**Understanding Attitudes towards Scientific Expertise**

**Across a Wide-Range of Policy Areas**

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**Abstract**

Recent debates over vaccinations, climate change, and the use of fracking technology to exploit shale oil reserves highlight the sometimes-controversial role of science in shaping public policy. We examine how political and contextual factors influence the willingness of citizens to accept scientific recommendations on policy issues. Using data from a large national survey on a wide-range of issues, we examine whether deference towards scientific expertise in policy discussions is influenced by (1) perceptions of scientific bias, and (2) other sources of opinion, such as religious authority and attitudes towards government efficacy. The data show that attitudes towards science and scientists vary only somewhat by topic, and that ideology and religious attitudes have a major impact on willingness to defer to scientists on public policy.

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**Introduction**

 For much of U.S. history, a belief in the efficacy of science has been pervasive among our governing elites: Thomas Jefferson committed to the “Corps of Discovery’s” exploration of the Missouri River; Abraham Lincoln believed in the engineers who argued that a transcontinental railroad could be built; Theodore Roosevelt trusted that a canal could be dug across the Panama isthmus; John Kennedy challenged the nation’s nascent space industry to place a man on the moon.[[1]](#footnote-1) Moreover, this trust in science is not simply an elite phenomenon; there is also evidence of this trust among the masses, binding together people who otherwise had little in common when it comes to their policy preferences (Yearley 1994). Thus, a pro-science belief system, with roots in the intellectual and epistemological tradition of the Enlightenment, has been a consistent characteristic of mass politics in America (Luhmann 1979). Perhaps equally important, this belief system has tended to exalt scientific expertise, in turn allowing a variety of public policies to form at least partially shielded from the hot-house of partisan politics (Parsons 1962; Barber 1952, 1975).

 Recently, however, scientific recommendations on specific issues, as well as the nature and origins of mass attitudes towards science, have become matters of intense debate (Gauchat 2012; Mooney 2005). Between 2010 and 2015, public dialogues on issues such as vaccinations, climate change, evolution, nuclear power, and gun violence have (unsurprisingly) directly involved scientific testimony. Less expected—though certainly well-documented—has been the fall-out over the presentation of that scientific evidence; those holding positions unsupported by this evidence have called into question the credentials, motives, and biases of scientists, while those with positions supported by science have called into question the native intelligence of their opponents (Mooney 2005; Gross et al. 2011; Oreskes and Conway 2010). Furthermore, these reactions have had a decidedly partisan and ideological bent, even as the role of these factors in shaping attitudes towards science is not well understood. We are well-aware that anti-intellectualism has been a durable feature of the American ethos (Hofstadter, 1962); still, one cannot help but be struck by the recent evidence that many have turned away from the conviction that science is synonymous with progress and that scientific expertise can transcend petty partisan debates. If true, this would represent an important change in the conduct and content of public policy deliberations.

 But is it true? To what extent are Americans willing to defer to scientific expertise on policy matters? And what explains the relative willingness or reluctance to do so? In this paper we offer both a general as well as a more specific analytical take on the interplay among the public, scientists, and policy-makers. At the most general level, we examine whether and how demographics and attitudes affect opinions about scientists and science. We suspect that reticence towards scientific recommendations and a belief that scientists are biased is due to a combination of religious beliefs and skepticism towards government and academics. From this perspective, the role of political attitudes—party identification and ideology—is potentially important, but is likely to be conditional upon other factors.

More specifically, we explore deference towards scientific expertise across a wide range of particular public policies. Here we expect deference to vary by the issue in question. As with the more general analysis, we also expect that scientific deference on specific policies is likely correlated with demographics (such as age, education, and race), religiosity, and political attitudes.

In engaging these questions, our method is straight-forward: we collect a representative sample from which we can assess the relationships between and amongst critical variables. Our data are original and (we think) singularly appropriate, as we rely on our own U.S. national survey of 2,000 registered voters. Somewhat surprisingly, we find that although opinions towards science vary across issues, they reflect a single attitudinal dimension. We also find support for the proposition that deference towards scientific advice on policy matters is strongly correlated with both religious and political attitudes, as well as broader perspectives on scientists and bias.

**What We Know (and Don’t Know) about Attitudes towards Science and Public Policy**

A Quick Review of the Facts

 Since the advent of survey research in the 1930s and 40s, there has been a fair amount of survey research investigating public opinion on science. Beginning in the 1950s, the Gallup Organization has periodically asked questions about scientific progress. In addition, surveys conducted by the Pew Charitable Foundation have queried representative samples of the scientific community and the public to compare their views on issues such as evolution and nuclear power. Beyond these, dozens of “one-time” independent polls have provided data shedding light on public attitudes about scientists and their role in public debates. But the mother-lode for research on mass attitudes towards science and scientists resides in the General Social Survey, which since 1972 has asked batteries of items on scientific knowledge, attitudes towards science and scientists, and, occasionally, opinions on controversial scientific issues.

 At the risk of over-simplifying the results, these surveys provide several important insights about science and politics. First, Americans tend to hold scientists in high regard. They are much more favorable than unfavorable towards them as a group. A related but distinct fact is that most Americans profess a belief in objective research, the scientific method, and the notion that science promotes human progress. These attitudes seem to be shaped by the cultural achievements of science; namely, the eradication of many diseases, improvements in agriculture, the rise of industry, the harnessing of diverse sources of energy, and awe-inspiring changes in the speed and scope of transportation (Barber 1990). These achievements have not only influenced public opinion in a positive way, they have also paved the way for the rise of secular institutions that embrace scientism and its core notions of objectivity and empiricism (Parsons 1962; Barber 1952, 1975, 1990). Indeed, some academics (and more than a few ordinary citizens) believe that scientific progress and technological innovation is critical to modernity itself.

Despite this high regard for scientists and their approach, another relevant finding is that Americans do not necessarily know what scientists know when it comes to policy matters (Gauchat 2008). Examples of public “ignorance” about basic scientific knowledge is common and need not be re-stated here, although we are partial to a recent Texas poll that found close to one-third of those surveyed believing that dinosaurs and humans walked the earth together.[[2]](#footnote-2) To explain this lack of knowledge, scholars have focused on education, and how additional years of schooling results in increasingly positive feelings towards science (Allum et al. 2008; Gauchat 2008, 2010). This is part and parcel of the so-called “deficit model.”

There are some problems with the deficit model, however. Although the model can be maintained in cross-national studies, scientific literacy and levels of education do not convincingly predict attitudes toward specific scientific controversies in the U.S. Furthermore, it is unclear whether, in the U.S., rising levels of education have led to greater trust in science over-time (Miller 2004). But perhaps the primary criticism of the deficit model, from our perspective, is that it does not account for the distinct cultural (and other) perspectives of sub-groups, nor does it appreciate how these perspectives might influence the relationship between individuals and social institutions (Gauchat 2012).

This last observation leads directly to a final facet of public attitudes towards science and scientists: there are important differences among particular sub-groups. Many studies show that trust in science is affected by a range of factors, such as race/ethnicity, income, religiosity, social capital, and political identifications (Gauchat 2008, 2010; Sturgis and Allum 2004; Yearley 2005). In addition, there is some evidence that while aggregate levels of support for scientists and science remains quite high, support among certain sub-groups has diminished over time. Most intriguing is the contention that support amongst political conservatives has diminished since the 1980s (Mooney 2005; Gauchat 2012).

Gaps in our Knowledge

Despite some impressive research characterizing the nature of mass opinion towards scientists and science, there are several notable deficiencies. Perhaps most limiting, the lion’s share of studies has focused on attitudes towards scientists and science generally, or else on a single policy issue. There are precious few studies that examine whether and how opinions towards science might vary by issue, or whether different factors found to correlate with skepticism towards science become operative depending on the issue under examination. We intend to fill this gap with a study examining attitudes towards scientific expertise across a truly wide-range of public policy areas in which science might be expected to provide counsel.

 A related deficiency of previous research is that few have identified and tested a satisfactory range of explanatory variables. Some examine the role of age and education; others economic self-interest or religious faith; still others ideology or partisanship. But we have yet to locate a study that tests the relative power of these plausible correlates across a range of policy issues.

 Then there is the matter of theoretical depth. As noted earlier, demographic and attitudinal factors presumably affect more general opinions towards science, scientists, and public policy. Yet few studies offer instrumentation on these attitudes in addition to their measures of specific issue opinions. More broadly, research on public support for science has yet to address sociological issues relating to group change over time and has insufficiently identified how ideological dispositions influence public attitudes irrespective of education.[[3]](#footnote-3)

 As a consequence of these deficiencies, we have been left with insufficient data from which to directly develop a more comprehensive theory of public attitudes towards science. But there are clues, both in the existing studies and in related research, that allow us to develop an inferential theory. Let us now turn to that theory, first focusing on how citizens develop attitudes towards science, and then on how they come to see science’s role in public policy debates. Here, we emphasize the following forces that shape these attitudes: socialization, rational self-interest, elite cues, and political ideology.

**Towards a Theory of Science Attitudes**

Socialization

Probably the most obvious force shaping attitudes towards science is socialization. People learn how to think about science (like other attitude objects) from exposure to family, friends, and peer groups, whose influence on attitudes has been copiously documented (see, for example, Campbell, et al. 1960). It is our expectation that socialization, as measured by a citizen’s educational and religious background, will have a powerful effect on how she views science.

Following the logic of the “deficit model,” we assume that more formal education is likely associated with an internalized knowledge of (and respect for) science and the scientific method (Bak 2001; Allum et al. 2008; Gauchat 2008). Teachers and professors emphasize the value of rigorous thinking and empirical evidence. Students are likely to come away from the classroom holding science in esteem and seeing how its application can inform and improve public policy. Conversely, those with relatively less formal education are in turn less likely to internalize (let alone defer to) the connection between science and scientists’ policy prescriptions.

 In contrast to the more highly educated, we assume that those who are more religiously observant are less likely to defer to science (Gauchat 2008, 2010; Sturgis and Allum 2004; Yearley 2005). Those with strong religious backgrounds are socialized to regard faith as a legitimate means of interpreting the world. However, it is not necessarily the case that religion is antithetical to science. Rather, clergy and ministers teach their followers that religious doctrine in conjunction with faith is instructive in its own right. The less religiously observant might also have an ethical or value system that challenges a purely scientific viewpoint, but this seems less likely – or, at least, unsystematic. It is also possible that for some appreciable portion of the religious, their attitudes towards science cluster mainly around the high profile “battle” between science and faith over the origins of man. From the Scopes Trial to present day conflicts over the teaching of evolution in schools, the religious may have generalized a perception of scientific hostility towards people of faith on the matter of evolution to a broader range of issues. This generalization seems likely to have developed early in a person’s life, when lessons about evolution, and alternative theories, are most likely to have been first encountered, and then reinforced over time.

Rational Self-Interest

 A second force that may affect attitudes towards science and policy is what we call “rational self-interest.” For example, a coal worker whose income and benefits depend on the economic viability of the industry has considerable motivation to be skeptical towards scientific research whose conclusions promote policies or regulations that favor the abandonment or significant curtailment of coal production. This policy disagreement could be narrowly construed, or it could result in a broader skepticism towards scientists.

 As a practical matter, however, we do not focus on self-interest as an explanation for science attitudes. For us, the main impediment is measurement. Identifying the self-interest of an individual respondent requires dedicated and extensive instrumentation that we could not achieve here. Of course, it is possible that rational self-interest could be thought of more broadly, such that those who benefit from “pro-growth” or “pro-business” policies are skeptical towards scientists and science research that promotes government regulation. But our preliminary analyses showed that income and class had little influence on science attitudes, and so we dropped these measures from our final estimates.

Elite Opinion

 Beyond these socializing and self-interested forces, elite opinion constitutes a third input influencing the attitudes of fully mature citizens towards science and the role of scientific opinion on public policy matters. Indeed, on most politically relevant issues, elite communications are the *sine qua non* of mass opinions (Converse 1964; Zaller 1992). More specifically, we know that when it comes to evaluating public policy, cues from political and social elites help citizens form their own preferences, especially when the issue is of little importance to that individual (Carsey and Layman 2006).[[4]](#footnote-4)

 What’s more, there is reason to believe that these cues have been less uniformly positive in recent years. Some researchers have pointed out that the ascendancy of science and its prevalence within policy-making institutions has made it a target for those anxious about the accumulation of power (Barber 1990; Merton 1938; Parsons 1962). Others have observed that the very foundations of critical scientific thought works to undermine the credibility of science. And as the core notions of empiricism and uncertainty spread amongst political and cultural elites, and as original research is more widely disseminated, some of these elites are likely to question policy prescriptions based on limited, time-bound data. This skepticism is especially likely as people begin to hold science accountable for the negative consequences of modernization, such as toxic waste, nuclear disasters, food contamination, and climate change (Beck 1992). Finally, any crack in the elite consensus is almost certain to be broadcasted. Those seeking to publicize their skepticism and grievances have the luxury of accessing a digital communication system that is infinitely more open to minority viewpoints than 25 years ago.

Political Ideology

The final factor that we presume to be important for understanding attitudes towards science and policy is political ideology. This presumption is largely based upon recent research. For example, a 2012 study documented a decline in the favorability rating of “scientists” in the General Social Survey from 1974 to 2010—a decline that appears to be driven mostly by changes in the evaluations of self-identified conservatives (Gauchat 2012). Another study found that when subjects are presented with findings on political and non-political topics, conservatives were more likely to attribute liberal findings to the liberalism of the researcher than liberals were to attribute conservative findings to the conservatism of the researcher (MacCoun and Paletz 2009). Based on these and related research, we may be seeing the activation of the conflict between scientific calls for federal government action and conservative skepticism about the efficacy of such attempts (Gaucaht 2012; Mooney 2005).[[5]](#footnote-5)

There is some research indicating that liberal ideology can produce anti-science attitudes, at least on issues such as genetic modification of foods, nuclear power, or vaccinations. We are open to this possibility. Indeed, such a finding would even be expected from a certain theoretical perspective: liberals, more than conservatives, should be sympathetic to humanistic and cultural factors when considering policy options, and should also be anxious about the ascendancy of technology and a blanket application of quantitative methodologies. Still, we expect anxiety about science to be more pronounced on the right than on the left.

On the subject of ideology and science, two points merit both articulation and elaboration. The first of these is that ideology has several possible meanings and we need to be clear with respect to which of these we are adopting. Some political scientists, for example, view ideology as synonymous with attitudinal constraint (e.g., Converse 1964). Other researchers view ideology as a summation of opinions across different issue domains (e.g., Jessee 2010). Another view—the one we are using here—is that ideology is a self-reported identity. That is, one is a “liberal” if one identifies as such to a survey researcher. Our view is common—for example, Gauchat (2012) and Mooney (2005) use this conceptualization in their recent studies of science attitudes and ideology—but still needs acknowledgment.

The other point we wish to raise with respect to ideology is that it is not the same thing as party identification. This is true theoretically, but also empirically. According to the American National Election Study in 2008, 51 percent of Americans identified as “Democratic” compared to 38 percent who identified as “Republican.”[[6]](#footnote-6) In that same poll, 22 percent identified as “liberals,” compared to 32 percent who identified as “conservatives.” In a simple regression, ideological identification explains roughly one-third (34 percent) of the overall variance in party identification.[[7]](#footnote-7)

What about Party Identification?

The debate about the role of science and public policy has spawned a side debate about the extent to which either Republicans or Democrats are “anti-science.” Of course we intend to measure this possibility empirically, but we think it unlikely that one party or the other will show a discernible anti-science tendency. In our view, the link between party identification and science attitudes is complex and conditional. Consistent with our previous discussion of socialization, one might posit that one party or the other is less likely to have been socialized to accept the value of science. We find this somewhat dubious. To socialize the many diverse, and at times changing, elements of either major party across multiple generations about an arguably apolitical attitude would be a spectacular feat of elite communication and organization – with, at best, an unclear goal. Since the notion that anti-science attitudes have a partisan bent has only recently emerged, it’s hard to understand how a multi-generation socialization process could manifest itself so suddenly.

More likely, partisans might engage in “motivated reasoning,” seeking out arguments or pieces of information that counter what they see as scientific policy recommendations that are inconsistent with their preferences (Lodge and Tabor 2000; Redlawsk, Civittini, and Emmerson 2010).[[8]](#footnote-8) This “over-riding” information could be a particular scientist’s ideology or partisan identification, or that partisans of the “other side” support a particular policy recommendation – each factor outweighing the policy recommendation of the scientist. Notice, then, that from this viewpoint, any partisan connection to anti-science sentiment is less about world-view (though this could be relevant) and more about questioning the partisan motives and objectivity of scientists. In other words, motivated reasoning may lead some partisans to discount the recommendations of scientists because of their association with the other party, while some partisans on the other side may find this association comforting in the absence of a true understanding of the policy trade-offs at play (Sniderman et al. 1991).

**Research Hypotheses**

We suspect that some citizens are going to be conflicted when scientists advocate an issue position that contradicts their religious values, self-interest, or political ideology. The more science challenges these other cognitive structures, the more intense the push-back will be. This expectation squares with a series of recent studies showing that moral beliefs and (to a lesser degree) political ideology influence people’s judgments of facts. These studies also discovered that these modest tendencies for distortion are strongest among people who (1) held strong moral convictions, (2) considered themselves most informed, and (3) were conservatives. We would note that this last finding was quite modest, so that even if conservatives’ views of science are a bit more distorted than liberals, there was ample distortion to go around.

As suggested above, we also think it is critical that the rise of 24/7 cable news, politically driven news websites, and the blogosphere has created a multitude of accessible means for skeptical (and even accusatory) viewpoints to find a public audience. Indeed, the pervasiveness of media and internet outlets available today means that push-back is almost certain to occur and to receive lots of attention, especially on issues where science crosses swords with religious faith or political ideology.

Of course, we do not wish to appear to believe that time began with the invention of the Internet: U.S. history offers dozens of examples of science being met with forceful push-backs. Besides, the number of issues on which (a) science has a strong, well-known position and (b) this position contradicts the position derived from other value systems seems limited, even in today’s hyper-polarized political world. In light of all this, we doubt the overall status of scientists has taken too much of a hit.

From these assumptions, we derive a small set of specific research hypotheses. Let us begin with a simple expectation about the relevance of science in different policy areas.

***H1: Attitudes towards science will be multi-dimensional.***

 It seems likely that on some issues resistance to science may be driven by religious beliefs, while on others education may be a powerful correlate, while on still others ideology may be determinative. At any rate, we would be mildly surprised if attitudes were effectively captured by a single summary dimension or factor. We say “mildly” because we do expect general attitudes towards scientific research to be a factor across all policy issues.

***H2: People will be more likely to defer to scientific expertise in narrower, more technical policy areas. They will be less likely to defer in policy areas involving ethical, humanistic, or ideological considerations.***

Since there are very few studies that examine opinions towards science across a wide range of political issues, this expectation is driven purely by theory. Some public policies are directly connected to science and scientific inquiry, and mass opinion could reasonably be expected to pick up on this. Moreover, those opposing scientific recommendations on these issues would probably have to engage in a debate on the technical aspects of science, which is relatively difficult. Other policies revolve around more esoteric issues that are less amenable to experimental or other forms of empirical research. These are likely to engender more skepticism and less deference. This leads directly to a third hypothesis:

***H3: In the face of scientific opinion on a policy issue, the most powerful and salient alternative sources of attitudes will be religious faith and political ideology.***

For our purposes, the key factor explaining anti-science attitudes is not necessarily the inherent relevance of science in developing and assessing public policy on a given issue. Rather, it is whether or not other policy cues are available. For example, we expect that religious adherents will be less deferential to science on issues involving ethics and faith. We also expect political ideology to matter, especially on issues where scientific consensus supports substantive regulation or expansive government intervention. The process by which the dissent occurs is straightforward: to reconcile their existing beliefs with contradictory scientific evidence or recommendations, some people engage in motivated reasoning and readily accept critiques of scientific methods or scientific objectivity.

***H4: Years of schooling will correlate with greater willingness to defer to science on policy matters, all things being equal.***

In spite of the mixed evidence for the “deficit model,” in general we expect those who have been exposed to significant formal schooling to be more likely to have knowledge of the scientific process and respect for scientific findings than others.

**Research Design**

 To assess attitudes towards science, we commissioned the company YouGov to administer a U.S. national survey.[[9]](#footnote-9) From October 24-31, 2013, 2,000 registered voters were interviewed online about their attitudes towards science and politics. For present purposes, three batteries of questions are relevant. The first battery begins by posing the following frame:

*“Some people think that our elected officials and policy-makers should follow the advice of scientists on many issues. Others think that scientists are often either biased or wrong on many issues. For each of the following issues, please use a 0-10 scale to indicate how much politicians and public officials should defer to scientists: 10 means to follow scientific advice completely, 0 means to ignore scientific advice, and 5 means to weight it equally with other factors.”*

We then presented participants with a randomized list of sixteen policy areas including: AIDS prevention, mandatory vaccinations, nuclear power, childhood obesity, birth control, stem cell research, mandatory background checks for gun owners, fetal viability, global warming, the regulation of coal, bio-tech foods, legalizing drug use, animal testing, evolution, mandatory health insurance, and gay adoption.

After experimenting with a similar but more general issue battery in an earlier study,[[10]](#footnote-10) for the present survey we sought to identify discrete policy concepts (for example, we dropped the overly broad “health care” item that ran in the earlier study in favor of “mandatory health insurance”). We also attempted to identify a range of policy items that varied on (a) the expected degree of government action and (b) the potential reactions along ethical and/or partisan lines. For example, we included not just “evolution” and “global warming” (which arguably induce skepticism towards science among the right), but also “vaccines” and “fetus viability” (which arguably induce skepticism towards science among the left). We will elaborate further on the potential dimensionalities of the policy battery, but wish to emphasize that the goal of this battery is breadth. This research improves dramatically upon previous studies, which largely concentrate on a single issue or lack a sufficient range of issues to generalize about the nature and power of partisan variables compared to other explanations of attitudes.

 The second battery of questions asks respondents to assess science and scientists, both on their own terms as well as in relation to other potential belief systems. We asked respondents for their level of agreement (on a 0-3 scale) with the following statements:

* *“Most of the time, instinct and gut reactions are just as good as the advice of scientists.”*
* *“Faith is a better guide than scientific evidence on most important questions.”*
* *“When faced with a difficult decision, politicians should follow the advice of relevant experts, even if it means going against their ideology.”* ***(Reverse Coded)***
* *“Scientists and academics are not hostile to people of faith.”* ***(Reverse Coded)***
* *“Scientists and academics are not concerned about the moral implications of their research.”*
* *“Industry-backed scientific research is inherently biased.”*
* *“Most university professors are liberals who are trying to push an ideological agenda with their research.”*
* *“Most economists are conservatives who are trying to push an ideological agenda with their research.”*
* *“Most scientists are liberals who are trying to push an ideological agenda with their research.”*

Notice that the first three questions ask respondents to assess the relative usefulness of non-scientific belief systems, whereas the other six items ask about perceptions of scientific bias. The first three items thus provide a broad, theoretical measure of the respondent’s openness to alternative belief systems that should predict skepticism towards science on particular issues. The latter six items provide us with a measure of motivated reasoning that should also predict skepticism towards science on particular issues. It is, of course, possible that responses to these different items will reflect a single broad attitude, that of skepticism towards science and scientists. Either way, we wish to develop a measure (or measures) that we can use to assess the conditional impact of global attitudes towards science on one’s willingness to defer to scientific recommendations on specific policy areas.

The third and final battery of questions asks respondents about their political attitudes and demographic characteristics. In particular, we ask people about their ideological orientation, party identification, age, education, race and ethnicity, church attendance, and their view on whether the Bible is the literal word of God. In addition, we also examined people’s level of scientific knowledge with a battery of questions borrowed from the Pew Research Center’s “Science and Technology Knowledge Quiz.” These provide us with a wide range of explanatory variables with which we hope to model both broader attitudes towards science, as well as deference towards scientific opinion on particular political issues.

Towards this end, we propose a model in which political attitudes and demographic characteristics, along with more general attitudes towards science and scientists, are used to predict willingness to defer to science on policy matters. Formed as an equation,

Deference to Science on Public Policies = α + β1(Republican) + β2(Democrat) + β3(Ideology) + β4(College education) + β5(Religious faith) + β6(Age) + β7(Gender) + β8(Race/Ethnicity) + β9(Measure of Attitudes towards Science & Scientists) + εi.

In this set-up, we first examine attitudes towards scientists. Preliminary explorations of the data indicate that there is a single dimension dominating how people view scientists and a single dimension dominating how deferential people are to the recommendations of scientists. If true, this contradicts our first hypothesis but simplifies our analysis—we can construct a summary measure of general attitudes towards scientists, and then use this variable along with our ideological, religious, educational, and political variables to explain a summary measure of deference to science on policy matters.

**Results**

Are There Different Dimensions to Science Attitudes?

Our ultimate goal is to understand the impact of religious beliefs, education, political ideology, and party identification on attitudes towards science and scientific expertise. But is there a uni-dimensional structure to respondents’ deference to scientific recommendations on policy matters as well as for general attitudes towards science? We prefer to test this empirically rather than assume it. Towards this end, we conducted several different dimensional analyses.

With respect to the policy deference questions, no matter what specification or estimator we used, the results were remarkably consistent: there is one dominant factor that structures most of the variance between and across the issue items. We were open to the possibility that issues invoking aspects of religious faith or partisan ideology might evince distinct response structures. Indeed, the multi-dimensionality of science attitudes was our first hypothesis. But this was not the case.[[11]](#footnote-11) On account of the single dimension underlying the policy items, a summary item was created from all items and used in the subsequent analyses.

With respect to the measures of general attitudes towards scientists and scientific research, the majority of the items were structured by a single factor with the remainder demonstrating no consistent secondary factor. We included the former items in a summary measure.[[12]](#footnote-12) The summary dimensions of the policy and attitude batteries were quite robust (alpha=0.94 and alpha=0.88, respectively).

 While somewhat unexpected, these results are not altogether surprising. As stated earlier, past research has shown that people have a generally high regard for science, and are even willing to defer to scientific recommendations on many public policies. This appears to have been the dominant reaction to our questions (more on this soon). What surprises us is that there does not appear to be any consistent and coherent structure explaining deviation from this norm. This makes us all the more curious to see how much variation there is that can be explained by demographic and political attitudes.

What Drives General Attitudes towards Science?

A major step towards understanding whether Americans are willing to accept the recommendations of scientists on public policy matters involves developing a better sense of how respondents’ general attitudes towards science and scientists vary. The simple, preliminary results to the battery of questions asking about (a) scientific bias and (b) the efficacy of alternative belief systems reinforce those observed across the policy items. In Table 1, we see that pro-science attitudes are the norm, although most respondents also think “gut reasoning” and religious faith can play a legitimate role in informing policy preferences. Furthermore, many Americans believe that science and scientists are subject to ideological or personal biases, while others are concerned about expansive government in the name of science.

[Table 1 about here]

In order to ascertain the independent impact of religion, education, political ideology, partisanship, and other potential factors on attitudes towards science, we estimate a multivariate model. In modeling the nine different attitudinal items, we include variables measuring science knowledge (measured from 0 to 5), education (college educated versus less than a college degree), religiosity (with a dummy variable for those who attend church at least once a week, and a three-point scale indicating the extent to which the respondent believes that the Bible is the literal word of God), self-rated political ideology (measured by a standard five-point scale), party identification (with separate Democratic and Republican dummy variables), age (under 30 years of age, and 65 and over), race (African-American or not and Asian or not), and ethnicity (Latino or not) to predict each rating.

Due to the limited, ordered nature of the dependent variable (which ranges from “strongly agree” to “strongly disagree”), we utilize an ordered logit model with maximum likelihood estimation. The dependent variables are coded such that higher scores indicate “pro-science” attitudes, and thus, for interpretation, positive coefficients indicate a greater support for science while negative coefficients indicate greater support for alternative cognitive structures or skepticism.

Figure 1 plots the coefficients (and attendant standard errors) for the models of attitudes toward science and scientists. The first row examines attitudes toward science when put in direct conflict with alternative cognitive structures, such as faith, gut instinct, and ideology. The second row focuses on attitudes towards scientists and scientific research. The final row examines perceptions of bias among researchers and scientists. In particular, whether university professors, economists, or scientists writ large are liberals (in the case of university professors and scientists) or conservatives (in the case of economists) trying to pursue an ideological agenda.

[Figure 1 about here]

A few striking results emerge from the nine models presented in Figure 1. First, the covariates displaying the most consistent effects include ideology and an adherence to biblical literalism – two alternative cognitive frameworks from which one might approach these questions. Ideology (measured with a five-point scale from liberal to conservative) is associated with a decreased esteem for science and scientists in seven of the nine models, an increase in one (increased conservative identification is associated with a decreased belief that economists are conservatives trying to push a conservative agenda), and one null effect relating to the objectivity of industry-backed research. Biblical literalism is universally associated with a decreased assessment of science and scientists across all nine models.

A second notable result is party’s mixed effect as a predictor. In particular, Republican identification has a mixed and generally inconclusive impact on one’s deference towards science when controlling for other factors. Republicans tend to hold that ideology should not be discounted in preference for science, but otherwise, Republican identification is not associated with a decreased assessment of science or scientists. In fact, Republicans are more likely to disagree with the notion that industry-backed scientific research is biased and with the notion that scientists and academics are hostile to people of faith. On the other side of the aisle, for seven of the nine models Democratic identification increases the likelihood that a respondent will hold a pro-science position. The exceptions include Democratic identification’s null effect on one’s willingness to elevate faith over science, and its leading to an increased feeling that economists are trying to pursue a conservative agenda.

The other covariates produce mixed effects across the battery of questions. Science knowledge is sometimes, though not always, associated with more pro-science positions, as is a college education, and, to a lesser extent, being young. The effect of education is notable and conforms to the theoretical expectations outlined in Hypothesis 4. Church attendance is generally, though not universally, associated with a more negative perception of science and scientists.

Taken together, these models paint a picture of the underlying nature of attitudes towards science; one in which Democrats are pro-science, conservatives and the most devoutly religious are skeptical, and Republicans and independents are non-descript.

What Drives Deference to Science on Public Policies?

Our primary focus is not on general attitudes towards science, however. Rather, we are most interested in the extent to which people say they are willing to defer to scientific expertise on matters of public policy. Figure 2 plots the average response for each of our 16 items, along with bars indicating the attendant 95 percent confidence intervals. Overall, the average rating on the 0 (completely ignore science) to 10 (completely defer to science) scale is 7.4. Only two issues—gay adoption (6.0) and mandatory health insurance (5.8)—fall within a point of the mid-point rating of 5.0, while AIDS prevention (8.2), nuclear power (7.6), and mandatory vaccinations (7.5) all score greater than 7.5. In light of this, as we discuss variation with respect to scientific deference, it is important not to obscure the fact that most Americans express a willingness to defer to science.

[Figure 2 about here]

Although the distribution of support for each of the policy deference items is interesting in its own right, to our mind the multivariate analysis is of greater import. Figure 3 displays the coefficient estimates for our explanatory variables on summary measures of (a) deference towards science and (b) general attitudes towards science.[[13]](#footnote-13) We use a least squares estimator here because it is simple, robust, and appropriate. In addition, we have continuous dependent variables and a reasonable expectation that the explanatory variables are exogenous with limited multi-colinearity. Preliminary examinations of the errors suggest that they are homoscedastic and serially uncorrelated.

[Figure 3 about here]

 As expected, the results of the least squares models indicate that those who believe in the literalism of the bible and those who identify themselves as more conservative are (a) less likely to rate themselves as deferential towards scientific expertise in policy debates and (b) less likely to offer pro-science attitudes. Both sets of effects are statistically significant (p<.001) and in turn provide support for our third hypothesis. Having at least a college degree, identifying as a Democrat, and, in the case of policy, though not with respect to science and scientists, whether one identifies as black or Hispanic are all associated with a positive, statistically significant effect on one’s deference towards science.

Given both these results and our conceptual framework, however, we need to account for the distinct possibility that global attitudes towards science serve as a mediator between religious faith, education, and political attitudes, on the one hand, and deference towards science in policy debates, on the other. Towards this purpose, we estimated three models using the simple Baron and Kenny (1986) approach. While we know that estimating mediation models is a contentious (Bullock et al. 2010) and still developing area (Preacher et al. 2007; Shrout and Bolger 2002), we believe it is theoretically and statistically instructive for our particular study.[[14]](#footnote-14)

The results of this approach are displayed in Table 2.[[15]](#footnote-15) Model 1 predicts global attitudes towards science using the same covariates we relied on in our previous models. The results show statistically significant and positive effects for Republican identification (p<.05), Democratic identification (p<.001), being young (p<.01), having at least a college degree (p<.001), and being black (p<.05). Negative, statistically significant effects occur for conservatism (p<.001), church attendance (p<.01), and biblical literalists (p<.001). Model 2 predicts deference towards the recommendations of scientists using the same covariates and, again, we see that Democratic identification (p<.001), college completion (p<.01), and being black or Hispanic (p’s<.001) are associated with greater deference. Conversely, ideology (p<.001) and biblical literalism (p<.001) are associated with a decreased deference for scientific recommendations in policy debates.

[Table 2 about here]

 The Baron-Kenny approach relies on the notion that in the third model the inclusion of a mediator (in this case the summary measure of attitudes towards science) should have a statistically significant effect and reduce the values of the other statistically significant coefficients – ideally to zero, though in practice this is unrealistic.

In Model 3 (presented in the third column) we see that the scientific attitude measure does overwhelm several of the other independent variables. The coefficient for ideology drops 59 percent from -0.22 to -0.09. Literalism loses its statistical significance entirely. But Democratic identification only reduces 41 percent from 0.41 to 0.24, while the effect of black and Hispanic identification remains essentially unchanged. This suggests that global attitudes towards science and scientists are most likely a mediator, but only for the alternative mental constructs of conservative ideology and religiosity. More broadly, these results lend some support to the notion that ideology and religiosity condition attitudes towards scientists, which in turn condition attitudes toward scientists’ roles in public policy debates.

**Further Discussion**

As noted earlier, most studies of the anti-science proclivities of one group or another are based on empirical analysis of a single issue. The span of issues under analysis here, along with the deeper questions concerning attitudes towards scientists and scientific bias, allows us to draw more far-ranging conclusions. Most prominently, these results rather comprehensively demonstrate that a strong religious belief system and a conservative political ideology produce a relative skepticism towards science. In addition, the relationship between partisanship and attitudes towards science is more complex than is often assumed. Partisanship does appear to affect attitudes towards science, but the main effect is that Democrats are more deferential to the recommendations of scientists than either Republicans or independents, even controlling for other factors. Indeed, it is these factors—most notably, religious adherence and a conservative political ideology—that drive GOP attitudes towards science and scientists. Survey research and analysis up until this point has lacked this conceptual distinction, leading to a false and now prevalent impression.

The robustness of the findings does not allay all concerns about our data and analysis. For example, constructing a battery of policy items with which to analyze deference to science was a challenging process. There are many potential goals that one might consider in building a battery with appropriate breadth. The most obvious goal for this research consisted of maximizing ideological, partisan and moral/ethical variance in the (assumed) reaction to scientific recommendations, but other considerations surely exist. For example, another goal might be to offer policy areas in which scientific recommendations may or may not result in the expansion or action of government; another might be to offer policy areas that vary in their degree of ideological difficulty (i.e., is there a clear liberal or conservative preference with respect to the likely scientific policy prescription?); finally, another might be to offer policy areas in which there could be varying perceptions of scientific consensus.[[16]](#footnote-16)

 The particular issue of consensus, or perceived consensus, is one we have mostly avoided discussing until now. It is potentially important for our study, however, because people might selectively mis-perceive scientific consensus so that it is always judged to be consistent with one’s view of the world.[[17]](#footnote-17) It is also possible (as alluded to earlier) that some people—especially those knowledgeable about the iterative and evolving nature of the scientific process—assume that scientists rarely reach a true consensus on the sort of controversial, humanistic questions that animate political debate. Either of these possibilities could lead respondents who might otherwise be skeptical of scientific policy recommendations to respond to our items as if they are “pro-science.” Conversely, people familiar with the iterative, evolving nature of science might be skeptical of basing policy on current scientific thinking.

With these possibilities in mind, we intentionally included items on which there is near scientific unanimity (evolution) as well as items on which there is substantial scientific debate (legalizing drug use). Table 3 illustrates how we *think* scientific consensus could be characterized on each of these issues,[[18]](#footnote-18) as well as which ideological group (conservatives or liberals) we *think* might object to the prevailing scientific consensus. The fact that our findings hold on those issue domains where scientific consensus is clear—most obviously, evolution—suggests that neither a willful misreading of scientific consensus nor a probabilistic understanding of scientific processes biases our results.

[Table 3 about here]

While we have found strong support for two out of four of our hypotheses, we have given short shrift to one alternative explanation: self-interest. Always a difficult concept to measure—especially within the context of a public opinion survey where statistical power decreases as one attempts to make finer grained categorizations from one’s sample—self-interest is not something that we have satisfactorily accounted for, or discounted, as a potential explanation. While this is unfortunate, we don’t view it as damning. Although self-interest may be important for a particular policy area, it is highly unlikely that it would systematically alienate an individual from science and scientific research across a number of different policy areas or cause one to believe scientists are biased. Given that the goal of our study is to make claims about broad attitudes toward science, and not about attitudes within a particular policy area, we think this lacuna in our own research is acceptable, but worth exploring further.

**Conclusion**

Taken as a whole, our study offers several important findings in light of the current debate over the causes and significance of anti-science attitudes for politics. First, we show that attitudes towards science and scientists are generally uni-dimensional and positive. Most Americans do not think that scientists are politically biased or insensitive to alternative belief systems. Furthermore, most citizens express a willingness to defer to scientific recommendations on a range of public policy areas. It is also true, however, that a sizable minority believes that alternative belief systems are at least as valuable as science.

Second, religious faith, political ideology, and education emerge as strong predictors of anti-science views in our statistical models. People who believe that the Bible is the literal word of God, people who self-identify as conservative, and people without a college education believe that scientists should not be held above other potential sources of policy direction, nor should people automatically defer to them on political issues. This powerful effect holds across a range of actors and attitudes.

A third major finding is that partisan differences exist with respect to global attitudes towards science and willingness to defer to scientific expertise on specific policy areas. The main difference, though, is that Democrats back science almost irrespective of the particulars and are much more deferential to science than either Republicans or independents.

Fourth and finally, broader attitudes towards scientists have developed among respondents, and these attitudes strongly correlate with deference to science on specific policy areas. Put another way, deference towards scientists’ specific policy recommendations is conditional upon one’s more general attitudes towards scientists.

On their own, these findings are of modest interest. They are much more interesting when viewed in context because, as we observed at the outset, many contend science is under assault in contemporary political debate. This belief extends the polarization argument in a substantial way, by suggesting that our trust in science—an intellectual tradition borne of the Enlightenment and a critical component of Liberalism—is itself under assault. We think this concern is over-stated. Instead, we find that science and scientists are very credible on a range of policy issues, and that the American public cares what they think. Perhaps more to the point, we do not see evidence for the kind of partisan divide over science that many argue has taken hold. In fact, science seems to be a promising basis for developing policy consensus. One practical strategic recommendation that emerges from the data is that parties could perhaps make their case more effectively by invoking science more directly, especially on medical and technical issues.

More speculatively, there is some evidence that science ought to be careful about its brand. The more involved it gets in issues of faith, economics, and governmental reach, the more resistance it invokes. We would also observe that there is a danger that science and scientists could come to be viewed as extensions of the government. This is especially likely if we continue to see projects funded by the federal government producing recommendations for greater government intervention in American society. This could drive Republican elites to unite in opposition to, say, federally funded scientists, which could reduce positive affect for scientists among rank-and-file Republicans.

Regardless of whether scientists promote or discourage particular government actions, they have been neglected in the study of political elites in the U.S. We think it is important to treat them as such. Indeed, one of the frustrating things about this project is the absence of time series data; as usual, the General Social Survey has some important broad measures of affect towards scientists, while the Pew Research Center for the People and the Press has done some fine work on measuring the attitudes of both citizens and scientists on comparable issues. But despite these efforts, we do not have much of a time series on mass opinion towards scientists, so we can’t do much more than speculate about the direction or trajectory of attitudes. At the very least we should continue to systematically measure these attitudes, creating a longitudinal base, while occasionally expanding the specific issues under the microscope to increase the breadth of our measurement and understanding.

**Table 1—Attitudes towards Science and Scientists**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Strongly agree** | **Somewhat agree** | **Somewhat disagree** | **Strongly disagree** | **Don’t know** |
| When faced with a difficult decision, politicians should follow the advice of relevant experts, even if it means going against their ideology. | 24% | 36% | 15% | 9% | 16% |
| Most of the time, instinct and gut reactions are just as good as the advice of scientists. | 12 | 34 | 21 | 19 | 13 |
| Faith is a better guide than scientific evidence on most important questions. | 19 | 21 | 21 | 26 | 12 |
| Scientists and academics are NOT hostile to people of faith. | 18 | 24 | 21 | 19 | 18 |
| Scientists and academics are NOT concerned about the moral implications of their research. | 20 | 28 | 24 | 14 | 15 |
| Most university professors are liberals who are trying to push an ideological agenda with their research. | 29 | 19 | 18 | 17 | 17 |
| Most economists are conservatives who are trying to push an ideological agenda with their research. | 11 | 22 | 26 | 18 | 23 |
| Most scientists are liberals who are trying to push an ideological agenda with their research. | 20 | 21 | 22 | 19 | 19 |
| Industry-backed research is inherently biased. | 19 | 35 | 18 | 6 | 21 |
| Regulation of business and industry is justified unless it can be shown that their activities do NOT cause harm. | 23 | 30 | 18 | 12 | 17 |
| I believe in science, but often disagree with the need for government programs or regulations in the name of it. | 29 | 30 | 18 | 10 | 13 |



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**Table 2—OLS Regressions examining mediation potential of scientific attitudes on policy attitudes**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Model 1 (Attitude Scores) | Model 2 (Policy Scores) | Model 3 (Policy Scores) |
|  | **Estimate** | **Std. Error** | **Estimate** | **Std. Error** | **Estimate** | **Std. Error** |
| **Republican** | 0.14 | 0.060 | 0.07 | 0.071 | 0.00 | 0.065 |
| **Democrat** | 0.33 | 0.058 | 0.41 | 0.069 | 0.24 | 0.064 |
| **Ideology** | -0.27 | 0.019 | -0.22 | 0.022 | -0.09 | 0.022 |
| **Science Knowledge** | 0.06 | 0.020 | 0.04 | 0.024 | 0.01 | 0.022 |
| **Female** | 0.05 | 0.047 | 0.10 | 0.056 | 0.08 | 0.051 |
| **Under 30** | 0.19 | 0.059 | 0.00 | 0.070 | -0.09 | 0.064 |
| **Over 65** | -0.03 | 0.061 | -0.07 | 0.072 | -0.05 | 0.065 |
| **College**  | 0.21 | 0.052 | 0.20 | 0.062 | 0.10 | 0.057 |
| **Church**  | -0.16 | 0.058 | -0.06 | 0.069 | 0.03 | 0.063 |
| **Literalism** | -0.32 | 0.038 | -0.16 | 0.046 | 0.01 | 0.043 |
| **Black** | 0.19 | 0.089 | 0.51 | 0.106 | 0.41 | 0.096 |
| **Hispanic** | 0.02 | 0.07 | 0.28 | 0.084 | 0.27 | 0.076 |
| **Asian** | -0.06 | 0.18 | 0.17 | 0.213 | 0.20 | 0.193 |
| **Science Attitude** |  |  |  |  | 0.50 | 0.038 |
| **Valid Cases** | 825 |  | 825 |  | 825 |  |
| **Adj. R2** | 0.56 |  | 0.37 |  | 0.50 |  |
| **Std. Error** | 0.64 |   | 0.76 |   | 0.70 |   |

**Table 3—Researcher Notions about Scientific Consensus on Tested Issues**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Scientific Consensus is…** | **Direction of Consensus…** | **Anticipated Objections mainly from…** |
| *Embryonic stem cell research* | Strong | Anti-regulation | Conservatives |
| *Fetus viability* | Mild | Anti-abortion | Liberals |
| *Global warming/Climate change* | Strong | Pro-regulation | Conservatives |
| *Childhood obesity and diet restrictions* | Strong | Pro-regulation | Conservatives  |
| *AIDS prevention* | Strong | Pro-regulation | Conservatives |
| *Birth control education* | Mild | Pro-education | Conservatives |
| *Legalizing drug use* | Unclear | N/A | Neither |
| *Mandatory health insurance*  | Unclear | N/A | Neither |
| *Regulation of coal production* | Strong | Anti-coal | Conservatives |
| *Mandatory background checks for gun permits* | Unclear | N/A | Neither |
| *Producing bio-tech food and crops* | Strong | Pro-bio-tech | Liberals |
| *Regulation of nuclear power* | Mild | Pro-nuclear | Liberals |
| *Animal testing for medical research* | Strong | Pro-testing | Liberals |
| *Mandatory childhood vaccinations* | Strong | Pro-vaccine | Liberals |
| *Teaching evolution and the origins of humans* | Strong | Pro-evolution | Conservatives |

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1. Of course, doubters existed for all of those (and undoubtedly many other) publicly-backed policy endeavors. [↑](#footnote-ref-1)
2. Ross Ramsey. (2010) “Texans: Dinosaurs, Humans Walked the Earth at the Same Time.” Texas Tribune (2/17/2010). http://www.texastribune.org/2010/02/17/texans-dinosaurs-humans-walked-the-earth-at-same/. Last accessed 2/18/2015. [↑](#footnote-ref-2)
3. We should note that the GSS contains a range of instrumentation on general attitudes towards science and scientists, as well as an array of plausible independent variables. In specific years, especially 2006, it also contains decent instrumentation for opinion on specific issues. The problem, from our perspective, is that (a) the issue items are not constructed to maximize potential variance across our critical independent variables, and (b) they do not directly ask about deference towards science in the specified policy domain. [↑](#footnote-ref-3)
4. There is also some evidence, however, that citizens are less likely to follow these cues if they have relevant knowledge pertaining to that policy (Bullock 2011). [↑](#footnote-ref-4)
5. Some have argued that this skepticism is driven the “New Right,” which critics identify as an amalgam of religious fundamentalism and transnational corporate interests (Mooney 2005). [↑](#footnote-ref-5)
6. Those who lean closer to one party or the other are treated as partisans. [↑](#footnote-ref-6)
7. It is true that the party system has “sorted” or “realigned” since the 1960s such that conservative Democrats and liberal Republicans are virtually extinct in the Congress. But this sorting is much less complete (and highly variable by region) at the mass level. [↑](#footnote-ref-7)
8. But see Zipp and Fenwick (2006) for a dissenting viewpoint. [↑](#footnote-ref-8)
9. Supporting information about the survey is available online. [↑](#footnote-ref-9)
10. We conducted a pilot test in an October 2012 statewide survey of Texas. [↑](#footnote-ref-10)
11. The main evidence here is a factor analysis. We relied on a principle components analysis of factors, using a varimax rotation method and extracting factors with eigenvalues greater than 1. Supporting information is available online. [↑](#footnote-ref-11)
12. The items not included were, “When faced with a difficult decision, politicians should follow the advice of relevant experts, even if it means going against their ideology,” “Most economists are conservatives who are trying to push an ideological agenda with their research,” and “Industry-backed scientific research is inherently biased.” [↑](#footnote-ref-12)
13. The summary measures were simple averages across all of the items within the respective batteries (as noted earlier, some items in the battery gauging general attitudes were reverse coded to insure larger values represent more pro-science attitudes). For details of the OLS models, see supporting information online. [↑](#footnote-ref-13)
14. Baron and Kenny (1986) consider a situation in which an independent variable X affects some mediator M that in turn affects some dependent variable Y. They propose a series of three regressions, showing: X affects M; X affects Y; and when X and M are included in the same regression, there is a significant partial effect of M and the partial (direct) effect of X on Y that is less than the effect of X on Y without controlling for M. Baron and Kenny argue that the strongest evidence for mediation is when this partial effect of X on Y is reduced to non-significance; they recommend using the Sobel test of the significance of the indirect effect of X on Y through M. [↑](#footnote-ref-14)
15. The coefficient estimates differ slightly here compared with those presented in Figure 3. The models in Table 2 only include those individuals who have no missing data for any of the relevant measures. This is a necessary condition for comparing coefficient estimates across the models. [↑](#footnote-ref-15)
16. Needless to say, there were limits to how many items we could include. Creating a battery that managed to elicit variation across all of the dimensions listed above would surely help to assuage any concern that the policy set was biased in its outcomes, but we’re confident that the consistency of the findings, both across policies and across the broader attitudes towards science, reflects the true underlying attitude structure and not some artifact of the battery. [↑](#footnote-ref-16)
17. For example, see <http://www.culturalcognition.net/blog/2014/4/28/science-and-public-policy-who-distrusts-whom-about-what.html> (last accessed on May 3, 2014). [↑](#footnote-ref-17)
18. Our characterization of consensus is based on a review of research accessed through science blog aggregators such as ResearchBlogging.org, Scienceblogging.org, and ScienceSeeker.org. We also checked more accessible public venues, such as *The New York Times*, *Nature*, *Science*, and *Wired*. [↑](#footnote-ref-18)