a way that (i) arouses emotion or makes the work seem more (ii) useful or (iii) interesting should increase the likelihood they are shared."

TAILORING INFORMATION TO AUDIENCES

Scientists and practitioners because of their expertise and experience with an issue are often not very good at understanding what members of the public want and need to know about a complex topic in order to make an informed decision. For example on climate change, experts tend to provide laundry lists of activities for mitigating climate change, making it difficult even for the most concerned to know what might be the most effective actions they can take to reduce emissions. Many individuals believe erroneously that energy efficiency steps like purchasing more efficient light bulbs is more effective at reducing emissions than energy conservation actions such as routinely turning off the lights. Because the presentation of large numbers of options can lead to choice overload and decision avoidance," write de Bruin and Bostrom (2013), "it may be better to concentrate communications on just the most effective activities."

Research suggests that people interpret new information in light of their existing beliefs and "mental models" about the world. Therefore, when designing communication materials to be used with the public such as brochures, reports, presentations, or web sites, the design should be based on evidence about the relevant beliefs that audience members already have and what they are still missing about the topic. Several methods exist for identifying the existing conceptions and mental models of an intended audience and for evaluating the effectiveness of communication materials. The most formal of these methods involves a "mental models" approach (de Bruin & Bostrom 2013); other methods include formative and evaluative focus groups; in depth interviews, or even testing of different ways of structuring information via experiments embedded in surveys (see Labov & Pope, 2008 as an example). The key take-away from this research is that leaders of scientific institutions, centers, and organizations when investing in communication initiatives, should budget for and partner with social scientists who can enable an evidence-based development of various communication materials and the testing of their effectiveness. This research is likely to reveal counter-intuitive findings about the existing barriers to public understanding and engagement and the successful ways to address those barriers.

For example, the National Academies in developing a report and related materials about evolutionary science to be used with school boards and community leaders expected that a convincing storyline would be an emphasis on past legal decisions and the doctrine of church-state separation. Yet the commissioned research revealed that audiences were not persuaded by this emphasis. Instead, somewhat surprisingly, the research pointed to the effectiveness of an alternative presentation

that defined evolutionary science as the modern building block for advances in medicine and agriculture. This emphasis then informed the development of the report and outreach activities (Labov & Pope, 2008).

de Bruin, W. B., & Bostrom, A. (2013). Assessing what to address in science communication. Proceedings of the National Academy of Sciences, 110(Supplement 3), 14062-14068.

Science communication often fails when scientific experts lack information about what people need to know to make more informed decisions or what wording people use to describe relevant concepts. de Bruin and Bostrom (2013) describe the relevance of "mental models" research that identifies people's decision-relevant beliefs or mental models of the topic under consideration, identify gaps and misconceptions in their knowledge, and reveal their preferred wording of concepts, topics, risks and other technical matters. The mental models approach is particularly relevant to experts and practitioners at government agencies, nongovernmental organizations, and others as they develop communication materials, such as brochures, presentations, videos, or websites, for members of the general public.

A "mental models" approach begins by determining what people should know about a complex topic by conducting a literature review and identifying recommendations from expert panels. The second stage involves interviews and surveys of target audiences to identify their existing mental models about the topic, including their current beliefs and decisions and the wording that they prefer or use to describe aspects of the topic. Follow surveys of a larger, more representative sample of subjects can further refine dimensions of the audience mental model. Often the differences between how experts and a target audience view an issue are represented in comparable conceptual diagrams or maps. By comparing the expert and lay decision models, experts and practitioners can identify the decision-relevant information that is missing from people's mental models. Communication materials are then developed that directly address the missing gaps in a target audience's mental model. These materials are then evaluated using focus groups and other methods

For example, in mental models research on Carbon Capture and Sequestration (CCS), initial interviews suggested that the public equated the risks of burying captured carbon emissions to those of nuclear waste, and as a result preferred investments in wind and solar power. Further, most existing communication about CCS focused exclusively on that technology, without drawing comparisons for the public to other low-emissions technologies. Research showed, for example, that the public believed that nuclear power emits CO₂ and that solar power was free. Drawing on this research, communication materials that tailored information about the features of common low-carbon alternatives, while addressing prevalent knowledge gaps and misconceptions about CCS and these other technologies, generated greater openness to CCS as part of a low carbon electricity portfolio.

de Bruin and Bostrom (2013) devote most of their article to explaining how a broad range of experts can invest resources and collaborate on mental models research to inform the design and use of more effective communication materials including web sites, op-eds, presentations, videos, and similar message formats. "Using the principles for developing effective communications need not be costly, because a large body of evidence already exists about people's informational needs regarding specific topics," write de Bruin and Bostrom (2013). "Nevertheless, developing effective communication strategies requires the adjustment of resources. Because of the high stakes that often ride on effective communications, such investments will be worthwhile."

Labov, J. B., & Pope, B. K. (2008). Understanding our audiences: the design and evolution of science, evolution, and creationism. *CBE-Life Sciences Education*, 7(1), 20-24.

In January 2008, the National Academies issued a revised edition of *Science, Evolution, and Creationism*, a report tailored to effectively engage audiences who remain uncertain about evolution and its place in the public school curriculum. To guide their efforts, the Academies commissioned focus groups and a national survey to gauge the extent of lay citizens' understanding of the processes, nature, and limits of science. They also specifically wanted to test various presentations explained why alternatives to evolution were inappropriate for science classes.

The Academies' committee had expected that a convincing storyline for the public on evolution would be an emphasis on past legal decisions and the doctrine of church-state separation. Yet the commissioned research revealed that audiences were not persuaded by this framing of the issue. Instead, somewhat surprisingly, the research pointed to the effectiveness of an alternative presentation that defined evolutionary science as the modern building block for advances in medicine and agriculture. The research also underscored the effectiveness of emphasizing the National Academies' long-standing position that evolution and religious faith can be fully compatible. Taking careful note of this feedback, the National Academies decided to structure and then publicize the final version of the report around these core themes.

To reinforce these messages, the National Academies report was produced in partnership with the Institute of Medicine and the authoring committee chaired by Francisco Ayala, a leading biologist who had once trained for the Catholic priesthood. The report opens with a compelling "detective story" narrative of the supporting evidence for evolution, yet placed prominently in the first few pages is a call out box titled "Evolution in Medicine: Combating New Infectious Diseases," featuring an iconic picture of passengers on a plane wearing SARS masks. On subsequent pages, a similar emphasis on evolutionary science and social benefits is made prominent in call out boxes titled "Evolution in Agriculture: The Domestication of Wheat" and "Evolving

Industry: Putting Natural Selection to Work.” Lead quotes in the press release feature a similar emphasis.

To engage religious audiences, at the end of the first chapter, following a definition of science, there is a prominent three page special color section that features testimonials from religious scientists, religious leaders and official church position statements, all endorsing the view that religion and evolution are compatible. Both the report and the press release state that: “The evidence for evolution can be fully compatible with religious faith. Science and religion are different ways of understanding the world. Needlessly placing them in opposition reduces the potential of each to contribute to a better future.” In a subsequent journal editorial, these core themes as featured in the report were endorsed by twenty professional science societies and organizations.

Cone, J., Rowe, S., Borberg, J., Stancioff, E., Doore, B., & Grant, K. (2013). Reframing engagement methods for climate change adaptation. *Coastal Management*, 41(4), 345-360.

Cone and colleagues used a mental models approach to identify the existing beliefs, knowledge, and attitudes of coastal property owners in Oregon and Maine about the risks of climate change and the most effective ways to prepare and adapt to those risks. Working with the state Sea Grant programs their goals were to: 1) discover the barriers that target audiences in the two states have to preparing for or responding to the effects of climate variability and change; 2) encourage and facilitate collaboration among and between decision makers and coastal property owners to determine and implement appropriate responses to climate variability and change; and 3) develop educational and informational materials and strategies addressing climate concerns.

Cone et al. began with a literature review and interviews with experts to construct an expert model specific to each state of preparing for and responding to the coastal impacts of climate change, constructing a visual diagram outlining this expert model. They then developed a local stakeholder and decision-maker model of the same topic using focus groups, workshop meetings, and surveys.

Drawing on their research findings, video programs were developed for each state by Sea Grant staff. The programs (made available in DVD and online formats) featured for example a discussion of how and why structural modifications could be made to a home to reduce its vulnerability to storm surge, sea-level rise, and erosion, a commonly voiced concern of local landowners and stakeholders and an area about which they had little knowledge. Their research also indicated that the target audience would be more open to this information if presented by someone identified from the local community, rather than an "expert." In this case, an individual coastal property owner discussed how and why she made modifications to her own home.

Drawing on their research, the Maine Sea Grant also produced an executive summary of research results to inform the communication activities of state and federal agency staff and members of the Maine legislature; developed an interactive website for property owners, and organized demonstration project tours for coastal property owners and municipal officials to spotlight locally implemented adaptation strategies. Apart from the research on how to tailor communication materials and activities, their experience also suggested that apart from any information provided, that many participants believed that simply coming together as community on the topic was productive in its own right, and that the most trusted and persuasive communicators were often early "communicative adopters," local property owners who had already started to engage in adaptive behaviors and were skilled at sharing those experiences with others.

FRAMING AND CLIMATE CHANGE COMMUNICATION

The concept of framing turns on what observers have understood for centuries: When it comes to communicating about complex issues and choices, we can often select from several different roughly equivalent interpretations, with these preferred meanings filtered by way of the background of our audience, shaping their judgments and decisions. There is no such thing as unframed information, and many scientists and science communicators by way of their writing, conversations, presentations, news interviews, social media use or other interactions are already effective at framing their opinions and positions, whether using frames intentionally or intuitively.

Frames are interpretive storylines that set a specific train of thought in motion, communicating why an issue might be a problem, who or what might be responsible for it, and what should be done about it. Framing, it should be noted, is not synonymous with placing a false spin on an issue, although some communicators do purposively distort evidence and facts. Rather, in an attempt to remain true to what is conventionally known about a complex topic, as a communication necessity, framing can be used to pare down information, giving greater weight to certain considerations and elements over others, thereby making scientific information and advice more relevant, credible, and persuasive. (Nisbet, 2009).

Frames are persuasive when they link two concepts, so that after exposure to this linkage, the intended audience now accepts the concepts' connection. Yet in making this linkage, a specific frame is only effective if it is relevant—or applicable—to the audience's preexisting worldviews or identity. In an oft-cited paper, Nisbet (2009) proposes that if scientists partnered with other professions and societal leaders to frame action on climate change in terms of moral and religious duty or obligations; in terms of benefiting economic development and technological innovation; and in terms of protecting and benefiting public health, such novel storylines are likely to be persuasive with a greater diversity of Americans, since these frames connect the complex issue to a broader set of societal and personal concerns (Nisbet, 2009).

For example, in Pope Francis' 2015 Encyclical on climate change, by framing climate change in terms of the religious and moral duty to act, he made the complex issue more personally relevant to many Americans. Following the release of the Encyclical and Pope Francis' visit to the U.S, in a national survey, seventeen percent of Americans and thirty-five percent of Catholics reported that the Pope's position on climate change had influenced their views. Moreover, in comparison to six months prior to the Pope's visit, significantly more Americans were likely to say that climate change was a moral issue, a social fairness issue, and a religious issue.¹⁵

Effectively communicating about climate change likely requires framing mitigation-related actions in terms of specific societal co-benefits. In other words, not only would addressing climate change benefit progress on the issue but such actions would also bring other societal returns. Controlling for a number of confounding influences, research conducted across countries finds that those individuals who believe that mitigation-related actions will benefit economic development and technological innovation; or make society more compassionate and caring; are more likely to say they are willing to become politically active in support of such actions (Bain et al., 2015).

Similarly, studies conducted in the US find that communicating about climate change in terms of its human health risks and the benefits to public health of mitigation-related actions is emotionally engaging to a broad spectrum of Americans (Myers et al., 2012). Other research finds that framing the impact of climate change on ocean ecosystems in terms of human health risks (rather than exclusively environmental risks) generates stronger support for regulation of the fossil fuel industry (Schuldt et al., 2016). Importantly, in each of these studies, human health risks and benefits were emphasized in terms of their local impacts, reducing psychological and social distance from the threat that often serves as a barrier to action.

To date, a common weakness in studies on framing and climate change is that they do not compare the effects of strategically designed messages in the context of competing frames emphasizing scientific uncertainty or economic costs. Thus studies may overestimate framing effects on attitude change, since they do not correspond to how most members of the public encounter information about climate change in the real world. By way of the news, social media, or conversations, individuals are likely to encounter multiple, often conflicting or competing frames. Those few studies that have examined the effects of public health or economic benefits frames in the presence of

¹⁵ Maibach, E., Leiserowitz, A., Roser-Renouf, C., Myers, T., Rosenthal, S. and Feinberg, G. 2015. The Francis Effect: How Pope Francis changed the conversation about climate change. George Mason University Center for Climate Change Communication: Fairfax, VA.

competing frames have found mixed results (see Nisbet E.C. et al, 2013).¹⁶ One recent study finds no effects on attitudes when reframing climate change, even in the absence of competing frames. In light of their findings, the authors recommend that communication efforts remain focused on explaining climate science and emphasizing the environmental risks of inaction.¹⁷

These results suggest that efforts to employ novel framing strategies on climate change that involve an emphasis on public health, the economic benefits of action, or the religious and moral duty to act will require sustained, well resourced, and highly coordinated activities in which these frames are repeated and emphasized by a diversity of trusted messengers and opinion-leaders. These efforts should also be localized and tailored to specific regions or states and periodically evaluated to gauge success and refine strategy. Such a strategy is all the more important in light of findings that unconventional frames about climate change such as focusing on the public health dimensions are less likely to be shared by way of social media than more conventional messages that focus on the environmental risks of climate change (Conor et al., 2016).

Nisbet, M. C. (2009). Communicating climate change: Why frames matter for public engagement. *Environment: Science and Policy for Sustainable Development*, 51(2), 12-23.

Nisbet reviews research on some of the psychological and social barriers to greater public concern over climate change, warning that major policy actions to address climate change in the U.S. require a broader and deeper intensity of public support. He reviews work to date on the role that framing plays in how journalists, experts, and advocates communicate about climate change and possible strategies for re-framing the issue in ways that overcome indifference and politically motivated skepticism. "To break through the communication barriers of human nature, partisan identity, and media fragmentation, messages need to be tailored to a specific medium and audience, using carefully researched metaphors, allusions, and examples that trigger a new way of thinking about the personal relevance of climate change," he writes.

Nisbet provides a useful primer on research in the social sciences on framing and its relevance to climate change communication. Frames are interpretive storylines that set a specific train of thought in motion, communicating why an issue might be a problem, who or what might be responsible for it, and what should be done about it. Audiences rely on frames to make sense of and discuss an issue; journalists use frames

¹⁶ McCright, A. M., Charters, M., Dentzman, K., & Dietz, T. (2015). Examining the Effectiveness of Climate Change Frames in the Face of a Climate Change Denial Counter-Frame. *Topics in cognitive science*.

¹⁷ Bernauer, T., & McGrath, L. F. (2016). Simple reframing unlikely to boost public support for climate policy. *Nature Climate Change*.

to craft interesting and appealing news reports; policymakers apply frames to define policy options and reach decisions; and experts employ frames to simplify technical details and make them persuasive.

Frames are persuasive when they link two concepts, so that after exposure to this linkage, the intended audience now accepts the concepts' connection. Yet this means that a specific frame is only likely to be effective if it is relevant—or applicable—to an audience's existing values, worldviews, or desired societal outcomes. Nisbet describes how advocates for action on climate change have historically framed the issue in terms of looming, potentially disastrous environmental consequences; the growing scientific certainty of the problem; and the role of industry and conservatives in blocking policy action. Opponents of action on climate change, in turn, have framed the issue in terms of scientific uncertainty and the "unfair" economic costs of action if countries like India and China are not also committed to lowering their emissions. These competing frames have led to a state of perceptual gridlock in which a minority of Americans strongly supports action; and an equally intense minority opposes action. But the great majority of Americans remain ambivalent, viewing the issue as relatively unimportant, or as just another example of political polarization.¹⁸

Yet Nisbet argues that emerging, novel frames of reference that define actions to address climate change in terms of religious and moral duty; the potential for economic growth, social progress, and technological innovations; and in terms of protecting and benefiting public health all have promise to engage this ambivalent middle. These frames suggest a "deductive set of mental boxes and interpretive storylines that can be used to bring diverse audiences together on common ground, shape personal behavior, or mobilize collective action," concludes Nisbet. "Additional research using in-depth interviews, focus groups, and sophisticated survey and experimental techniques needs to further explore, identify, and test these frames across audiences."

Bain, P. G., Milfont, T. L., Kashima, Y., Bilewicz, M., Doron, G., Garðarsdóttir, R. B., ... & Corral-Verdugo, V. (2015). Co-benefits of addressing climate change can motivate action around the world. *Nature climate change*.

Bain and colleagues hypothesize that a promising strategy for communicating about climate change is to re-frame mitigation-related actions in terms of their co-benefits to society. In other words, not only would such actions help reduce greenhouse gas emissions, but they would lead to other desirable outcomes as well. Drawing on past research, Bain and colleagues categorize these potentially persuasive co-benefits in terms of "development co-benefits" related to economic development,

¹⁸ See Nisbet, M.C. & Markowitz, E. (2016, Feb). American Attitudes about Science and Technology: The Social Context for Communication. Commissioned report prepared for the Alan Leshner Leadership Institute of the American Association for the Advancement of Science, Washington, DC.

technological innovation, and scientific advances; "benevolence co-benefits" related to a more caring and moral society; and the more conventionally emphasized "avoiding dysfunction co-benefits" related to reducing environmental pollution and protecting public health.

To test these expectations, Bain and colleagues, analyzed data from surveys of college students in 24 countries; as well as community samples in 10 countries. After being asked about their beliefs about the reality and importance of climate change, those respondents convinced that climate change was real were prompted to think about what their nation would be like in the future if action had successfully mitigated climate change. They were then asked about possible development, benevolence, and avoiding dysfunction co-benefits. Those who were not convinced of the reality of climate change were simply asked to consider their nation's future and the related co-benefits if mitigation actions were taken.

In their analysis, Bain and colleagues evaluated how belief in the likelihood of these co-benefits were related to motivations to participate politically in terms of voting for pro-environment candidates; contributing time/money to groups; participating as consumers in terms of conserving energy or buying "green" goods; and "financially" in terms of their willingness to donate to an environmental group.

Among subjects convinced of climate change, controlling for a number of other factors and attitudes, belief in the likelihood of development co-benefits and benevolence co-benefits were substantial predictors of stated willingness to participate. Interestingly, among those unconvinced of climate change, belief in development co-benefits had a similar effect. For both groups, the more traditionally emphasized co-benefits reducing pollution or protecting public health were actually the weakest motivators of action overall. "Communicating the co-benefits of addressing climate change could provide a way to foster public action, and thereby influence government action, even among those unconvinced or unconcerned about climate change," conclude Bain and colleagues. "Rather than insisting that the public develop stronger concerns about climate change, the present findings show the potential for connecting climate change mitigation to the broader social concerns of the public."

Myers, T. A., Nisbet, M. C., Maibach, E. W., & Leiserowitz, A. A. (2012). A public health frame arouses hopeful emotions about climate change. *Climatic Change*, 113 (3-4), 1105-1112.

Myers and colleagues evaluated the persuasiveness of framing climate change in terms of public health risks and the benefits to health if mitigation related actions were adopted. In an initial study, the team of authors conducted in depth interviews with 70 respondents from 29 states, recruiting subjects from six previously defined audience segments. These segments ranged in a continuum from those individuals deeply alarmed by climate change to those who were deeply dismissive of the problem. Across

all six audience segments, individuals said that information about the health implications of climate change was both useful and compelling, particularly when locally-focused mitigation and adaptation related actions were paired with specific benefits to public health.¹⁹ In a follow up study, Myers and colleagues conducted a nationally representative Web survey in which respondents from each of the six audience segments were randomly assigned to three different experimental conditions allowing for an evaluation of their emotional reactions to strategically framed messages about climate change. The messages included a conventional environmental framing of climate change emphasizing the risks to the environment and the benefits of acting; a national security framing emphasizing the risks to security and the benefits of action; and a public health framing emphasizing the risks to health and the benefits of acting.

Though people in the various audience segments reacted differently to some of the messages, in general, framing climate change in terms of public health generated more hope and less anger than framed messages that defined climate change in terms of either national security or environmental threats. By generating hope among many respondents, and by defusing anger among those inclined to doubt the problem, other research suggests that such emotions are likely to promote greater levels of public participation on matters related to mitigation and adaptation actions. Somewhat surprisingly, their findings also indicated that the national security frame could “boomerang” among audience segments already doubtful or dismissive of the issue, eliciting unintended feelings of anger.

Schuldt, J. P., McComas, K. A., & Byrne, S. E. (2016). Communicating about ocean health: theoretical and practical considerations. *Phil. Trans. R. Soc. B*, 371(1689), 20150214.

Communicating about climate change impacts on ocean ecosystems is among the more difficult challenges facing scientists. Surveys across countries indicate that few members of the public actively connect in their minds problems such as species depletion, ocean acidification, or bacteria outbreaks with climate change. As Schuldt and colleagues review, among the main reasons for a lack of awareness or concern include the psychologically and geographically distant perceptions of such threats; the unfamiliarity of ocean species and concepts in comparison to terrestrial environmental topics; and the politicization of climate change more generally. To overcome these barriers, Schuldt and colleagues evaluated the effectiveness of framing oceans and climate change in terms of the risks to public health. In this research involving 500 subjects recruited from among passengers on a Seattle, WA-area ferry boat, participants were randomly assigned to two frame conditions in which they read presentations that defined the impact of climate change on oceans. In the first condition, the

¹⁹ Maibach, E. W., Nisbet, M., Baldwin, P., Akerlof, K., & Diao, G. (2010). Reframing climate change as a public health issue: an exploratory study of public reactions. *BMC Public Health*, 10(1), 1.

consequences of climate change were framed in terms of their risks to marine species such as oysters. In the second condition, climate change was framed in terms of risks to humans who may eat contaminated oysters. The framing of ocean impacts in terms of risks to human health appeared to depoliticize perceptions. In this case, the human health framing condition had no discernable impact on the views of Democrats and Independents, but it did influence the outlook of Republicans. Right leaning subjects in the human health condition were significantly more likely to support regulating the fossil fuel industry in order to reduce greenhouse gas emissions.

Nisbet, E. C., Hart, P. S., Myers, T., & Ellithorpe, M. (2013). Attitude change in competitive framing environments? Open/closed mindedness, framing effects, and climate change. *Journal of Communication*, 63(4), 766-785.

Past studies provide promising findings on the effectiveness of framing action on climate change in terms of public health or economic benefits, but what happens when experimental subjects encounter these messages in the context of competing frames emphasizing scientific uncertainty or the economic costs of action? Nisbet E.C. and colleagues examined among a nationally representative sample of Americans how the effects of competitively framed video presentations about climate change may differentially influence support for government action. Their competitive frame condition featured contrasting arguments pitting an emphasis on climate change as an "environmental disaster" versus counter-arguments that action to address the problem would be an "economic disaster." They subsequently examined subjects' support for government action. To their surprise, they did not observe a statistically significant main effect for the competitive frame condition. Instead, the competitive frame actually boosted support for government action among individuals scoring high on open-mindedness. They reasoned that the competitive condition motivated open-minded participants to weigh the overall benefits of climate change mitigation to a much greater degree than their closed-minded counterparts, which consequently increased their support for action. In contrast, close-minded individuals they surmised are less open to change, and are more likely to "seize" on initial opinions in order to avoid dwelling on alternative perspectives.

Connor, P., Harris, E., Guy, S., Fernando, J., Shank, D. B., Kurz, T., Bain, P.G., & Kashima, Y. (2016). Interpersonal communication about climate change: how messages change when communicated through simulated online social networks. *Climatic Change*, 1-14.

In this study, Connor and colleagues examine how the framing of climate change messages influences their share-ability and spread-ability by way of Facebook and similar social media. Apart from how persuasive specific frames about climate change might, are some frames more likely to be shared and spread by way of Facebook and other social media? Even if a framed message is shown to be persuasive in the context

of an experiment, unless it is widely voiced and shared, than it is unlikely to reach an intended audience.

In their experiment, Conor and colleagues evaluated the spread-ability of a conventional frame about climate change that emphasized its impacts on nature including plants, animals, and the likelihood of natural disasters. In comparison, drawing on Bain et al., (2015) they also tested the spread-ability of four alternative frames about the social relevance of climate change. The first emphasized the links between climate change and the competence of society including our capabilities and skills. The second frame emphasized links between climate change and communality and benevolence in society, including how caring and warm we are to each other. The third emphasized links between climate change and economic development and technological innovation. The fourth emphasized the connections to public health including infectious diseases and air pollution. Each of these five strategically framed messages were further evaluated by whether they emphasized the "losses" of failing to act on climate change or the "benefits" if action were to occur.

Rather than test how these frames effect perceptions, their interest was in how each of these frames in emphasizing either losses or benefits motivate people to share information about climate change. In past research on share-ability, those messages that are perceived as conventional in a community are more likely to be passed on than those that are considered unconventional. "This process gradually leads to a conventionalization of messages, and can play a central role in the maintenance of cultures by reinforcing shared understandings and marginalizing unconventional ones," they explain. If this past finding applied to climate change, then the authors reasoned that the more conventional framing of climate change in terms of the environment and nature is more likely to be shared online than less conventional messages about relevance of climate change to different sectors of society. The exception might be the message framed in terms of public health, since environmental issues for several decades have been discussed in terms of health risks. Messages framed in terms of losses or risks -- given their emphasis historically -- were also more likely to be perceived as conventional, and therefore passed on in comparison to those framed in terms of benefits to action.

A sample of two hundred and nineteen US Facebook-using participants were recruited via Amazon's Mechanical Turk. Subjects completed an online survey and then were presented with a climate change message formatted like a Facebook post and asked to imagine it was posted by a Facebook friend. Participants were instructed that they would later reproduce the message from memory. Participants were randomly assigned to a loss/benefit condition about the impacts of climate change. The gain condition statements were all about benefits of climate change mitigation, the loss condition statements were all about costs of non-mitigation, and the mixed condition used one gain-framed and one loss-framed statement. Each condition contained ten statements; two from each selective framing emphasis that included the connection

between climate change nature, competence, communality, economic development, and public health. After reading the messages, participants were instructed to imagine that they had decided to share the message with a Facebook friend. In a box, they were asked to "repost" the message they had just read, using their own words.

Like a game of telephone, the messages that were reproduced by participants first in the chain were then presented to participants second in the chain, and the reproductions from participants second in the chain were presented to participants third in the chain using URL links. Overall, reproductions tended to echo the original message emphasis, consisting of gain-framed statements in the all gain condition, loss-framed statements in the all loss condition, and both gain- and loss-framed statements in the mixed condition. In terms of the framing of messages, results indicated that statements concerned with the impact of climate change over nature and health were more likely to survive when passed through three-person communication chains than statements concerned with societal competence, communality or development. Also of relevance, gain-framed statements survived more than loss-framed statements in the first position of communication chains, but loss-framed statements survived more than gain-framed statements later in communication chains.

The findings suggest that although efforts to frame climate change in unconventional ways may prove persuasive to targeted audiences; there are still major challenges in getting these messages to reach the public. Their experiment shows that "conventionally" matters to the spread-ability and share-ability of messages about climate change. Messages that focus on the environmental risks of climate change are far more likely to be shared on Facebook and by way of other social media than less conventional messages about the economic or community co-benefits of mitigation. "Motivating public action on climate change can benefit by drawing on a broader range of messages, such as how addressing climate change has positive benefits for society," conclude the authors. "However, these positive effects may only be fully realized if there is a concerted effort from climate change communicators to emphasize and conventionalize these aspects of the issue.

NARRATIVES AND STORYTELLING

Scientists, practitioners, and social scientists all tend to agree that narrative and storytelling is a key component of effective communication. Yet despite this recognition, there is little formal focus among scientists and practitioners on the components of persuasive narratives. Among social scientists, though there has been much formal research tracking the type of narratives that appear to shape science-related policy debates, there has been much less research empirically testing the effects of different narratives on public perceptions and decisions. The unfortunate takeaway is that in policy-debates such as those over climate change, more research is needed in identifying and testing different narratives relative to their learning and persuasive

effects. More work is also needed in translating the findings of this research into direct implications for effective communication practice.

A narrative uses a particular voice to set up a conflict, unresolved question, or tension relative to a science-related debate and describes action, unfolding over time, to resolve that conflict (Dahlstrom, 2014). Narratives about policy problems establish a common scientific, legal, political, or ethical framework for understanding the problem, setting the terms of debate for decisions. The narrative features a plot that ties characters as heroes and villains in opposition to each other, featuring a storyline of decline, conspiracy, redemption, blame the victim, or stymied progress. The narrative culminates in a resolution in the form of a policy solution or at least a temporary fix where conflict and/or the problem is resolved (Jones, 2014).

Narratives are particularly persuasive because they describe a specific experience told through the lens of a character rather than general truths, meaning "that narratives have no need to justify the accuracy of their claims; the story itself demonstrates the claim," notes Dahlstrom (2014). "Similarly, the structure of narrative links its events into a cause-and-effect relationship, making the conclusion of the narrative seem inevitable even though many possibilities could have happened."

Jones (2014) notes that communication efforts about climate change often lack a clear narrative, storyline, or set of heroes and villains. Instead, communication efforts have focused on the translation and simplification of scientific concepts or complex statistical trends; an emphasis on a litany of impending risks; and a diffuse set of possible benefits to action. In a series of studies, Jones (2014) has tested specific narratives about climate change as a policy problem that reflect prevailing worldviews in American society. Interestingly, Jones finds consistently that the main effect of these selective stories is to generate emotional identification with the featured protagonists or heroes in the stories, rather than any direct effect on risk perceptions or policy preference. Instead, in those cases where attitudes and preferences are impacted, it is indirectly by way of identification with the hero. The more respondents liked a hero, the more they believed climate change was real, that it poses a problem for them individually and society, and the more they supported the policy solution presented in the narrative.

Professional experience and formal research both suggest that narratives are often a more engaging and persuasive format for public communication about science-related issues. Jones' (2014) research suggest that narratives if properly constructed can also have the indirect impact of bolstering identification with scientists as heroes who are working to solve a policy problem. But more research and practical work is needed in helping scientists and their partners create, promote, and deliver narratives that create strong character identification and that resonate with the worldviews or background of particular audiences.

Dahlstrom, M. F. (2014). Using narratives and storytelling to communicate science with nonexpert audiences. *Proceedings of the National Academy of Sciences*, 111(Supplement 4), 13614-13620.

After formal education ends, entertainment and news media are the dominant sources of information about science and technology for the public, meaning that most Americans receive and expect information about science to be in a narrative format. A narrative uses a narrator's voice to set up a conflict, unresolved question, or tension within a given context and describes action, unfolding over time, to resolve that conflict. Research suggests that narrative formats in compared to more standard technical expositions about science are associated with greater interest and motivation, recall, ease of comprehension, and persuasion.

Narratives are persuasive because they describe a specific experience rather than general truths. The structure of a narrative links its events into a cause-and-effect relationship, making the conclusion of the narrative seem inevitable even though many possibilities could have happened. This apparent inevitability allows a communicator to also imply normative judgments evaluating right or wrong without need to articulate or defend them. Each of these attributes makes opposing narratives difficult to counter. Research shows that narratives can influence attitudes about vaccines, environmental issues, and other scientific topics. To great success, they have been actively employed in best-selling books by scientists like Carl Sagan and by Hollywood producers working with scientists to create scientifically accurate blockbuster films like *Contact*. But there are several ethical choices involved in using narratives to communicate about science.

The first relates to whether narrative communication is intended to promote persuasion or comprehension. A narrative aiming to persuade would emphasized a preferred side of the issue such as action on climate change while championing a character who is rewarded for making the "right" choices, notes Dahlstrom. In contrast, a narrative aiming to increase comprehension about climate change would emphasize instead how science informs a diversity of energy policy choices, featuring a character who actively considers and deliberates among the options. The examples used in a narrative also matter. Selecting a worst-case scenario in telling a narrative about climate change may be representationally inaccurate. Yet such a selection of an unlikely outcome could be more persuasive or at least gain more attention from an audience.

Jones, M. D. (2014). Cultural characters and climate change: How heroes shape our perception of climate science. *Social Science Quarterly*, 95(1), 1-39.

Past research has shown that narrative communication plays an important role in shaping perceptions of risk relative to several examined issues, but to date, studies have not systematically examined the influence of narratives on climate change-related risk perceptions and policy preferences. Drawing on work in the policy sciences, narratives about policy problems like climate change consist of:

- 1 -- Fixed referents within the story that few contest such as scientific information or legal rules. The role of the setting is to affix the story to a framework that some meaningful portion of the population will accept.
- 2 -- A plot that ties characters with the setting and usually assigns blame and/or causality. Common policy plotlines include the story of decline, conspiracy, blame the victim, and stymied progress, among others.
- 3 -- Every policy narrative must have characters. There will be a villain or adversary who harms a victim and there will be a hero who offers a solution to either prevent or stop the victim from being harmed.
- 4-- Every policy narrative culminates in a policy solution or a moral to the story. That is, for a policy narrative to officially move beyond critique or argument, it must culminate in a solution that seeks to somehow control the policy outcome.

Drawing on past research in cultural theory, Jones outlines and tests with a national sample of respondents three different narratives or stories about climate change as a policy problem and its solutions that are commonly employed by advocates, political leaders, experts, and journalists. Each story or narrative conforms or reflects a particular set of values or worldviews.

Profligacy: An Egalitarian Story. In this story, the cause of global warming is overconsumption, materialism, capitalism, and selfish-ness that has driven the world to the brink of destruction. The villains are profit-driven corporations, governments that facilitate these corporations, and any group that supports the status quo. The heroes are groups like 350.org or Greenpeace that seek the elimination of greenhouse gases (GHGs) and advocate for fundamental changes in a fragile world where humans have overstepped their bounds. The moral of the story is that humankind is doomed if it does not correct for past mistakes. The solution is to invest in less consumptive, smaller scale renewable energy resources.

Lack of Global Planning: A Hierarchical Story. In this story, the cause of climate change is mismanaged societal systems and economic growth that does not allow for growth to take place a sustainable place that climate can tolerate. The heroes in this story are groups such as the Club of Rome, impartial scientists, and the governments that employ them. Hierarchs advocate for increased scientific management and governmental intervention to curtail climate change. The hierarchical story favors expert-driven solutions such as nuclear energy.

Business as Usual: An Individualistic Story. The individualistic story's heroes are groups such as the Cato Institute and organizations like the Wall Street Journal. The cause of global climate change for these groups are generally naive but dangerous

idealists (egalitarians) and self-interested government representatives (hierarchs) that have fabricated the story (it is a hoax). Should they admit climate change is reality, they will find the only acceptable solution for climate change is to allow market forces to move naturally as individuals compete and innovate to create new technologies that reduce carbon emissions and allow adaptation. The moral of the story is that markets must operate with minimal interference, thus solutions to climate change that rely upon market mechanisms, such as cap and trade, are likely to be more acceptable to the individualist.

In the experiment, subjects in the survey were randomly assigned to one of the three experimental narrative conditions and asked to read a brief description of climate change organized by way of the egalitarian, hierarchical, or individualist storyline. Other subjects were also assigned to a control condition. Accounting for a number of confounds including social demographics and ideology, the specific narratives tested did not show consistent effects on either risk perceptions or policy preferences. But in each of the respective narrative conditions, respondents tended to relate more positively and emotionally to the featured "hero" groups. For example, in the hierarchical storyline, subjects related positively to the Club of Rome and scientists. In the Individualist storyline, subjects related positively to the Cato Institute.

Further analysis showed that the more that subjects identified with each "hero" group the more likely they were to be concerned about the risks of climate change and to support policy solutions consistent with the hero groups' storyline. For example, subjects in the Hierarchical storyline were more likely to identify with the Cato Institute as a "hero," and by way of this identification they held greater risk perceptions of climate change and were more supportive of market-based solutions such as cap and trade. "In short, this research shows that narrative structure helps people form initial emotional assessments of characters, and helps steer those assessments in particular directions," concludes Jones. "It would seem that narrative structure matters. More specifically, respondents are persuaded through the vehicle of the hero."

COUNTERING MISINFORMATION AND FALSE BELIEFS

Although the politicization of science is not a new phenomenon, there has been a rapid build-up of empirical social scientific research on its causes and possible cures over the past few years. This renewed interest in understanding the root causes of misinformation, politicization, and false beliefs is undoubtedly driven at least in part by well-documented efforts to undermine the credibility of science in numerous domains, including public health, climate change, and environmental conservation. These efforts have largely been successful, in so far as science has become a weapon used both by proponents and opponents in many political battles currently being fought across a wide diversity of issues, from climate change to gun control to gay rights.

Recent empirical work has detailed time and again the challenges that communicators face in effectively debunking myths and misinformation once they have become embedded in the minds of non-experts. Misinformation is difficult to counter and correct under most circumstances (Lewandowsky et al, 2012) and well-intentioned but ill-conceived, intuitive efforts to debunk misinformation often has the unintended effect of reinforcing false beliefs (see for example, Nyahn et al., 2014).

The good news is that although more work is clearly needed, science communication researchers have begun to identify a number of concrete strategies that scientists and their allies can employ to correct false beliefs, even more effectively, to prevent misinformation from being taken up by audiences in the first place. The most effective of these strategies involves “inoculating” audiences against intentional efforts to mislead the public, which can often be accomplished by providing warnings that people may be exposed to misinformation. These inoculation efforts involve providing warnings with explanations of *why* misleading information is being promoted. Research suggests that highlighting the motivations of organizations or individuals who are responsible for misleading the public on scientific issues may be particularly effective at preventing false beliefs (Lewandowsky et al., 2012).

For example, across two survey experiments, the Bolsen and Druckman (2015) find that if scientists and their partners as part of early communication on an issue were to provide warnings about future efforts to politicize the scientific topic, such a strategy is likely to significantly reduce the effects of later politicization on audiences, leading people to utilize scientific information more objectively in decision-making. Consider the example of a statement warning of politicization on carbon nanotubes (CNTs) that Bolsen and Druckman (2015) used as part of their experimental evaluation, embedded within a larger explainer about the topic: “Some say that it is difficult to assess the benefits of this process because people only point to evidence that supports their position. However, the assessment of CNTs should not be politicized; a consensus of scientists believes CNTs are better for the environment than other energy production methods.” In contrast, simply providing a correction to dismiss politicization after someone has already been exposed to a politicizing message, on its own does not do much to combat the effects of politicization. Only when people are simultaneously motivated by an advance warning to pursue accuracy goals do corrections improve uptake.

Once false beliefs are already held, dislodging them requires replacing people’s false “mental models,” or their understanding of how a phenomenon operates, with factually correct but also more compelling alternative models. Often these alternative models must be simpler than the misinformation they are meant to replace, otherwise there is a risk that the new information will simply go unused. Overall, the emerging body of research on misinformation, politicization, and false beliefs highlights just how difficult it is to encourage the public’s use of scientific expertise in the face of so much competing, and often worldview-reinforcing, false information. Yet progress can be

made if communicators are careful to follow emerging best practices and avoid potential pitfalls.

Nyhan, B., Reifler, J., Richey, S., & Freed, G. L. (2014). Effective messages in vaccine promotion: a randomized trial. *Pediatrics*, 133(4), e835-e842.

The authors tested four message-based interventions aimed at increasing parental intentions to vaccinate their children. All four interventions mimicked current practices in the health communication field, including providing information about the lack of evidence tying the MMR vaccine to autism; information about the dangers of diseases prevented by MMR; images of children with diseases prevented by MMR; and, a dramatic story about an infant who almost died of measles. None of the interventions increased intentions to vaccinate. Worse, the refuting information caused intentions to vaccinate to decrease, and the images of sick children increased belief in an autism/vaccine link. Perhaps even more troubling, the negative effects of pro-vaccine messages was most pronounced among those participants with the least favorable initial attitudes towards vaccination, indicating that the types of messages often used to try to convince skeptical parents to vaccinate are in fact backfiring. The results indicate the importance of carefully pre-testing any messages about politicized science-related issues prior to rolling out large-scale messaging campaigns.

Nyhan, B., & Reifler, J. (2015). Does correcting myths about the flu vaccine work? An experimental evaluation of the effects of corrective information. *Vaccine*, 33(3), 459-464.

The authors empirically test the effectiveness of correcting myths many individuals hold about vaccination leading to contraction of the vaccinated disease, examining beliefs about the flu vaccine. Using a nationally representative survey, the authors find that over 40% of Americans believe that the flu vaccine can give people the flu. When they gave participants corrective information from the CDC indicating that in fact one cannot contract the flu from the flu vaccine, the correction was successful in reducing belief in the myth. However, among respondents with high levels of concern about side effects of vaccines, the correction also led to lower levels of intention to vaccinate. These results suggest that simply refuting myths about vaccination, as with other politicized scientific issues, is unlikely to be sufficient in improving decision-making, and may in fact make matters even worse among certain segments of the population. The results highlight the importance of measuring not only beliefs but also behavior (or intentions) when exploring debunking strategies. Only examining beliefs rather than also evaluating the effects on behavior may lead to the conclusion that interventions are more successful than they in fact are.

Lewandowsky, S., Ecker, U. K., Seifert, C. M., Schwarz, N., & Cook, J. (2012). Misinformation and its correction continued influence and successful debiasing. *Psychological Science in the Public Interest*, 13(3), 106-131.

Correcting misinformation once audiences have been exposed to it is notoriously challenging. Retractions and even vehement counter-arguments often fail to dislodge false beliefs from individuals' minds. The authors review a diverse literature on cognitive and social factors that play a role in maintaining the negative effects of misinformation and lay out practices for more effective debunking. Misinformation effects occur at the societal and individual level and the dissemination of misinformation can be intentional or unintentional. The evolution of scientific knowledge makes misinformation inevitable to a certain degree, as the science becomes more refined over time, but misinformation is also spread intentionally via media and interpersonal communication by vested interests, governments, politicians, and others. The Internet and new media have provided a platform for a vast increase in the reach of intentional efforts to spread misinformation. Mischaracterizations of science can also happen unintentionally or when a new finding is taken up by the media and simplified or otherwise misrepresented. Unfortunately, even public awareness of efforts to spread misinformation do little to alter the uptake of the false information.

Multiple cognitive processes allow for the uptake of misinformation and account for the difficulty in correcting it. First, people have a difficult time assessing the accuracy of many pieces of information they encounter, particularly on the Internet. Next, if a piece of information is assessed as compatible with one's existing knowledge, it becomes resistant to change, as the consequences reconciling inconsistent information is mentally uncomfortable, a process that psychologists refer to as "cognitive dissonance." People often accept information that "feels right," rather than go through the difficult cognitive work of checking for validity. Information that fits into a larger, coherent story also becomes difficult to dislodge. In addition, repeated information is more likely to be accepted as true, in part because hearing something multiple times (from multiple sources) builds a sense of consensus.

At the same time, retractions and corrections often have little effect on individuals' reliance on misinformation. Explanations for this "continued influence effect" include: people build mental models (understanding of how a phenomenon works) around the misinformation and simple retractions leave gaps in understanding that are often not fully replaced; memory retrieval failures lead to people recalling the wrong information; retractions actually reinforce false concepts people were exposed to earlier; and, when people are challenged in their beliefs, they often react by denigrating messengers who provide the corrections. Three factors have been shown to increase effectiveness of retractions: warnings at the time of initial exposure to misinformation, repetition of retractions, and corrections that tell coherent, alternative stories. The third approach is most likely to be successful, but alternative explanations must be plausible, tell a more convincing and complete story than the original misinformation and must

also try to explain where the misinformation came from in the first place, including the motivation behind the initial information. In some cases, inducing skepticism or distrust of certain messengers or messages can help combat misinformation effects. Simple brief rebuttals and fostering skepticism, along with reaffirming individuals' worldviews and personal identities, can also help avoid backfire effects.

Bolsen, T., & Druckman, J. N. (2015). Counteracting the politicization of science. *Journal of Communication*, 65(5), 745-769.

The authors provide a very succinct definition of politicization of science: when someone emphasizes or plays up the uncertainties inherent to science in order to cast doubt on the existence of scientific consensus specific to an issue or policy decision. Politicization occurs once there is a solid body of evidence on some phenomenon, approaching consensus. Yet because scientific findings contain inherent uncertainties; individuals or groups are able to accentuate that uncertainty in the service of their own political goals and to shape the outcome of decision-making. Across two survey experiments, the authors find that if scientists and their partners in the process of early communication on an issue were to provide warnings about future efforts to politicize the scientific topic, such a strategy is likely to significantly reduce politicization effects on audiences and lead people to utilize scientific information more objectively in decision-making. Consider the example of a statement warning of politicization on carbon nanotubes (CNTs) that they used as part of their experimental evaluation, embedded withing a larger explainer about the topic: "Some say that it is difficult to assess the benefits of this process because people only point to evidence that supports their position. However, the assessment of CNTs should not be politicized; a consensus of scientists believes CNTs are better for the environment than other energy production methods." In contrast, simply providing a correction to dismiss politicization after someone has already been exposed to a politicizing message, on its own does not do much to combat the effects of politicization. Only when people are simultaneously motivated by an advance warning to pursue accuracy goals do corrections improve uptake.

CONSENSUS MESSAGING

Even for individuals who closely follow political debates such as those over climate change or childhood vaccination, it is impossible to track the latest scientific findings or studies, much less parse the many complexities involved. Instead, people may be more likely to use as a mental short cut what they perceive as the consensus opinion of relevant experts. Yet the problem is that many members of the public are not very good at accurately estimating the true level of scientific consensus. For example, recent surveys find that only one out of ten Americans correctly estimate agreement among climate scientists as greater than ninety percent.

As simple as it might sound, some researchers argue that correcting misperceptions of scientific consensus can serve as an important "gateway belief," influencing other attitudes about climate change or vaccination, which in turn, shape policy support and personal decisions. As a consequence, they argue that an effective communication strategy would be for scientists and others to emphasize the level of expert agreement on a contentious issue, repeating the emphasis in conversations, social media, presentations, advertising, communication campaigns, and media interviews (see van der Linden et al, 2015; van der Linden, Clark, & Maibach, 2015).

Other researchers, however, have voiced doubt about the effectiveness of such a strategy, warning that when put into practice, consensus messaging may actually serve to deepen polarization, rather than erode it. Kahan (2015) argues that recent history suggests that messages about scientific consensus on climate change are often paired with attacks on Republicans and conservative groups. In doing so, advocates like Al Gore make it easy for conservatives to dismiss such arguments, reinforcing their doubts and antipathy towards proposed policy actions.

In all, more research is needed on the efficacy of consensus messaging, the conditions under which it is likely to be effective, and strategies for embedding such information within personal conversations, presentations, media interviews, and communication efforts. In the meantime, however, emphasizing scientific consensus on climate change via talking points such as "97% of climate scientists have concluded that human-caused climate change is happening" is likely to be effective with some audiences, especially those who do not strongly identify as conservative or Republican. Such a point of emphasis is also a comfortable talking point for most scientists to adopt, since it does not necessitate advocating on behalf of a policy position. Yet in emphasizing such information, like with other communication strategies, it is wise for scientists and their partners to avoid partisan-focused judgments or evaluations.

van der Linden, S. L., Leiserowitz, A. A., Feinberg, G. D., & Maibach, E. W. (2015). The scientific consensus on climate change as a gateway belief: Experimental evidence. *PLoS one*, 10(2), e0118489.

To evaluate strategies for correcting perceptions of expert consensus about climate change, in a series of experiments involving a nationally representative sample of U.S. adults, researchers tested the effects of 11 different variations on the same message: "97% of climate scientists have concluded that human-caused climate change is happening." In one experimental condition, subjects were presented just with the text of the message. In a second condition, the text was paired with a pie chart visually conveying the level of consensus. In other conditions, subjects were presented with variations on a relevant metaphor such as "If 97% of engineers concluded that a particular bridge is unsafe to cross, would you believe them? 97% of climate scientists have concluded that human-caused climate change is happening."

Across each of their experimental conditions, boosting awareness of scientific consensus increased beliefs that climate change is happening, that it is human caused, and a worrisome problem. These shifts in beliefs in turn increased subjects' support for policy action, with some of the largest increases observed among Republicans, who tend to be more dismissive of the issue. This last finding could be due to a "ceiling effect." In other words, given their relatively higher scores in perceived consensus, there is less room for correction among Democrats than Republicans.

Overall, however, the researchers did not observe evidence of polarization in reaction to the consensus messaging. Instead, they observed shifts in the "opinions of both Democrats and Republicans in directions consistent with the conclusions of climate science." As the authors conclude: "Repeated exposure to simple messages that correctly state the actual scientific consensus on human-caused climate change is a strategy likely to help counter the concerted efforts to misinform the public. Effectively communicating the scientific consensus can also help move the issue of climate change forward on the public policy agenda."

Interestingly, in comparison to the tested metaphors, subjects who received either the simple text statement or the pie chart displayed the greatest increase in their beliefs. Metaphors are especially useful for explaining complex mechanisms related to climate science, reasoned the researchers, but when trying to convey the strength of scientific consensus "presenting information in a way that is short, simple, and easy to comprehend and remember seems to offer the highest probability of success for all audiences examined," they concluded.

van der Linden, S. L., Clarke, C. E., & Maibach, E. W. (2015). Highlighting consensus among medical scientists increases public support for vaccines: evidence from a randomized experiment. BMC public health, 15(1), 1.

Studies show that news reports about vaccines tend to falsely balance consensus views on safety with claims that vaccines pose adverse health risks. Other research indicates that such falsely balanced presentations magnify public uncertainty about the safety of vaccines and promote vaccine hesitancy among parents. To examine the possibility that views of scientific consensus on vaccines may be a key "gateway belief" driving perceptions of vaccination, the researchers recruited an online sample of 206 American adults, randomly assigning them either to a control group or to three different experimental message conditions.

Using a pie chart in each of the message conditions, the researchers tested either a "descriptive" message about vaccine consensus ("90% of medical scientists agree that vaccines are safe,") a "prescriptive" message endorsing mandatory vaccination ("90% of medical scientists agree that all parents should be required to vaccinate their children,") or a combination of the two messages. Participants in the control group received no information about vaccination. In comparison to the control

condition, exposure to the tested messages resulted in significantly higher estimates of scientific consensus. Specifically, after exposure to the messages, subjects estimated expert consensus on vaccination at 90% compared to 84% among the control group. In line with a "gateway belief" hypothesis, this upward shift in estimates of scientific consensus was linked to fewer concerns about vaccines, a reduced belief in an autism-vaccine link, and to greater support for vaccination. Interestingly, there were no observed differences by political ideology; the consensus messages shifted the views of liberals, moderates, and conservatives alike.

Consensus messaging on vaccines may offer experts and others an efficient and simple communication strategy for reducing vaccine-related risk perceptions and hesitancy. The strategy is particularly promising; the authors argue, since it avoids the often-committed mistake of repeating a misinformation "myth" such as mentioning a link between vaccines and autism. People tend to remember such sticky "myths" even in the face of corrections, but the consensus messaging strategy side-steps this possibility. Yet the authors also conclude that more research is needed including testing the efficacy of consensus messages with a more nationally representative sample of adults; with vaccine hesitant parents; and in controlled field trials and settings such as patient waiting rooms at doctor offices.

Kahan, D. M. (2015). Climate science communication and the measurement problem. *Political Psychology*, 36(S1), 1-43.

Kahan reviews research indicating that on politically contentious issues like climate change, scores on a general measure of science literacy have little influence on public opinion and beliefs. The reason is that answers to questions about climate change reflect expressions of political identity. Given the longstanding disagreement over climate change among liberal and conservative political leaders and activists, and the communication of these differences by way of the media and other forms of communication, answers to questions about climate change reflect a form of "identity-protective cognition." Questions about climate change enable liberal and conservative members of the public to express who they are politically, and whose side they are on.

From this perspective, Kahan argues that despite their promising findings, consensus messaging studies on climate change lack external validity. Offering respondents information about expert consensus and then asking them to answer questions about climate change does not correspond to how Americans are likely to encounter such information in the real world. Kahan argues that messages about scientific consensus have been prominent in U.S. culture for at least a decade, most notably as expressed in Al Gore's *An Inconvenient Truth*, news coverage, and numerous public communication campaigns. Yet this emphasis on consensus has done little to shift public opinion. The reason, he argues, is that in the real world messages about expert consensus are not expressed neutrally and on their own, instead they are often embedded in highly politicized arguments that also attack or denigrate conservative

political leaders or groups. Under such conditions, it becomes easy for conservative Americans to resort to identity protective-forms of reasoning and to remain resolute in their beliefs about climate change, beliefs that are consistent with their ideological and partisan identity.

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