Making Climate-Science Communication *Evidence*-based—All the Way Down

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Scientists and science communicators have appropriately turned to the science of science communication for guidance in overcoming public conflict over climate change. The value of the knowledge that this science can impart, however, depends on its being *used scientifically*. It is a mistake to believe that either social scientists or science communicators can intuit effective communication strategies by simply consulting compendiums of psychological mechanisms. Social scientists have used empirical methods to identify which of the myriad mechanisms that could plausibly be responsible for public conflict over climate change actually are. Science communicators should now use valid empirical methods to identify which plausible real-world strategies for counteracting those mechanisms actually work. Collaboration between social scientists and communicators on evidence-based field experiments is the best means of using and expanding our knowledge of how to communicate climate science.

1

It would be incorrect to say that social scientists have been studying the dynamics that constrain public comprehension of climate science for as long as climate scientists have been trying to communicate what they know to the public. Social scientists began studying the relevant science-communication dynamics way earlier.

The impetus for the scientific study of science communication was the divide between the public and experts on nuclear power in the late 1970s and early 1980s. In that case, members of the public were more worried than scientists rather than less. The nation's most preeminent scientists assured the public that nuclear power was quite safe—in fact saf*er* for the environment than use of fossil-fuel energy sources such as coal (Bethe 1976). The failure of widely accessible and seemingly compelling science to quiet public conflict over nuclear power (and a variety of other environmental risks) motivated Paul Slovic, Daniel Kahnemann, Baruch Fischhoff, and other collaborators to invent the psychometric theory of risk perception, a common ancestor of all the modern decision sciences (Slovic, Fischhoff & Lictenstein 1976; Kahneman, Slovic & Tversky 1982; Slovic 1987).

Far from social scientists beginning to study science communication in response to public conflict over climate science, it was the intensity of public conflict over climate change that shocked scientists, policy analysts, and a whole lot of other people into discovering the science of science communication. Had this body of knowledge been integrated into the practice of science and science-informed policymaking back in 1988, when James Hansen made his initial warn-

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ings about the impact of anthropogenic global warming, perhaps political conflict could have been avoided or at least reduced.

One might say "better late than never," except the situation is not yet as good as it should be. At this point, many more scientists, government officials, and public advocacy groups recognize that a science of science communication exists and that it has generated knowledge relevant to understanding and resolving problems like political conflict over climate change. But mere familiarity with the science of science communication is not sufficient. For genuine progress to be made, it is necessary for these actors and others to proceed scientifically in making *use* of such knowledge.

Decision science comprises a rich array of concepts and mechanisms. Any creative person can easily use them to construct an account—or two or three—of why the public is divided on climate change and what to do to about it. Plausible-sounding communication strategies informed by "heuristics and biases," "tipping points," "nudges," "framing," "narratives," "fMRI neurocorrelates," and the like abound in newspaper op-eds, blog posts, and animated "how to" climate-communication guides.

The number of plausible accounts of any complicated phenomenon will always be larger than the number that are actually true. The primary mission of social science is to help extricate the latter from the vast sea of the former. A style of analysis that treats decision science as a grab bag of story-telling templates necessarily can't do that. Only the disciplined forms of observation, measurement, and inference distinctive of science can (Watts 2011).

It's fine—essential, even—to engage in imaginative conjecture informed by valid decision science. But the results must be recognized for what they really are—not genuine "scientifically established" conclusions but rather plausible hypotheses that merit testing by valid empirical means.

Moreover, when such tests have been carried out, the evidence they yield must actually be used. Assessments of the relative likelihood of competing conjectures must be updated in light of such evidence. As accounts that seemed plausible at one point are shown to be less so, those accounts shouldn't be endlessly recycled and dumped back into the stream of information being directed to practitioners looking for guidance on how to communicate in real-world settings.

Nor should general insights derived from laboratory experiments be oversold. They identify mechanisms of consequence, but they do not in themselves furnish meaningful, determine guides to action. If they are valid and skillfully designed, they tell communicators where to train their attention and stimulate them to formulate concrete hypotheses about how the results obtained in the lab might be reproduced in the real-world setting in which they are working. Social scientists should help them *test* those hypotheses in field studies designed to determine which plausible conjectures about which real-world strategies actually work and which don't .

What I am advocating is an approach to science communication that is genuinely *evidence*-based from beginning to end. I will try to make the nature of this approach more vivid by displaying it. In successive parts, I will identify one com-

monplace hypothesis about the source of public conflict over climate science that is not empirically supported, and another hypothesis that is. I'll then outline the sort of field testing that should be done to convert the knowledge generated by the sorts of laboratory studies used to test these hypotheses into effective real-world strategies for communicating climate science.

2

I will call the first hypothesis the "public irrationality thesis" or "PIT." PIT attributes public controversy over climate change, in effect, to a deficit in public comprehension.

The public, on this view, doesn't really know much science. As a result, it can't understand what climate scientists are telling them, or are easily misled about what the state of the scientific evidence really is.

In addition, members of the public don't think the way that scientists do. Whereas scientists reason in a conscious, deliberate, and highly analytical fashion—what Kahneman (2011) calls "System 2" in his deservedly popular book *Thinking: Fast and Slow*—members of the public form perceptions of risk in a largely unconscious, affect-driven fashion—what Kahneman calls "System 1" reasoning. Forlorn polar bears drifting on shrinking patches of ice are less emotionally gripping than an airliner fuselage embedded in a flaming high rise. Members of the public thus end up predictably underestimating the hazard posed by climate change relative to more dramatic but actuarial remote risks, such as terrorism.

PIT is widely espoused, even among social scientists engaged in synthetic or interpretive assessments (Weber 2006; Sunstein 2007). Indeed, what makes this account plausible is that it is rooted in valid social science. But PIT is still only a conjecture—a hypothesis about the nature of public controversy over climate science.

It has also been tested. In one study (Kahan, Peters, Wittlin, Slovic, Ouellette, Braman & Mandel 2012), my colleagues and I asked a large, nationally representative sample of U.S. adults to indicate "how much risk" they believe "climate change poses" on a scale of 0 (for "no risk") to 10 ("extreme risk"). Responses to this item are known to be highly correlated with the ones ordinary members of the public will give when asked whether they believe the earth is heating up, whether humans are causing it, whether such warming will cause particular catastrophic results—or pretty much any other more particular question that members of the public can understand. So it makes for an efficient single-item indicator of what amounts to a generalized latent disposition that members of the public have toward climate change and other risks (Dohmen, Falk, Huffman, Sunde, Schupp, & Wagner 2011).

The point of using a measure like this isn't to see how close people generally are getting to the "right answer" (who knows what that would be on this scale) but to explore variance in climate change risk perceptions. By correlating responses with individual characteristics, we can see what sorts of people tend to be more concerned and which ones less. That information can be used to test hypotheses about why the "average" member of the public is not *as* concerned as climate scientists think he or should be.

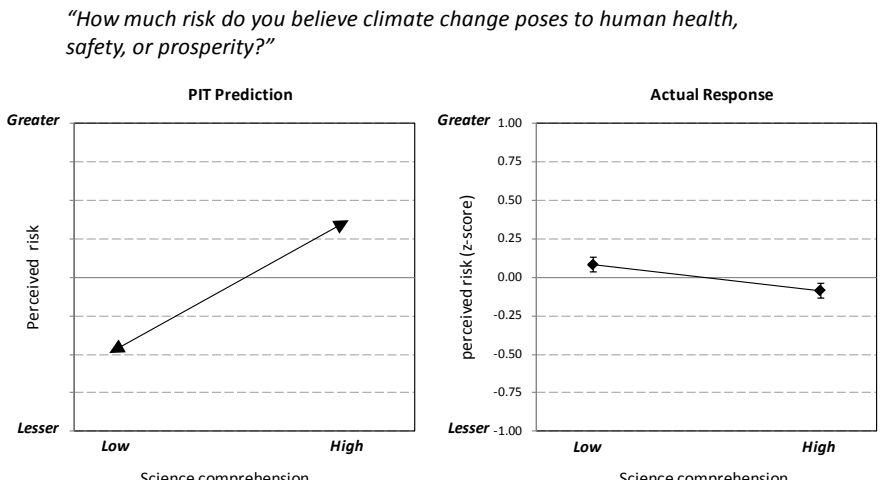

Figure 1. PIT prediction vs. actual impact of science comprehension on climate-change risk perceptions. Contrary to PIT's predictions, higher degrees of science literacy and numeracy are not associated with an increase in the perceived seriousness of climate-change risks but instead with a small decrease. Score on 11-point Likert measure (M = 5.7, SD =3.4) transformed to z-score. CIs reflect 0.95 level of confidence. *Source* Kahan, D.M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L.L., Braman, D. & Mandel, G. The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Climate Change* 2, 732-735 (2012).

PIT generates a testable predication. If the reason that the average member of the public doesn't take climate change risks as seriously as she should is that she doesn't understand enough science and doesn't think the way scientists do, then we should expect perceptions of risk to increase as people become more science literate and more adept at systematic or so-called System 2 reasoning (Figure 1).

Accordingly, we also measured our subjects' *science literacy* and *numeracy* as well. For the former, we used the National Science Foundation's "Science Indicators," a quiz on topics in biology and physics that is conventionally employed in studies of science literacy. We also used standard items to measure numeracy, which involves the capacity to engage in quantitative and related forms of technical reasoning (Peters, Västfjäll, Slovic, Mertz, Mazzocco & Dickert 2006). Numeracy has been shown to be a valid predictor of individuals' disposition to rely on the conscious and deliberate form of information processing that Kahneman labels System 2 and to avoid the cognitive biases that are the signature of over-reliance on the affect-driven form of information processing that Kahneman labels System 1 (Reyna, Nelson, Han & Dieckman 2009).

Science literacy and numeracy, it turned out, cohered very nicely with each other, allowing them to be combined into a valid scale. Because theses measures did not display the requisite coherence with education to justify melding education into the mix, it is reasonable to view the science-literacy/numeracy scale as measuring a latent "science comprehension" aptitude distinct from how educated a person is.

This science comprehension measure, we found, was *not* positively correlated with climate-change risk perception. On the contrary, it was negatively correlated with it, although only to a very slight degree (Figure 1).

We did not observe the strong positive correlation one would expect to if PIT were correct. On this basis, then, someone with a genuinely evidence-based orientation would reduce downward her estimation of the likelihood that a deficit in science knowledge or a tendency to over-rely on heuristic-driven System 1 reasoning explains the failure of the U.S. public to converge on a perception of risk that reflects the concern scientists believe they ought to have.

The study, it turns out, furnishes still more reason to discount PIT, and to an even stronger degree. But it will be easier to appreciate the significance of this additional evidence in connection with my discussion of the next plausible and more amply supported account of the source of public controversy over climate change.

3

The second plausible hypothesis can be called the "motivated reasoning thesis" (MRT). Motivated reasoning refers to the tendency of people to conform their assessment of information—whether empirical data, logical arguments, the credibility of information sources, or even what they perceive with their own senses—to some goal or interest extrinsic to forming an accurate belief (Kunda 1990). The classic study, from the 1950s, showed that students from to Ivy League colleges formed diametrically opposed perceptions of the correctness of certain disputed officiating calls made in a game between their schools' respective football teams: the emotional stake the students had in experiencing solidarity with their peers had unconsciously affected what they *saw* in viewing a film of the game (Hastorf & Cantril 1954). MRT asserts that the same thing is happening when ordinary members of the public form perceptions of climate change risks: that is, they selectively credit or discredit evidence in patterns that reflect their commitments to important or self-defining social groups. Again, a plausible conjecture in need of testing by empirical studies.

One such study tested the hypothesis that MRT explains the failure of expert consensus to dispel public controversy on disputed risks (Kahan, Jenkins-Smith & Braman 2011). In the study, subjects (a large, nationally representative sample of U.S. adults) were asked to indicate whether they viewed the featured scientists as "knowledgeable and credible experts" on climate change, nuclear wastes, and gun control. Each scientist, the subjects were told, had received graduate training in a field related to the specified topic, was on the faculty of an elite U.S. university, and was a member of the National Academy of Sciences (Figure 3). For each scientist, half the subjects were shown a book excerpt (patterned on writings from actual scientists) that took the "high risk" position on the relevant issue: anthropogenic climate change is real and unless arrested will impose catastrophic consequences; deep geologic storage of nuclear wastes is unacceptably dangerous; or permitting ordinary citizens to carry concealed handguns in public increases the crime rate. The other half were shown an excerpt that took the "low risk" position: the evidence on climate change is inconclusive; deep geologic isolation of nuclear waste is safe; permitting citizens to carry concealed handguns deters violent predation.

We picked these three issues for two reasons. First, each of them had been addressed in a National Academy of Sciences "expert consensus" report.

Second, the issues were ones known to divide members of the public on *cultural lines*. In research that examines "cultural cognition"—a version of MRT that posits individuals will form perceptions of risk that connect them to others who share their cultural values (Kahan 2012)—subjects' "worldviews" or preferences for how to organize society or other collective enterprises are characterized along two orthogonal dimensions. "Individualism-communitarianism" (or simply "Individualism") reflects their relative preference for social orderings that treat individuals as responsible for securing the conditions of their own well-being versus ones that assign such responsibility to the group or collective. "Hierarchy-egalitarianism" (or simply "Hierarchy") reflects their relative preference for social orderings that are pervaded with rankings that tie authority to social roles versus ones that deny that who can tell what to do can depend on any sort of socially stratified system of classifications. In previous studies, we and other researchers had found that individuals with simultaneously "hierarchical" and "individualistic" worldviews and those with simultaneously "egalitarian" and "communitarian" ones tend to hold opposing perceptions of environmental risks, including ones associated with climate change and nuclear power, and risks associated with guns and gun control (Kahan 2010).

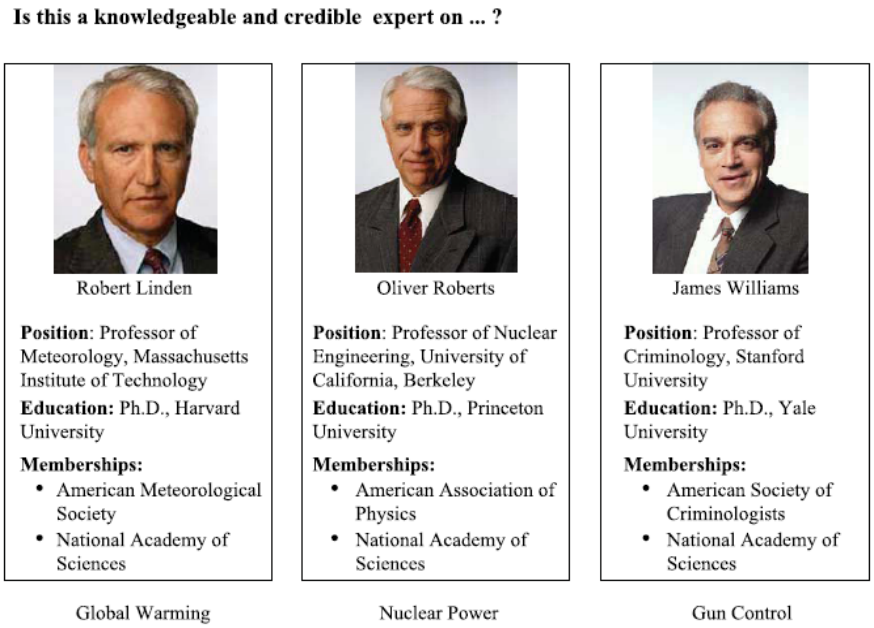

Figure 2. Featured scientists. Subjects were instructed to indicate whether they viewed the featured scientist as an expert on the issue of climate change risks, disposal of nuclear wastes, and the consequences of permitting citizens to carry concealed handguns. The positions that the featured scientists were experimentally manipulated: each was represented to one-half of the subjects as having taken the "high societal risk" position, and to one-half as having taken the "low societal risk" position, on the relevant issue. *Source*: Kahan, D.M., Jenkins-Smith, H. & Braman, D. Cultural Cognition of Scientific Consensus. *J. Risk Res.* 14, 147-174 (2011).

Now we were, in effect, asking individuals whose cultural worldviews varied along these lines to assess whether scientists who had reached conclusions on these issues were genuine "experts." The answer, we found, depended strongly on the fit between the position the scientist was depicted as taking on the indicated

risk issue and the position that predominates within the subjects' own cultural groups (Figure 3). Thus, where the relevant scientist endorsed a "high risk" conclusion on climate change, an "egalitarian communitarian" subject was (all else equal) 72 percentage points more likely than a "hierarchical individualist" one to designate him an "expert" on that issue. But where the same scientist endorsed a "low risk" conclusion on climate change, the hierarchical individualist subject was 54 percentage points more likely to identify him as an expert than an egalitarian communitarian. Subjects with these values also formed radically divergent perceptions of the relevant scientists' expertise conditional on the position they were depicted as endorsing on the safety of the disposal of nuclear wastes and the effect of concealed-carry laws.

The position of "experts" is generally regarded as highly relevant on disputed risk issues like these. But when shown a highly accomplished scientist who had reached a conclusion on such an issue, subjects in the experiment were unlikely to perceive that he *was* an expert unless he took the position consistent with the one that predominated in their cultural group. This is exactly what MRT would predict: like the students viewing the tape of the disputed officiating calls, the subjects unconsciously adjusted the weight they afforded the evidence in patterns that reflect their commitments to others with whom they share a strong social bond.

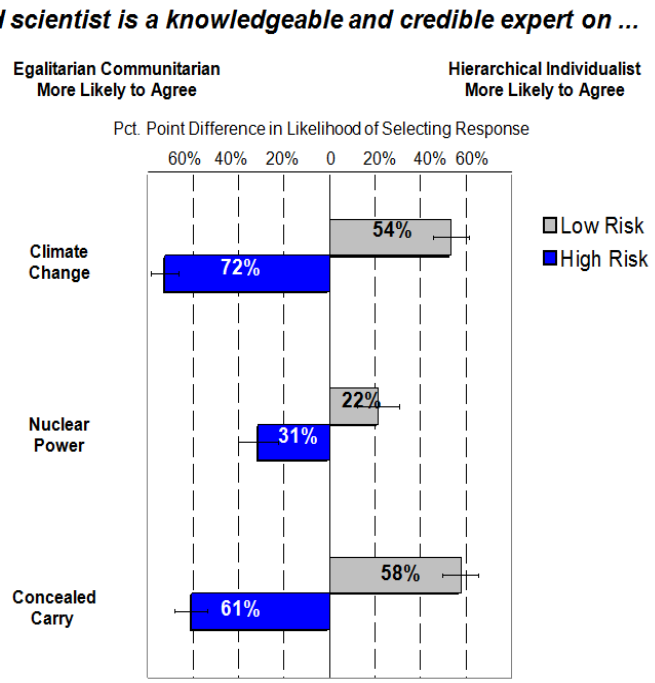

Figure 3. Impact of cultural cognition on perceptions of scientific expertise. Bars indicate how much more likely a subject with the indicated worldview is to agree than is a subject with the opposing worldview that the author is a 'knowledgeable and trustworthy expert' when that author is assigned a particular position ('high' or 'low risk'). Confidence intervals reflect .95 level of confidence. *Source*: Kahan, D.M., Jenkins-Smith, H. & Braman, D. Cultural Cognition of Scientific Consensus. *J. Risk Res.* 14, 147-174 (2011).

If people are similarly selective in crediting evidence on what "experts" believe when they encounter it outside the laboratory, then they will end up culturally po-

larized about what expert "scientific consensus" is on such issues. In another component of the same study, we found exactly that: subjects with hierarchical and individualistic values, on the one hand, and ones with egalitarian communitarian values, on the other, had highly divergent beliefs about what scientific consensus is on the risks of climate change, on the safety of deep geologic isolation of nuclear wastes, and on the impact of permitting citizens to carry concealed weapons.

Indeed, the point of the study was to test MRT in relation to competing conjectures about why scientific consensus on climate change has not quieted public conflict over it. A popular surmise was—and continues to be—that climate skeptics either reject the authority of science or are members of a benighted ideological or cultural group whose members are uniquely disabled from forming reliable perceptions of what scientific consensus is.

However plausible these hypotheses might have been, the study results strongly undermine them. Neither of the cultural groups that are polarized on climate change, nuclear power, and gun control says it doesn't care what scientists believe. Rather, members of each believe that the position their group espouses is *consistent* with scientific consensus.

Moreover, they are all poorly attuned to what scientific consensus actually is. Another reason we picked the risks posed by climate change, the safety of deep geological isolation of nuclear wastes, and the impact of concealed-carry hand gun laws is that each of these issues has been addressed in a National Academy of Sciences "expert consensus" report. At least if we use these reports as the benchmark, members of each group are right about scientific consensus about 1/3 of the time.

Neither group is very reliable, in other words, in discerning what scientists believe on issues like these because they both are unconsciously motivated to fit evidence of expert opinion to their cultural predispositions. Or at least this is the conclusion most supported by the study results.

One thing individuals with these cultural outlooks apparently *do* agree on is that personal observation of local weather is a good indicator of whether climate change is occurring. Or in any event, whether they perceive climate to be changing is predicted by their perception of recent weather conditions.

What they perceive the weather to have *been*, however, is not predicted by what it actually *was* (Akerlof, Maibach, Fitzgerald, Cedeno, Neuman 2012). It is predicted instead by their cultural worldviews: individuals with an egalitarian predisposition perceive that recent temperatures in their area have been warmer than usual, while those with an individualist predisposition perceive that it has in fact been cooler (Goebbert, Jenkins-Smith, Klockow, Nowlin & Silva 2012).

This is consistent with MRT—one might expect individuals selectively to notice and recall aberrant weather in patterns supportive of the position that predominates in their cultural group—and strongly inconsistent with another PIT-related popular surmise, namely, that the public concerns have been impeded by the lack of any personal experience with the effects of climate change but can be

expected to grow as individuals "feel" the impact of climate change for themselves (Weber 2006).

There are numerous additional studies supportive of MRT (Hart & Nisbett 2011). Some of these also address the impact of scientific knowledge on climate-change risk perceptions (Hamilton, Culter & Schaefer 2012), and conflict over perceptions of scientific consensus (McCright, Dunlap, Xizo 2013; Corner 2012). Others investigate risk conflicts unrelated to climate change (Kahan, Braman, Cohen, Gastil & Slovic 2010; Kahan, Braman, Slovic, Gastil & Cohen 2009).

The confidence with which the inference that the result of any particular study reflects the impact of MRT on public conflict over risk gains strength from the fit between that study and this wider body of findings. Indeed, treating a single study as if "proved" that a particular mechanism was at work is another sign of an evidence-free, story-telling orientation toward the science of science communication.

But I now want to return to the study with which I started. In the study in which we examined how science comprehension relates to variance in climate change risk perceptions, we measured subjects' cultural worldviews, too (Kahan *et al.* 2012). Unsurprisingly, we found that subjects with hierarchical individualist worldviews and those with egalitarian communitarian ones were highly polarized. The reason we measured the subjects' worldviews, however, wasn't so that we could observe this pattern for the 50th time. It was so that we could see how cultural cognition—the form of motivated reasoning that features the influence of cultural worldviews on information processing—*interacts* with the subjects' science comprehension.

By itself, cultural cognition might seem perfectly compatible with PIT. Individuals who have acquired a significant degree of scientific knowledge and who are able to reason in the reflective manner associated with science, according to PIT, can be expected to recognize and make sense of the best available scientific evidence on climate change risks. But those who don't possess very much scientific knowledge and who can't engage in the sort of technical reasoning necessary to understand scientific evidence must necessarily rely on imperfect heuristics to figure out what is known to science. One of these might involve finding out what others who share their values think and basically deferring to them. If cultural cognition is essentially a heuristic substitute for science comprehension, then cultural polarization over climate change risks can itself be viewed as reflecting the sort of deficit in reason associated with PIT (Sunstein 2006; Leiserowitz 2006).

Such an account generates another set of testable predictions. If cultural cognition is a heuristic substitute for science comprehension, then subjects with hierarchical and individualistic values ought to become more concerned with climate change risk as their level of science comprehension increases. In addition, because they will now be basing their perceptions to a greater extent on the best available evidence, culturally diverse individuals who enjoy greater science comprehension ought to converge in their risk perceptions.

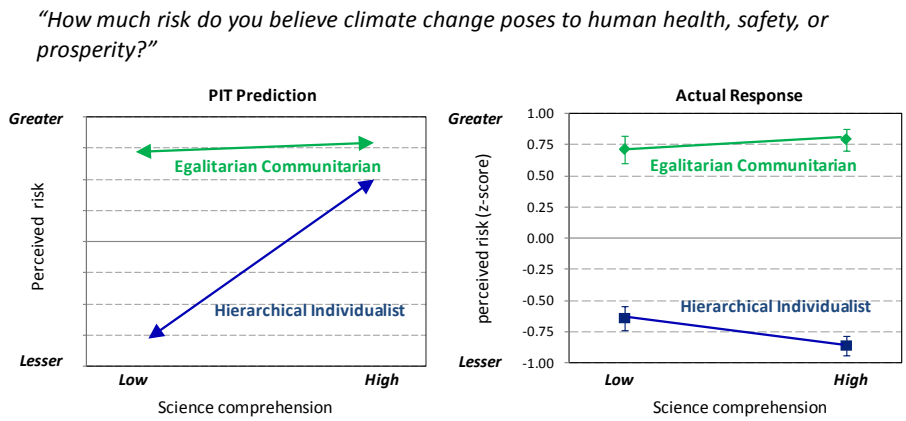

Figure 4. PIT prediction vs. actual impact of interaction between science comprehension and cultural worldviews. Contrary to PIT's predictions, highly science-literate and numerate Hierarchical Individualists are more skeptical, not less, of climate-change risks. CIs reflect 0.95 level of confidence. *Source* Kahan, D.M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L.L., Braman, D. & Mandel, G. The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Climate Change* 2, 732-735 (2012)..

The evidence doesn't support these predictions (Figure 4). Subjects who are more egalitarian and communitarian in their values do become slightly more concerned about climate change risks as their level of science comprehension increases. But for subjects whose values are hierarchical and individualistic, an increase in science comprehension predicts less concern with climate change risks, not more. As a result, the already sizeable gap between subjects of opposing cultural worldviews who are low in science comprehension only becomes larger as people with those values become more science literate and more numerate. Greater scientific knowledge and a stronger disposition to use System 2 reasoning, in other words, magnify the MRT effect reflected in cultural cognition.

This evidence, then, simultaneously increases the likelihood that MRT explains public conflict over climate change risk and decreases the likelihood that PIT does. It doesn't "settle the issue"; nothing ever does, because if one adopts an evidence-based stance one always regards one's current best understanding as just a "prior" subject to revision in light of any new, valid evidence. But if one does want to adopt this evidence-based orientation toward the science of science communication, then it would be a mistake not to take account of the strength of the evidence for MRT and the paucity of evidence for PIT in advising communicators and in designing further research.

4

The point of trying to figure out why there is public controversy about climate change is to guide efforts to figure out what to do to dispel such conflict. Consider this interpretation, which I offer by way of informed conjecture and for the sake of stimulating the formulation of proposed strategies that can themselves be tested for effectiveness.

The evidence I've reviewed so far suggests that the source of public conflict over climate change is not a deficit in public rationality but an excess of it. Cultural

polarization is a consequence of how proficient individuals are in extracting from the science communication environment the information on climate change that matters most for their own lives. Nothing any ordinary member of the public personally believes about the existence, causes, or likely consequences of global warming will effect the risk that climate changes poses to her, or to anyone or anything she cares about. Nothing she does as a consumer, as a voter, as a contributor to political campaigns and causes, or as a participant in public conversation will be of sufficient consequence on its own to have any impact. However, if she forms the wrong position on climate change relative to the one that people with whom she has a close affinity—and on whose high regard and support she depends on in myriad ways in her daily life—she could suffer extremely unpleasant consequences, from shunning to the loss of employment. Because the cost to her of making a mistake on the science is zero and the cost of being out of synch with her peers potentially catastrophic, it is indeed *individually* rational for her to attend to information on climate change in a manner geared to conforming her position to that of others in her cultural group.

One doesn't have to be a rocket scientist, of course, to figure out which position *is* dominant in one's group, particularly on an issue as high-profile as climate change. But if one *does* know more science and enjoy a higher-than-average technical reasoning capacity, one can do an even better job seeking out evidence that supports, and fending off or explaining away evidence that threatens, one's persistence in the belief that best coheres with one's group commitments.

As much as it suits the interest of any individual to form his or her perception of climate change risks this way, however, it frustrates their collective interests when all individuals do this simultaneously. For in that case, democratic institutions of government are less likely to adopt policies that reflect the best available evidence on the risks culturally diverse citizens all face. This consequence, however, doesn't change the incentive that any individual faces to engage information about climate change or other disputed risks in a manner is better suited to connecting her to her cultural group's position than to the truth—because again, nothing she believes, says, or does is going to have any meaningful impact on the level of risk she or her community faces from climate change or what democratic institutions of government do about that.

Dispelling controversy over climate change, then, requires overcoming this "tragedy of the science communication commons." We need science communication strategies that make crediting the best available evidence compatible with membership in the diverse cultural groups that comprise our pluralistic liberal society. If we can rid the science communication environment of the toxic partisan resonances that transform positions on climate change into badges of loyalty to contending factions, then we can be confident that ordinary members of the public, using the normal and normally reliable faculties that they use to discern who knows what about what, will converge on the best available scientific evidence on climate change as they do on the vast run of other questions for which science supplies the best answer.

What are those strategies? I *refuse* to answer.

The reason is not that I have no ideas about how to counteract the influences that generate motivated reasoning of the sort that figures in cultural cognition. Decision scientists, including ones using the methods of the science of science communication to address climate change risk perceptions have done lots of work that I think helps to identify plausible lines of attack (Myers, Nisbet, Maibach & Leiserowitz 2012; Hart & Nisbett 2011; Kahan, Jenkins-Smith, Tarantola, Silva & Braman 2012).

But here too the number of strategies that it is plausible to believe will work exceeds the number it's reasonable to believe will actually work. If I were to say, "Here's the answer: do this!," I'd be engaging in the very form of story-telling that it is the central aim of this essay to discredit.

I can't tell those engaged in the mission to improve public engagement with climate science what to do but I can tell them *how* to do it: by engaging in a genuinely evidence-based approach to science communication. To make this prescription responsibly more concrete, I'll say one thing about the methods that should be employed for this purpose, and another about where to use them.

a. Methods. In my view, both making use of and enlarging our knowledge of climate science communication requires making a transition from *lab models* to *field experiments*. The research that I adverted to on strategies for counteracting motivated reasoning consist of simplified and stylized experiments administered face-to-face or on-line to general population samples. The best studies build explicitly on previous research—much of it also consisting in stylized experiments—that have generated information about the nature of the motivating group dispositions and the specific cognitive mechanisms through which they operate. They then formulate and test conjectures about how devices already familiar to decision science—including message framing, in-group information sources, identity-affirmation, and narrative—might be adapted to avoid triggering these mechanisms with communicating with these groups.[1]

But such studies do not in themselves generate useable communication materials. They are only *models* of how materials that reflect their essential characteristics might work. Experimental models of this type play a critical role in the advancement of science communication knowledge: by silencing the cacophony of real-world influences that operate independently of anyone's control, they make it possible for researchers to isolate and manipulate mechanisms of interest, and thus draw confident inferences about their significance, or lack thereof. They are thus

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[1] Unrepresentative convenience samples are unlikely to generate valid insights on how to counteract motivated reasoning. Samples of college undergraduates are perfectly valid when there is reason to believe the cognitive dynamics involved operate uniformly across the population. But the mechanisms through which motivated reasoning generates polarization on climate change don't; they interact with diverse characteristics—worldviews and values, but also gender, race, religiosity, and even regions of residence. It is known, for example, that white males who are highly hierarchical and individualistic in worldviews or conservative in their political ideologies tend to react dismissively to information about climate change (Leiserowitz 2005; McCright & Dunlap 2011, 2012; Kahan, Braman, Gastil, Slovic & Mertz 2007) . Are they likely to respond to a "framing" strategy in the same way that a sample of predominantly female undergraduates attending a school in New York City does (Feygina, Jost & Goldsmith 2010)? If not, that's a good reason to avoid using such a sample in a framing study, or not to rely much on the conclusions of a study that did.

ideally suited to reducing the class of the merely plausible strategies to ones that there communicators can have an empirically justified conviction are likely to have an impact. But one can't then take the stimulus materials used in such experiments and send them to people in the mail or show them on television and imagine that they will have an effect.

Communicators are relying on a bad model if they expect lab researchers to supply them with a bounty of ready-to use strategies. The researchers have furnished them something else: a reliable map of where to look. Such a map (it is hoped) will spare the communicators from wasting their time searching for non-existent buried treasure But the communicators will still have to *dig*, making and acting on informed judgments about what sorts of real materials they believe might reproduce in the real-world contexts the effects that researchers elicited in their models.

The communicators, moreover, are the only ones who can competently direct this reproduction effort. The science communication researchers who constructed the models can't just tell them what to do because they don't know enough about the critical details of the communication environment: who the relevant players are, what their stakes and interests might be, how they talk to each other, and whom they listen to. If researchers nevertheless accept the invitation to give "how to" advice, the best they will be able to manage are banalities—"Know your audience!"; "Grab the audience's attention!"—along with Goldilocks admonitions such as, "Use vivid images, because people engage information with their emotions. . . but beware of appealing *too much* to emotion, because people become numb and shut down when they are overwhelmed with alarming images!"

Communicators possess knowledge of all the messy particulars that researchers not only didn't need to understand but were obliged to abstract away from in constructing their models. Indeed, like all smart and practical people, the communicators are filled with many plausible ideas about how to proceed—more than they have the time and resources to implement, and many of which are not compatible with one another anyway. What experimental models—if constructed appropriately—can tell them is which of their surmises rest on empirically sound presuppositions and which do not. Exposure to the information that such modeling yields will (if the models are elegant) activate experienced-informed imagination on the communicators' part, and enable them to make evidence-informed judgments about which strategies they believe are most likely to work for their particular problem.

At that point, it is time for the scientist of science communication to step back in—or to join alongside the communicator. The communicator's informed conjecture is now a hypothesis to be tested. In advising field communicators, science of science communication researchers should treat what the communicators do as experiments. Science communication researchers should work with the communicator to structure their communication strategies in a manner that yields valid observations that can be measured and analyzed.

Indeed, communicators, with or without the advice of science of science communication researchers, should not just go on blind instinct. They shouldn't just read a few studies, translate them into a plausible-sounding plans of action,

and then wing it. Their plausible surmises about what will work are likely to be more plausible, more likely to work, than the ones dreamed up by less worldly laboratory researchers. But the researchers' plausible surmises are still just that. They are still only hypotheses. Without evidence, we will not learn whether policies based on such surmises did or didn't work. If we don't learn that, we won't really have learned anything, including how we can do even better next time.

Genuinely evidence-based science communication must be based on evidence *all the way down*. Communicators should make themselves aware of the existing empirical information that science communication researchers have generated (and steer clear of the myriad stories that retail consumers of decision-science work like to tell) about why the public is divided on climate science. They should formulate strategies that seek to reproduce in the world effects that that have been shown to help counter the dynamics of motivated reasoning responsible for such division. Then, working with empirical researchers, they should *observe* and *measure*. They should collect appropriate forms of pretest or preliminary data to try corroborate that the basis for expecting a strategy to work is sound and to calibrate and refine its elements to maximize is expected effect. They should also collect and analyze data on the actual impact of their strategies once they've been deployed.

Finally, *they should make the information that they have generated at every step of this process available to others so that they can learn from it too*. Every exercise in evidence-based science communication itself generates knowledge. Every such exercise itself furnishes an instructive *model* of how that knowledge can be intelligently used. The failure to extract and share the intelligence latent in *doing* science communication perpetuates the dissipation of collective knowledge that it is the primary mission of the science of science communication to staunch.

b. Local adaptation. Consider this paradox. If one is trying to be elected to Congress in either Florida or Arizona, it is not a good idea to make "combating global climate change" the centerpiece of one's campaign. Yet both of these states are hotbeds of local political activity focusing on climate adaptation. A bill passed by Florida's Republican-controlled legislature in 2011 and signed into law by its tea-party Governor (Laws of Florida. 2011) has initiated city- and county-level proceedings to formulate measures for protecting the state from the impact of projected sea-level rises, which are expected to be aggravated by the increased incidence of hurricanes. Arizona is the site of similar initiatives (Ariz. Dept. of Energy Quality 2013). Overseen by that state's conservative Governor (who once punched a reporter for asking her whether she believed in global warming (Wing 2012)), the Arizona proceedings are aimed at anticipating expected stresses on regional water supplies.

Climate science—of the highest quality, and supplied by expert governmental and academic sources—is playing a key role in the deliberations of both states. Florida officials, for example, have insisted that new nuclear power generation facilities being constructed offshore at Turkey Point be raised to a level higher than contemplated by the original design in order to reflect new seal-level rise and storm-activity projections associated with climate change (Kenward 2011). The basis of these Florida officials' projections are the same scientific models that Florida Senator Marco Rubio, now considered a likely 2016 presidential candidate, says

he still finds insufficiently convincing to justify national regulation of carbon emissions (Bennett-Smith 2013).

The influences that trigger cultural cognition when climate change is addressed at the national level are much weaker at the local one. When they are considering adaptation, citizens engage the issue of climate change not as members of warring cultural factions but as property owners, resource consumers, insurance policy holders, and tax payers—identities they all share. The people who are furnishing them with pertinent scientific evidence about the risks they face and how to abate them are not the national representatives of competing political brands but rather their municipal representatives, their neighbors, and even their local utility companies. What's more, the sorts of issues they are addressing—damage to property and infrastructure from flooding, reduced access to scarce water supplies, diminished farming yields as a result of drought—are matters they deal with all the time. They are the issues they have always dealt with as members of the regions in which they live; they have a natural shared vocabulary for thinking and talking about these issues, the use of which reinforces their sense of linked fate and reassures them they are working with others whose interests are aligned with theirs. Because they are, in effect, all on the same team, citizens at the local level are less likely to react to scientific evidence in defensive, partisan way that sports fans do to contentious officiating calls.

Nevertheless, it would be a mistake to assume that local engagement with adaptation is impervious to polarizing forms of motivated reasoning. The antagonistic cultural meanings that have contaminated the national science communication environment could easily spill over into local one as well. Something like this happened—or came close to it—in North Carolina, where the state legislature enacted a law that restricts use of anything but "historical data" on sea-level in state planning. The provision got enacted because proponents of adaptation planning legislation there failed to do what those in the neighboring state of Virginia did in creating a rhetorical separation between the issue of local flood planning and "global climate change." Polarizing forms of engagement have bogged down municipal planning in some parts of Florida—at the same time as progress is being made elsewhere in the state.

The issue of local adaptation, then, presents a unique but precarious opportunity to promote constructive public engagement with climate science. The prospects for success will turn on how science is communicated—by scientists addressing local officials and the public, certainly, but also by local officials addressing their constituents and by myriad civic entities (chambers of commerce, property owner associations, utility companies) addressing the individuals whom they serve. These *climate-science communicators* face myriad challenges that admit of informed, *evidence*-based guidance, and they are eager to get guidance of that kind. Making their needs the focus of field-based science-communication experiments would confer an immense benefit on them.

The social science researchers conducting such experiments would receive an immense benefit in return. Collaborating with these communicators to help them protect their science communication environment from degradation, and to effec-

tively deliver consequential scientific information within it, would generate a wealth of knowledge on how to adapt insights from lab models to the real world.

There are lots of places to do science communication field experiments, of course, because there are lots of settings in which people are making decisions that should be informed by the best available climate science. There is no incompatibility between carrying out programs in support of adaptation-science communication simultaneously with ones focused on communicating relevant to climate policymaking at the national level.

On the contrary, there are likely to be numerous synergies. For one thing, the knowledge that adaptation-focused field experimentation will likely generate about how to convert laboratory models to field-based strategies will be relevant to science communication in all domains. In addition, by widening the positive exposure to climate science, adaptation-focused communication is likely to create greater public receptivity to open-minded engagement with this science in all contexts in which it is relevant. Finally, by uniting on a local level all manner of groups and interests that currently occupy an adversarial relation on the climate change issue nationally, the experience of constructive public engagement with climate science at the local level has the potential to clear the air of the toxic meanings that have been poisoning climate discourse in our democracy for decades.

5

A central aim of the science of science communication is to protect the value of what is arguably our society's greatest asset. Modern science has conferred on us the *knowledge* necessary to live healthier, safer, and more prosperous lives than our forbears could even have imagined, much less lived. But the same conditions of political liberty and cultural pluralism that have nourished the advancement of science have multiplied the competing number of certifiers of what is collectively known (Kahan 2013). Our prospects for actually making effective *use* of what science has taught us about the workings of nature demands that we use *science* to improve our understanding of how to enable culturally diverse citizens to converge on the best scientific evidence as they deliberate over how to pursue their common ends.

The imperfect state of the science of science communication is part of the explanation for cultural polarization over climate science. But it is no more than a *part* of it. Another, perhaps even larger one is the failure for decades to have made effective use of what had already been learned as a result of the scientific study of risk perception and communication.

Now, many public-spirited citizens and institutions are turning to the knowledge associated with the science of science communication to try dispel the fog of cultural conflict that obscures the best available scientific evidence on climate change. But unless we use *evidence-based* methods, this decisive opportunity to integrate the science of science communication with the practice of science will end up wasted, too.

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