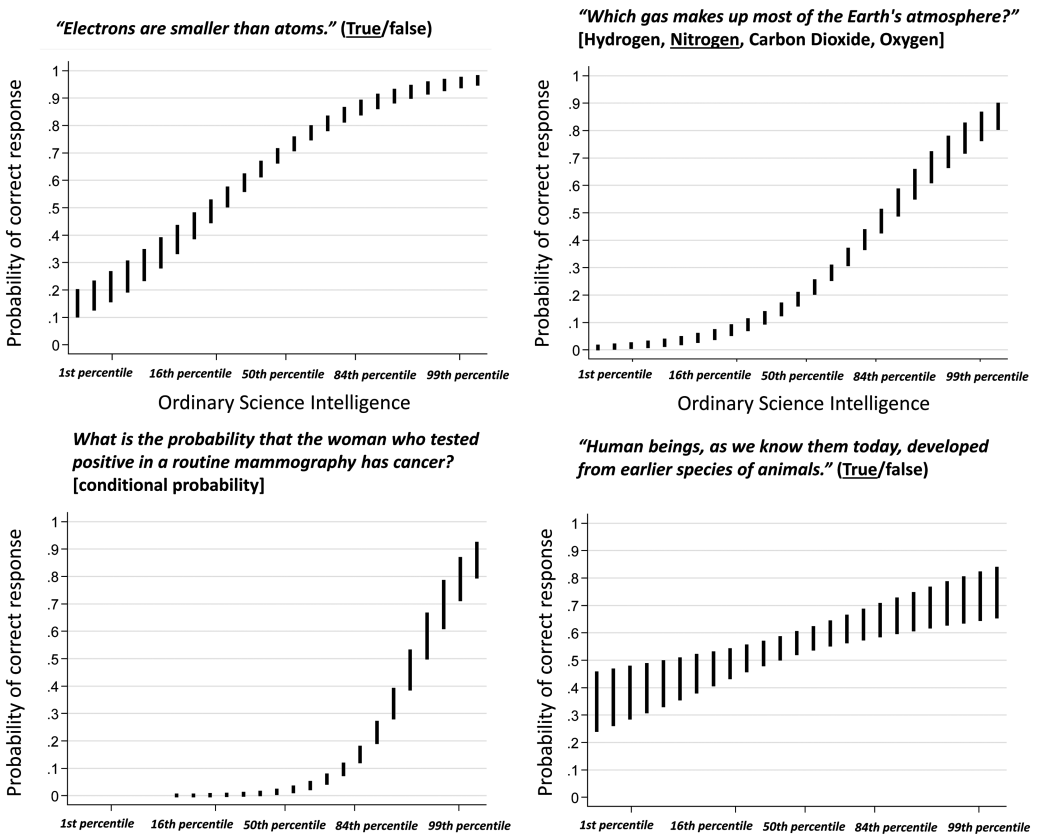

Figure 1. Select OSI item-response curves. Using item-response theory 2PL model, figures plot the predicted probability of correctly responding to the item conditional on score on OSI scale. Black bars reflect 0.95 confidence intervals.

"Nitrogen," the Pew multiple choice item on which gas is most prevalent in the earth's atmosphere, is relatively difficult (Figure 1). Someone with a mean OSI score is only about 20% likely to give the correct response. We would expect a test taker to be more likely than not to select the correct response to this item only if she ranks at or above the 84th percentile—a standard deviation above the mean—in a general population measure of the OSI aptitude.

"Conditional Probability" is a Numeracy battery item (Weller et al., 2013). It requires a test taker to determine the probability that a woman who is selected randomly from the population and who tests positive for breast cancer in fact has the disease; to do so, the test taker must appropriately combine information about the population frequency of breast cancer with information about the accuracy rate of the screening test. A problem that assesses facility in drawing the sort of inferences formalized in Bayes's' Theorem, Conditional Probability turns out to be super hard. At the mean level of OSI, there is virtually no chance a person will get this one right. Even someone who scores in the 90th percentile is still more likely to get it wrong than right (Figure 1).

With this form of item-response analysis (Embretson & Reise, 2000), we can do two things. One is identify *invalid* items—ones that don't genuinely measure the underlying disposition in an acceptably discerning manner. We'll recognize an invalid item if the probability of answering it correctly doesn't increase appreciably as the latent disposition measured by the OSI test as a whole increases.

The NSF Indicator's "Evolution" item—"human beings, as we know them today, developed from earlier species of animals, true or false?"—is pretty marginal in that regard. In contrast to the

Divergence on belief questions.

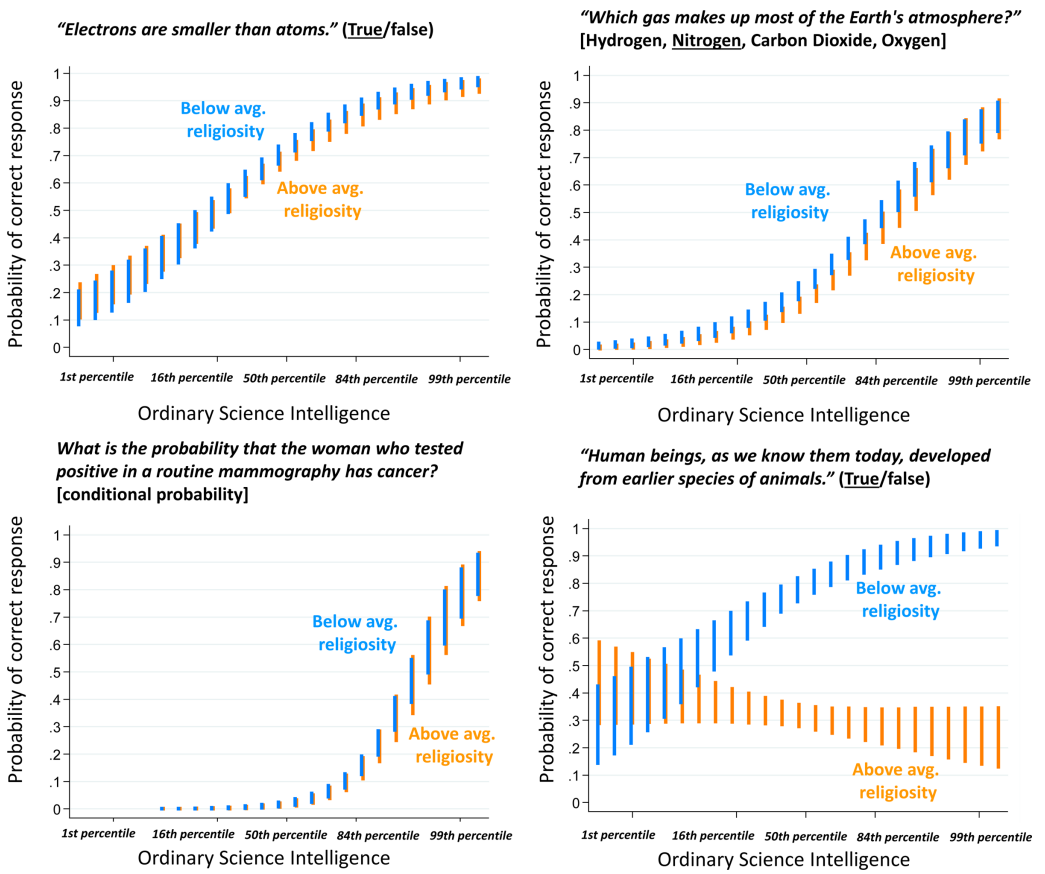

Figure 2. Differential item function curves. Using item-response theory 2PL model, figures plot the predicted probability of correctly responding to the item conditional on score on OSI scale. Predicted probabilities for "Below" and "Above avg. religiosity" determined by setting predictor on religiosity scale at −1 and +1 SD, respectively. Colored bars reflect 0.95 confidence intervals.

person who is merely average in OSI and whose probability of answering Conditional Probability correctly is epsilon.

Under these conditions, one would have to possess a very low OSI score (or a very strong unconscious motivation to *mis*interpret these results [Kahan, Peters, Dawson, & Slovic, 2013]) to conclude that a "belief in evolution" item like the one included in the NSF Indicator battery validly measures science comprehension in a general population sample. It is much more plausible to view it as measuring something else: a form of cultural identity that either does or does not feature religiosity (cf. Roos, 2012).

One way to corroborate this surmise is to administer to a general population sample a variant of the NSF's Evolution item designed to *disentangle* what a person knows about science from *who he or she is* culturally speaking. When the clause, "[a]ccording to the theory of evolution . . ." introduces the proposition "human beings, as we know them today, developed from earlier species of animals" (National Science Foundation, 2006, 2014), the discrepancy between relatively religious and relatively nonreligious test takers disappears! Freed from having to choose between conveying what they understand to be the position of science and making a profession of "belief" that denigrates their identities, religious test takers of varying levels of OSI now respond very closely to how nonreligious ones of corresponding OSI levels do. The profile of the item-response curve—a positive slope in relation to

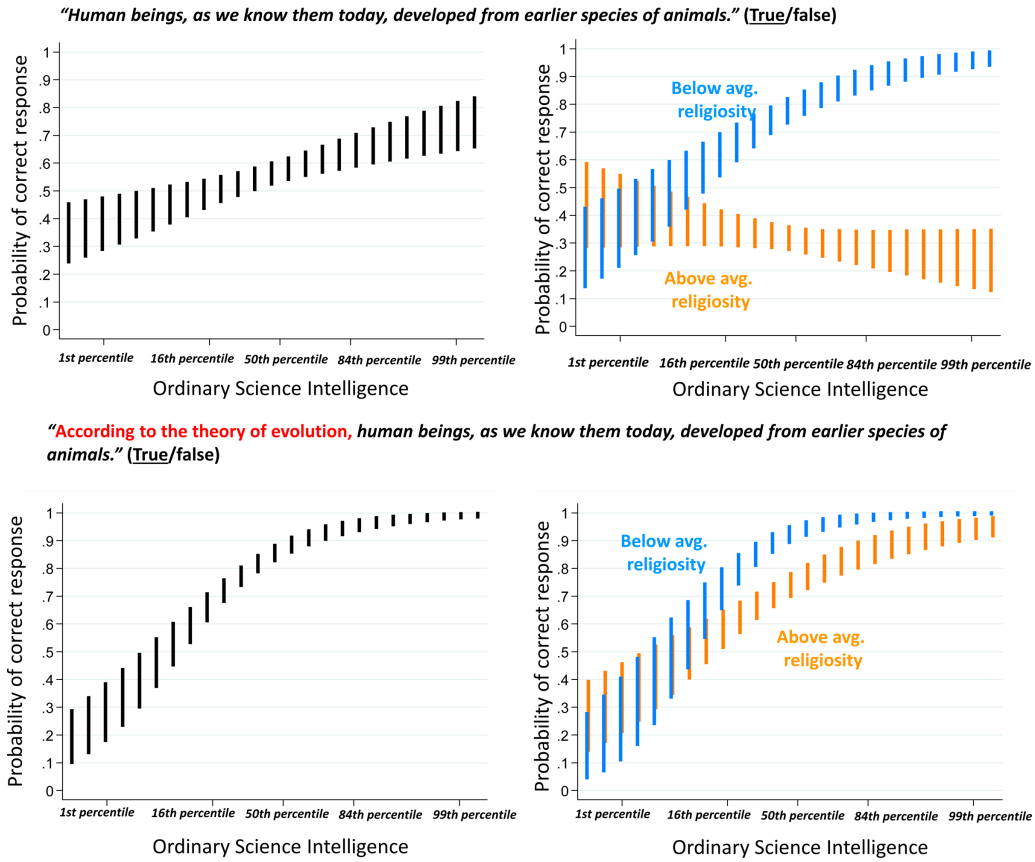

Figure 3. Impact of disentangling identity from knowledge on Evolution item. Using item-response theory 2PL model, figures plot the predicted probability of correctly responding to the item conditional on score on OSI scale. Predicted probabilities for "Below" and "Above avg. religiosity" determined by setting predictor on religiosity scale at −1 and +1 SD, respectively. Colored bars reflect 0.95 confidence intervals.

both—at the very same time. But only when the dualistic quality of their reason as collective-knowledge acquirers and identity protectors is not interfered with by forms of assessment that stray from science comprehension and intrude into the domain of cultural identity and expression. A simple (and simple-minded) test can be expected to force disclosure of only one side of their reason.

What Does "Belief in" Global Warming Measure?

Just as we can use empirical methods to determine that a survey item eliciting "belief in" evolution measures "who one is" rather than "what one knows," so too can we use these methods to assess what an item eliciting "belief in" global warming measures.

An illuminating way to start is by seeing what a valid measure of "belief in" global warming looks like. Figure 4 presents a scatter plot of the responses to a survey item that asked respondents (2,000 members of a nationally representative sample, interviewed in April/May 2014; the same individuals whose OSI results were featured in the last section) to rate "how much risk . . . global warming poses to human health, safety, or prosperity" in "our society." The item, which I'll call the "Industrial Strength Measure" (ISM) (Kahan, 2011), used an 8-point response scale, running from "none at all"

The correlation between politics and climate

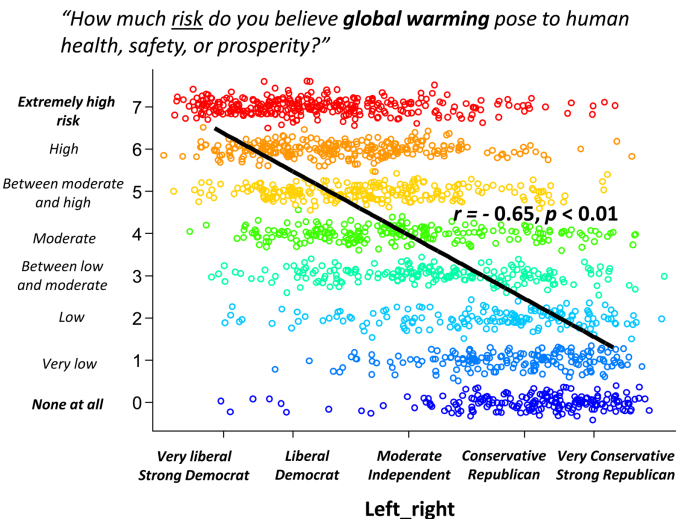

Figure 4. Climate-change risk perceptions. $N = 1{,}751$. *X*-axis is continuous political outlook scale formed by aggregating responses to 7-point party identification item and 5-point "liberal-conservative" ideology item ($\alpha = 0.78$).

to "extremely high risk," with each point in between assigned a descriptive label. The survey participants are arrayed along the y-axis in relation to their score on "Left_Right," a reliable ($\alpha = 0.78$) composite index or scale formed by aggregating their responses to a 7-point "party self-identification" measure ("Strong Republican" to "Strong Democrat") and a 5-point "ideology" one ("Very liberal" to "Very conservative) (Kahan, 2014a). The strong correlation between risk perceptions and political outlooks is highlighted by the dense concentration of observations in the upper left and lower right and by the paucity of them in the lower left and upper right.

Exactly how "strong," though, is that correlation? An "*r*" of "−0.65" might intuitively seem pretty big, but determining its practical significance requires a meaningful benchmark.

As it turns out, subjects' responses to the party self-identification and liberal-conservative ideology items are correlated to almost exactly the same degree ($r = 0.64$, $p < 0.01$). So in this nationally representative sample, perceptions of the risk of global warming are as strongly associated with respondents' right-left political outlooks as the indicators of their political outlooks are with one another.

We could thus combine the global-warming ISM with the party-identification and liberal-conservative ideology items to create an even more reliable political outlook scale ($\alpha = 0.81$), one with which we could predict with even greater accuracy their positions on issues like Obamacare and abortion rights.

The global-warming ISM has another interesting property, one it shares with ISMs for other putative hazards: it coheres very strongly with professed *belief*s about the facts relevant to assessing the specified risk source (Dohmen et al., 2011; Ganzach, Ellis, Pazy, & Ricci-Siag, 2008; Weber, Blais, & Betz, 2002). "Cronbach's α" is a conventional measure of scale reliability that ranges from 0.0 to 1.0; a score of 0.70 is generally regarded as signifying that a set of indicators display the requisite degree of intercorrelation necessary to measure some underlying latent variable. When the global-warming ISM is combined with items measuring whether people believe that "average global temperatures are increasing," that "[h]human activity is causing global temperatures to rise," and that global warming will result in various "bad consequences for human beings" if not "counteracted," the resulting scale has a Cronbach's α of *0.95* (Kahan, 2011). These "belief" items, then, can also be viewed as measuring the *same thing* as the "risk seriousness" item—viz., a latent, one-dimensional (Kahan, 2014a) disposition to form coherent sets of beliefs about the facts and consequences of climate change.

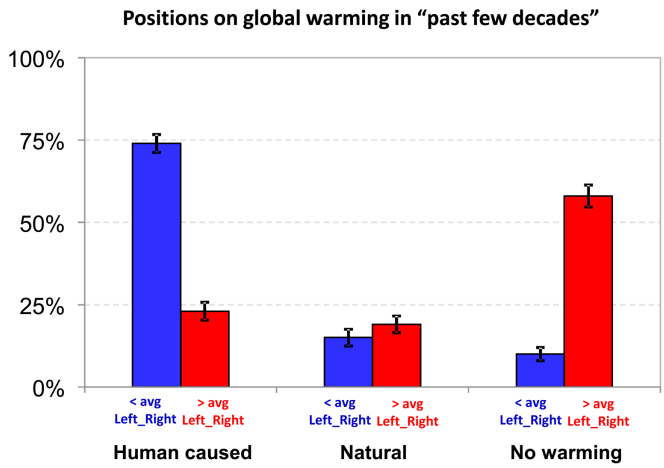

Figure 5. Polarization on facts of global warming. $N = 1{,}769$. Subjects classified in relation to "Left_Right," a continuous political outlook scale formed by aggregating responses to 7-point party-identification item and 5-point "liberal-conservative" ideology item ($\alpha = 0.78$). "Positions" reflect aggregated responses to two questions: first, whether subjects agreed or disagreed that "there [is] solid evidence that the average temperature on earth has been getting warmer over the past few decades"; and if so, second, whether they believed that "the earth is getting warmer mostly because of human activity such as burning fossil fuels" or instead "mostly because of natural patterns in the earth's environment." CIs reflect 0.95 level of confidence for estimated population mean.

Not surprisingly—indeed, as a matter of simple logic—there is a comparably high degree of coherence between "belief in climate change" and political outlooks. In this sample, some 75% of the individuals whose scores placed them below, or to the "left" of, the mean on the Left_Right political outlook scale indicated that they believe human activity is the primary source of global warming. Only 22% of those whose scores placed them to the "right" of the mean indicated that they believed that, and 58% of them indicated that they did not believe there was "solid evidence that the average temperature on earth has been getting warmer over the past few decades" (Figure 5). These figures accord with ones consistently reported by scholars and public opinion research centers for over a decade (e.g., Silver, 2013).

So we could form an even *better* scale ($\alpha = 0.86$)—an even more discerning, one-dimensional measure of the disposition that orients individuals with respect to disputed political issues (Kahan, 2014a)—by simply combining responses to the global-warming ISM, the "belief in" global-warming measure, and the two political outlook items (liberal-conservative ideology and partisan self-identification). From a psychometric perspective, all four of these items can be viewed as measuring the *same thing*: a latent (unobserved) disposition that causes different groups of people to adopt coherent sets of opposing stances on political matters (DeVellis, 2012).

Nevertheless, advocacy groups regularly report polls that paint a very different picture. "A *new* study," their press releases announce, show that "an overwhelming majority of Americans"—"Blue State and Red ones alike," enough "to swing" an upcoming presidential election etc.— "support taking action" immediately to combat global warming. The producers of such polls do not always release information about the survey's wording or the (mysteriously characterized) methods used to analyze them (e.g., Koch, 2013). But when they do, researchers note that the questions posed were likely to confuse, mislead, or herd the survey respondents toward desired answers (Kohut, 2010).

Given the source of these surveys, one could infer that they reflect an advocacy strategy aimed at fostering "overwhelming majority support" for "action on climate change" by insisting that such support already exists. If so, the continued generation of these surveys itself displays determined

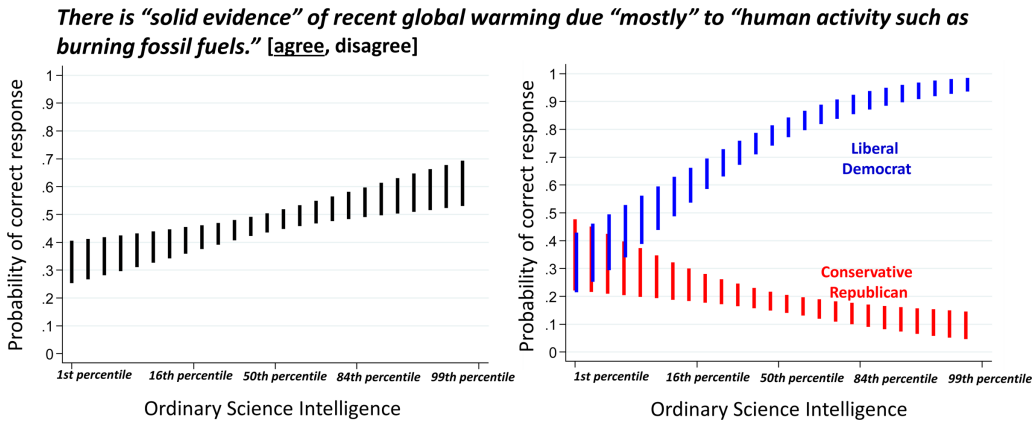

Figure 6. Differential item function: belief in climate change. Using item-response theory 2PL model, figures plot the predicted probability of correctly responding to the item conditional on score on OSI scale. Predicted probabilities for "Liberal Democrat" and "Conservative Republican" determined by setting predictor on Left_Right scale at −1 and +1 SD, respectively. Colored bars reflect 0.95 confidence intervals.

if they indicated both that "there [is] solid evidence that the average temperature on earth has been getting warmer over the past few decades" and that "the earth is getting warmer mostly because of human activity such as burning fossil fuels" as opposed to "mostly because of natural patterns in the earth's environment." As was so for the NSF Indicator version of Evolution, the probability of a correct response was largely unresponsive to differences in the disposition measured by OSI. In addition, the probability of a correct response varied dramatically in relation to political outlooks. At the OSI mean, an individual who identified as "Liberal" and "Democrat" had close to an 80% likelihood of answering the question correctly, whereas one who identified as "Conservative" and "Republican" had under a 20% likelihood of doing so. Indeed, the likelihood of a correct response sloped downward for individuals who were conservative Republicans: at a +1 SD OSI score, the predicted probability of a correct answer was only 13% (± 3%, $LC = 0.95$) for such individuals—as opposed to 90% (± 3%) for liberal Democrats.

Thus, to say there is "no relationship" between science comprehension and belief in climate change would definitely be incorrect. There is a very large one. But the nature of it depends on the test takers' identities. Those whose cultural commitments predispose them to be concerned about climate change become even more so as their level of science comprehension increases. Those whose commitments predispose them to be less concerned become all the more skeptical (Figure 6). Far from increasing the likelihood that individuals will agree that human activity is causing climate change, higher science comprehension just makes the response that a person gives to a "global-warming belief" item an *even more reliable indicator* of who he or she is.

Is Identity-Protective Cognition Irrational?

The idea that "disbelief" in global warming is attributable to low "science literacy" is not the only explanation for public conflict over climate change that fails to survive an encounter with actual evidence. The same is true for the proposition that such controversy is a consequence of "bounded rationality."

Indeed, the "bounded rationality thesis" (BRT) is probably the most popular explanation for public controversy over climate change. Members of the public, BRT stresses, rely on "simplifying heuristics" that reflect the emotional vividness or intensity of their reactions to putative risk sources

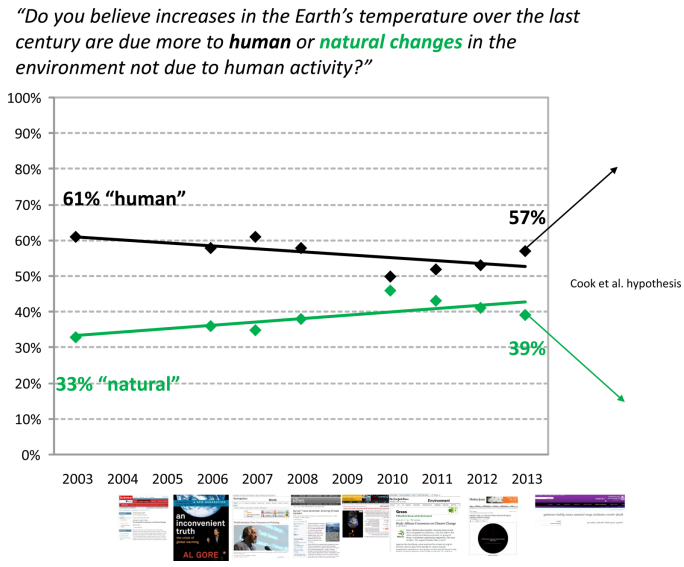

Figure 8. Shift in public opinion in relation to release and publicization of studies quantifying extent of scientific consensus on climate change. Icons on x-axis represent dates of studies quantifying scientific consensus, plus release of the documentary *Inconvenient Truth* and the commencement of the associated social-marketing campaign.

Sciences, the Royal Society, and the IPCC, all of which concluded that human activity is heating the planet. High-profile and massively funded campaigns to dispute and discredit these sources were conducted too. People endured devastating heat waves, wild fires, and hurricanes, punctuated by long periods of weather normality. The Boston Red Sox won their first World Series title in over eight decades.

It would surely be impossible to disentangle all of these and myriad other potential influences on U.S. public opinion on global warming. But one doesn't need to do that to see that whatever the earlier scientific-consensus "messaging" campaigns added to the mix *did not* "clos[e] the consensus gap" (University of Queensland, 2013).

Why, then, might a reflective, realistic person conclude otherwise—and indeed counsel communicators to spend millions of dollars to repeat exactly that sort of "messaging" campaign?

The answer could be laboratory studies. One (Lewendowsky et al., 2012), published in *Nature Climate Change*, reported that the mean level of agreement with the proposition "CO_2 emissions cause climate change" was higher among subjects exposed to a "97% scientific consensus" message than among subjects in a control condition (4.4 vs. 4.0 on a 5-point Likert scale). Immediately after being advised by the experimenter that "97% of scientists" accept CO_2 emissions increase global temperatures, those subjects also formed a higher estimate of the proportion of scientists who believe that (88% vs. 67%).

Is it possible to reconcile this result with the real-world data on the failure of previous "scientific consensus" messaging campaigns to influence U.S. public opinion? The most straightforward explanation would be that the *NCC* experiment was not *externally valid*—i.e., it did not realistically model the real-world dynamics of opinion-formation relevant to the climate change dispute.

The problem is *not* the sample (90 individuals interviewed face-to-face in Perth, Australia). If researchers were to replicate this result using a U.S. general population sample, the inference of external invalidity would be exactly the same.

For "97% consensus" messaging experiments to justify a social marketing campaign featuring studies like the *ERL* one, it has to be reasonable to believe that what investigators are observing in laboratory conditions—ones created specifically for the purpose of measuring opinion—tell us what is likely to happen when communicators emphasize the "97% consensus" message in the real world.

Baseline correct answers on what others believe

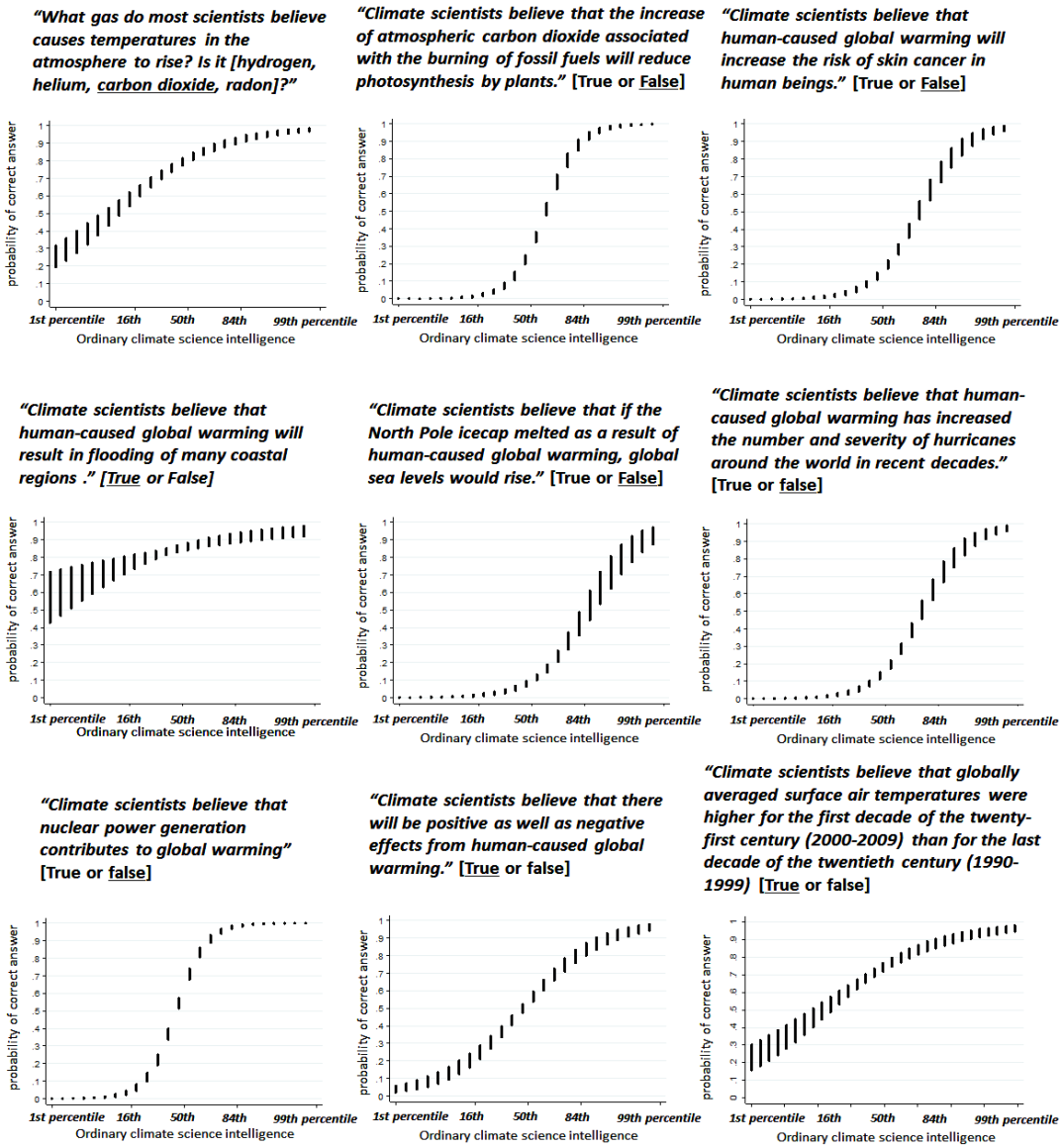

Figure 11. OCSI item-response curves. Using item-response theory 2PL model, figures plot the predicted probability of correctly responding to the item conditional on score on OCSI scale. Black bars denote 0.95 confidence intervals.

give the *incorrect* answer to items such as "human-caused global warming will increase the risk of skin cancer in human beings" ("Cancer") and "the increase of atmospheric carbon dioxide associated with the burning of fossil fuels will reduce with photosynthesis by plants" ("Photosynthesis"). By the same token, those respondents affectively disposed to be skeptical of climate change risks could be expected to supply the correct answer to Cancer and Photosynthesis but the wrong ones to Carbon and Floods. The only respondents one would expect to be likely to answer all four correctly are ones who know and are disposed to give the correct response independent of their affective orientations.

The aim of disentangling (unconfounding) affective orientation and knowledge was complimented by a more general assessment-construction tenet, which counsels use of items that feature incorrect responses that are likely to seem *correct* to those who do not genuinely possess the

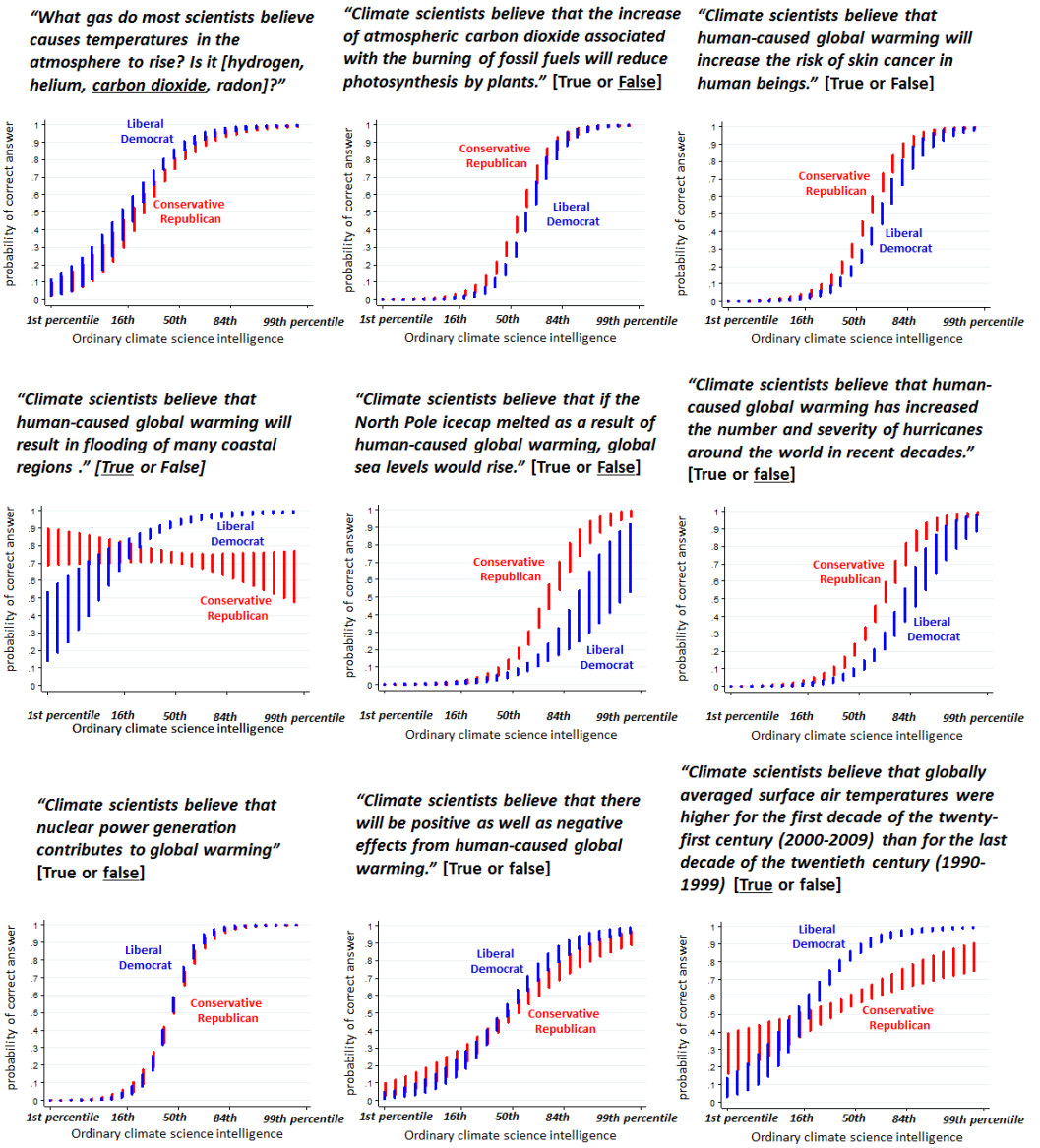

Figure 15. Differential item function: belief in climate change. Using item-response theory 2PL model, figures plot the predicted probability of correctly responding to the item conditional on score on OCSI scale. Predicted probabilities for "Liberal Democrat" and "Conservative Republican" determined by setting predictor on Left_Right scale at −1 and +1 SD, respectively. Bars reflect 0.95 confidence intervals.

These results cast an entirely different light on studies finding that citizens of opposing cultural and political outlooks have different beliefs about "scientific consensus" on climate change. They do, but only when the question that they are answering measures *who they are*. Not surprisingly, people refuse to take the bait when asked whether they and those they are closely aligned with should be viewed as cretins. That *is* the question being put to people by the "consensus" messaging "Pop Quiz," whether it is administered in a typical opinion survey on climate change "beliefs" or in a political communication. But if the question is put in a manner that disentangles identity and knowledge, there is no "consensus gap" between scientists and the public. There is no "misunderstanding" to be

Other controversial issues have different politics.

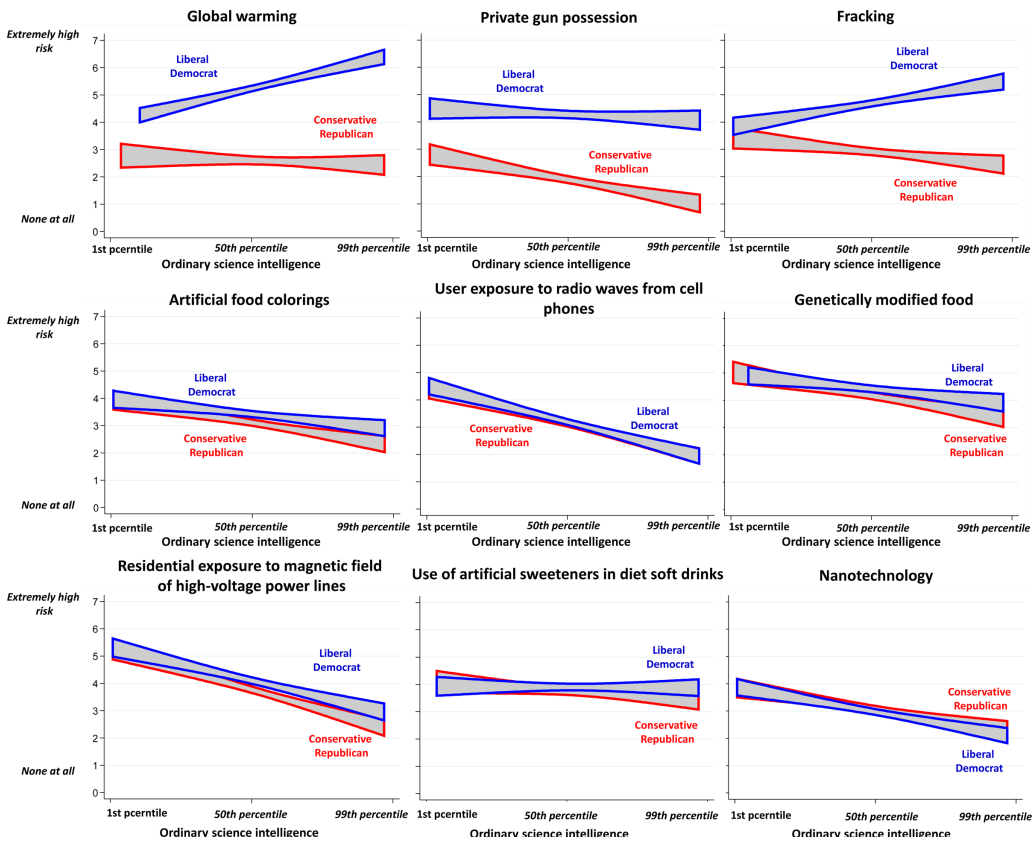

Figure 17. OSI and political polarization on risk perception. $N \approx 1800$.

former have in common without examining whether those same characteristics are or are not present in the latter.

The proposition that the public is divided on global warming because its members do not know or comprehend enough basic climate science fails spectacularly when tested in relation to the relevant class of risk issues. Members of the public do not know more about the impact of cell-phone radiation than nuclear radiation. The reason there is conflict on climate change but not raw milk is not that biologists have done a better job explaining pasteurization than climate scientists have done articulating the greenhouse effect. Members of the public would do no better in a "science assessment" geared to these issues than they did on the OCSI test.

There's nothing either surprising or alarming about that either. To live well—in order just to live, really—one has to accept as known by science much more than one can possibly comprehend or verify for oneself. The sort of expertise—the kind of ordinary science intelligence—that is necessary, then, consists in being able reliably to *identify* who knows what about what (Keil, 2003; Yetton & Bottger, 1982). Around 50% of Americans think that antibiotics kill viruses and not just bacteria (NSF, 2014); that doesn't adversely affect their health, because only a miniscule percentage thinks one should do something other than go to the *doctor* when one is ill and takes the medicine she prescribes.

The "science communication environment" can be thought of as the sum total of cues and signs that people reliably make use of to orient themselves properly with respect to collective knowledge (Kahan, 2012). By far the most important component of the science communication environment

People, of all cultural outlooks, trust scientists and are eager to make use of what science knows to improve their lives (National Science Foundation, 2013; Pew Research Center, 2009). But the people whose orienting influence they need to observe are *not* scientists. They are the people in their everyday lives whose guiding example ordinary members of the public use to figure out *what* evidence of scientific belief they should credit and which they should dismiss.

The communication of normal science, *by scientists*, is vital to practical decision makers—from insurance agents to farmers, from investment brokers to military leaders. But what needs to be communicated to ordinary members of the public, in their capacity as citizens, is the *normality* of using climate science. And they have to communicate that *to themselves*.

Or so one might *conjecture* based on an assessment of the relevant sample of cases in which the members of a highly pluralistic society do and don't converge on what is known to science. It is one that further investigation of which, moreover, is very much warranted by the evidence of its correctness that we already have in hand.

3. The "normality" of climate science in Southeast Florida. Southeast Florida is not Berkeley, Cali-fornia, or Cambridge, Massachusetts. The political climate of Southeast Florida, for one thing, differs at least as much from the political climate that Berkeley and Cambridge share as the natural climate of Southeast Florida differs from the natural climate of either of these cities. Unlike these homoge-nously left-leaning communities, Miami-Dade, Broward, Palm Beach, and Monroe counties are politi-cally conventional and diverse, with federal congressional delegations, county commissions, and city governments occupied by comparable proportions of Republicans and Democrats.

Indeed, by one measure of "who they are," the residents of these four counties look a *lot* like the United States as a whole. There is the same tight connection between how people identify themselves politically and their "beliefs" about global warming—and hence the same deep polarization on that issue. Just as in the rest of the United States, moreover, the degree of polarization is highest among the residents who display the highest level of science literacy (Figure 18).

But like Berkeley and Cambridge—and unlike most other places in the United States—these four counties have formally adopted *climate action plans*. Or more precisely, they have each ratified a joint plan as members of the Southeast Florida Regional Climate Change Compact. Unlike the largely hortatory declarations enacted by one or another university town, the Compact's Regional Climate Action Plan sets out 110 substantive "action items" to be implemented over a five-year period.[4]

Many of these, understandably, are geared to protecting the region from anticipated threats. The Plan goals include construction of protective barriers for hospitals, power-generating facilities, and other key elements of infrastructure threatened by rising sea levels and storm surges; the enactment of building codes to assure that existing and new structures are fortified against severe weather; measures to protect water sources essential both for residential use and for agriculture and other local businesses.

But included too are a variety of measures designed to mitigate the contribution the four counties make to climate change. The Plan thus calls for increased availability of public transportation, the implementation of energy-efficiency standards, and the adoption of a "green rating" system to constrain carbon emissions associated with construction and other public works.

The effects of the member counties' climate mitigation efforts will be admittedly modest—indeed, wholly immaterial in relation to the dynamics at work in global climate change. But they mean something; they are part of the package of collective initiatives identified as worthy of being pursued by the city planners, business groups, and resident associations—by the conservation organizations, civic associations, and religious groups—who all took part in the public and highly participatory process that generated the Plan.

[4] I am a member of the research team associated with the Southeast Florida Evidence-based Science Communication Initiative, which supplies evidence-based science-communication support for the Compact.

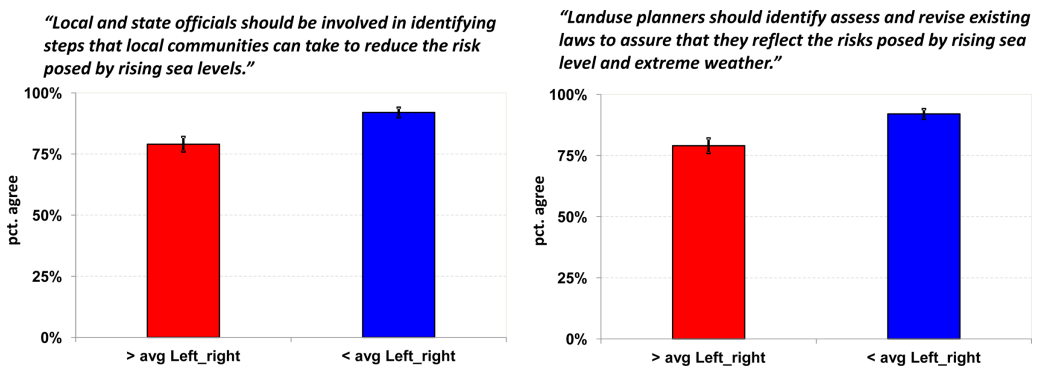

Figure 19. Bipartisan support for government action on climate. $N = 1478$. Broward, Miami-Dade, Palm Beach, and Monroe Counties. Data collected by the Southeast Florida Evidence-Based Science Communication Initiative, September 2013.

That's *normal*. It's what government is supposed to do in Southeast Florida. And it better be sure to pick up the garbage every Wednesday, too, their citizens (Republican and Democrat) would add.

The Compact effectively informed its citizens of the appropriateness of using the best available science for these ends but not through a "messaging" campaign focused on "scientific consensus" or anything else. The Compact's "communication strategy" *was its process*. The dozens of open meetings and forums, convened not just by the Compact governments but by business, residential, and other groups in civil society filled the region's science-communication environment with *exactly* the information that ordinary people rationally rely on to discern what's known to science: the conspicuous example of people they trust and recognize as socially competent supporting the *use* of science in decision making directly bearing on their lives.

Indeed, far from evoking the toxic aura of tribal contempt that pervades "messaging" campaigns ("what? Are you stupid? What part of '97% AGREE!' don't you understand?!"), Compact officials aggressively, instinctively repel it whenever it threatens to contaminate the region's deliberations. One of those occasions occurred during a heavily attended "town meeting," conducted in connection with the Compact's 2013 "Regional Climate Leadership Summit," a two-day series of presentations and workshops involving both government officials and representatives of key public stakeholder groups.

The moderator for the town meeting (a public radio personality who had just moved to Southeast Florida from Chicago) persistently tried to inject the stock themes of the national climate-change debate into the discussion as the public officials on stage took turns answering questions from the audience. What do Republicans in Washington have against science, the moderated asked? And what "about the level of evidence that's being accepted by private industry"—how come *it's* doing so little to address climate change?

After an awkward pause, Broward County's Democratic Mayor Kristin Jacobs replied. "I think it's important to note," she said, gesturing to a banner adorned by a variety of corporate logos, "that one of the sponsors of this Summit today is the Broward Workshop. The Broward Workshop represents 100 of the largest businesses in Broward County." The owners of these businesses, she continued, were "not only sponsoring this Summit," but actively participating in it and had organized their own working groups "addressing the impacts of water and climate change." "They know what's happening here," she said to the moderator, who at this point was averting his gaze and fumbling with his notes.

"I would also point out," Jacobs persisted, "when you look across this region at the Summit partners, the Summit Counties, there are three Mayors that are Republican and one that's Democrat, and