

ORIGINAL ARTICLE

Counteracting the Politicization of ScienceToby Bolsen¹ & James N. Druckman²

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Few trends in science have generated as much discussion as its politicization. This occurs when an actor emphasizes the inherent uncertainty of science to cast doubt on the existence of scientific consensus. In this article, we offer a framework that generates predictions about when communications can be used to counteract politicization efforts aimed at novel energy technologies. We then present evidence from nationally representative survey experiments to demonstrate how warnings to dismiss future politicization and corrections to ignore past claims can counteract politicization's effects. The results provide novel insights about science communication in a politicized era and offer a blueprint on which future work can build.

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Few trends in science have generated as much discussion as its politicization. Politicization occurs when an actor emphasizes the inherent uncertainty of science to cast doubt on the existence of scientific consensus. This causes citizens to dismiss credible scientific information and undermines the positive role that science can play in informing political debates on issues with substantial scientific content (Dietz, 2013). Yet, politicization does not occur in a vacuum: Scientists and other opinion leaders can and do work to counteract it. Whether and when their attempts are successful, however, remain unanswered questions.

We address these questions by first offering a precise definition of the politicization of science. We then develop a framework that generates predictions about the conditions under which communications can counteract politicization efforts aimed at novel energy technologies, focusing on support for hydraulic fracturing and carbon nanotubes (CNTs). We test these predictions with survey experiments conducted on nationally representative samples in the United States. The results demonstrate that communication efforts to counteract politicization can be effective under certain conditions. Specifically, warnings about future politicization attenuate its effects and lead

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to an increase in the impact of consensual scientific information on opinions. Corrections to dismiss politicization also counteract it, although, as we anticipate and discuss, they are not as effective as warnings due to the prevalence of directional motivated reasoning.

The politicization of science

Individuals base their opinions on a host of ingredients including values, identities, and factual information. Social scientists have developed a fairly thorough understanding of: how factual information affects opinions (e.g., Bauer, Allum, & Miller, 2007; Delli Carpini & Keeter, 1996; Miller, 1998); how individuals account for knowledge shortfalls (Lupia, 2006); how being uninformed or misinformed about politics influences views (e.g., Kuklinski et al., 2000); and how individuals may biasedly interpret factual information (Druckman, 2012; Taber & Lodge, 2006). This work reveals a subjective element in the interpretation of facts despite the fact that a fact, by itself, is not inherently subjective information (Shapiro & Bloch-Elkon, 2008).¹

One of the most useful types of facts is “scientific evidence” that reports a verifiable and reproducible observation(s) stemming from the use of the scientific method. Dietz (2013) states, “A good decision must be factually competent [and] reflect our understanding of how the world works. Here, the role of science is obvious: Science is our best guide to developing factual understanding” (p. 14082; also see Kahneman, 2011). This is where *politicization* enters the picture. Although the term has been used in varying ways, close examination of the literature makes its meaning clear (e.g., Jasanoff, 1987; Oreskes & Conway, 2010; Pielke, 2007).

Three defining features include:

- There *exists a scientific finding* or, in many cases, a body of scientific work that has been produced according to sound scientific procedures (i.e., through the use of the scientific method). Although it is not required, in many cases, politicization occurs once there is a body of work that approaches what many would consider a “*consensus position*” among scientists (Shwed & Bearman, 2010).
- Any *scientific finding(s) contains inherent uncertainty*. This is the case because science provides a method for evaluating evidence in support of, or in opposition to, a conclusion rather than confirming it with certainty: “After all, future observations may change.... [Moreover], falsification can never be ... definitive” (Shadish, Cook, & Campbell, 2002, p. 15; also see Popper, 1984, p. 5). Thus, “scientific information is always, to some degree, vulnerable to concerns about uncertainty because scientists are trained to focus on uncertainty” (Dietz, 2013, p. 15084).
- An agent or agents call scientific consensus into question by *accentuating a finding’s inherent uncertainty* and suggesting alternative possibilities. This is typically done *not* in an effort for scientific accuracy but rather in pursuit of a particular agenda.

Thus, *politicization occurs when an actor emphasizes the inherent uncertainty of science to cast doubt on the existence of scientific consensus*. This definition coheres

with that put forth by one of the most noted books on politicization—*Merchants of Doubt*—which defines politicization as “exploiting the inevitable uncertainties about aspects of science to cast doubt on the science overall . . . thereby magnifying doubts in the public mind” (Steketee, 2010, p. 2; also see Oreskes & Conway, 2010; Pew Research Center, 2009). The consequence is that “even when virtually all relevant observers have ultimately concluded that the accumulated evidence *could* be taken as sufficient to issue a solid scientific conclusion . . . arguments [continue] that the findings [are] not definitive” (Freudenburg, Gramling, & Davidson, 2008, p. 28; italics in the original). Horgan (2005) notes that this undermines the scientific basis of decision-making because opinions diverge from the scientific consensus as groups conduct campaigns with the goal of altering public policy to advance a favored agenda (also see Lupia, 2013).

We believe our definition of politicization makes clear how this is a unique communicative tactic. As intimated, politicization differs from other communication strategies that influence opinion formation insofar as: (1) politicization is about emphasizing the inherent uncertainty of science to cast doubt on the existence of scientific consensus—it is not competitive framing of an issue, which would involve emphasizing, for example, the environmental and economic consequences of energy-related policies; (2) it need not come from a political actor—the source of politicization could be an interest group, a fellow citizen, or any other actor; and (3) it is not misinformation *per se* but rather involves accentuating the inherent uncertainty of science to cast doubt about the existence of a scientific consensus. This latter point is important as the concepts are related but misinformation refers to “false, misleading, or unsubstantiated information” (Nyhan & Reifler, 2010, p. 304). Politicization involves questioning the existence of scientific consensus but not offering false information *per se* (this would be called pseudo science; Hansson, 1996).

Only one study, to the best of our knowledge, isolates the effects of politicization on opinion formation. Bolsen, Druckman, and Cook (2014a) show that messages that emphasize politicization not only stunt the impact of otherwise persuasive information from a credible source (e.g., the National Academy of Sciences [NAS]) but also directly *increase* anxiety and perceptions of threat and *decrease* overall support for an emergent energy technology’s usage. Thus, as many worry, politicization undermines the impact of positive, consensual scientific information.²

Although these findings and other commentaries on politicization are telling, they also are limited when one considers the reality of science communication as an ongoing competitive process (Chong & Druckman, 2007). Scientists and other actors attempt to counteract politicization, when it exists, by asserting scientific consensus. It is these types of communication efforts to which Uhlenbrock, Landau, and Hankin (2014) refer when emphasizing that “[scientific] societies and organizations can play a central role in science policy discourse in addition to an individual scientist’s voice” (p. 98, also see Newport et al., 2013). We next present a framework that generates predictions about when efforts to counteract politicization are likely to be effective.

Table 1 Concepts and Definitions

Concept	Definition
Scientific consensus	General agreement within a field about existing knowledge (e.g., Shwed & Bearman, 2010)
Politicization	When an actor emphasizes the inherent uncertainty of science to cast doubt about the existence of scientific consensus (e.g., Steketee, 2010, p. 2; Oreskes & Conway, 2010)
Warning	A message that alerts individuals about the content of an upcoming message (Eagly & Chaiken, 1993, p. 347)
Correction	A message that provides information to individuals about a misperception they may hold, stemming from exposure to a prior communication (e.g., Cobb et al., 2013; Nyhan & Reifler, 2010)
Directional motivated reasoning	Tendency to view evidence as more effective when it is consistent with prior opinions (e.g., often dismissing information inconsistent with prior beliefs regardless of objective accuracy) (Taber & Lodge, 2006)
Accuracy motivated reasoning	Tendency to evaluate information/evidence with the goal of forming an accurate (or “correct”) belief by attempting to engage in an “objective,” or evenhanded, assessment of new information (Druckman, 2012)

Politicization and opinion formation

We focus here on opinion formation about two relatively novel energy technologies—CNTs and hydraulic fracturing—where consensual scientific information exists. We recognize that defining a scientific consensus is not straightforward; yet, this strikes us as a critical starting point for an empirical investigation because, as mentioned, politicization undermines scientific consensus. We explore how varying types of counteractive communication efforts influence opinions *relative* to the possession of no (communicated) information on a given technology (see Druckman (2001) on using this as a baseline). We present Table 1, which offers definitions of key concepts, to facilitate presentation of the theoretical framework motivating the hypotheses we state below.

We begin by considering the impact of scientific consensus: information on which there is general agreement within a field about existing knowledge (see Table 1) (Shwed & Bearman, 2010). Such information matters because forming opinions about emergent technologies inevitably involves assessing uncertain future risks and benefits (National Research Council, 1994; Polasky, Carpenter, Folke, & Keeler, 2011). Moreover, psychological work on attitude change shows that “consensus implies correctness” (Kruglanski & Stroebe, 2005, p. 358); this is particularly

the case when a communication includes the “citation of ... evidence [which] appears to enhance [persuasiveness]” (O’Keefe, 2002, p. 186; also see, e.g., Eagly & Chaiken, 1993; Miller, 1998). In this case, positive consensual scientific information *reduces anxiety and perceived threat about the future impact of emergent technologies* (Constans, 2001; Maner & Schmidt, 2006; National Research Council, 1994; Polasky, Carpenter, Folke, & Keeler, 2011; Weisenfeld & Ott, 2011). Reductions in anxiety and perceived threat, in turn, lead individuals to become more supportive of the technology (Bolsen et al., 2014a). Based on this work, we hypothesize that individuals will become less threatened and anxious and more supportive of an emergent technology’s usage, when they receive positive consensual scientific information, relative to those who receive no information (hypothesis 1).³

When science is politicized—which, as presented and defined in Table 1, occurs when the inherent uncertainty of science is emphasized to cast doubt about the existence of scientific consensus—the confidence instilled by consensual scientific information is undermined. Psychological work suggests that anxiety—such as that stemming from politicization—generates a preference for risk aversion (i.e., favoring the status quo), and thus, decreases support for novel innovations (Arceneaux, 2012; Caplin & Leahy, 2001; Druckman & McDermott, 2008; Hirsh, Mar, & Peterson, 2012; Kahneman, Knetsch, & Thaler, 1991). Consequently, when individuals are exposed to politicization, they become uncertain about whether to trust consensual scientific information in this context and more anxious due to greater perceived uncertainty and risk stemming from the technology’s use. Increased anticipated risk, in turn, heightens anxiety (Constans, 2001; Maner & Schmidt, 2006). This will render any positive impact of the consensual scientific information on individuals’ opinions impotent. We thus predict that individuals will become more threatened and anxious and less supportive of an emergent technology’s usage in the presence of politicization, relative to those who receive no information (hypothesis 2).⁴

The existing literature stops here, leaving the impression that politicization trumps scientific consensus; yet, attempts to counteract politicization do occur. For instance, the mission of the NAS is to engage in such counter efforts by documenting consensus about contemporary scientific issues when it exists and providing “independent, objective advice to the nation on matters related to science and technology” (<http://www.nationalacademies.org/about/whatwedo/index.html>). Nonetheless, even though scholars have called for research on ways to counteract politicization (Dietz, 2013; Nature, 2010), empirical work has remained silent on the matter.

There are two potential ways to use competitive communications to counteract politicization (Chong & Druckman, 2010). Counteractive communications can take the form of a *warning* that a scientific consensus exists and efforts to call into question this consensus should be dismissed, or a *correction* with similar content that follows politicization. As shown in Table 1, a warning is a message that alerts individuals to the content of an upcoming message (Eagly & Chaiken, 1993, p. 347); in this case, it would be a communication that warns individuals to ignore/not believe future politicization

toward an emergent energy technology. This could occur when scientific organizations, or individuals, anticipate politicization, which happens on many scientific issues (e.g., see Lupia, 2013). On the flip side, a correction is a communication that provides information to individuals about a belief they may hold, stemming from *exposure to a prior* communication (e.g., Cobb, Nyhan, & Reifler, 2013; Nyhan & Reifler, 2010): In this case, it would be a message that tells individuals to dismiss a prior communication accentuating politicization toward an emergent technology.

Warnings, corrections, motivated reasoning, and counteracting politicization

We turn to the theory of motivated reasoning to understand the process by which warnings and corrections may counteract politicization. We follow Taber and Lodge (2006) and focus on two primary motivations that drive the processing of information: *directional* and *accuracy* goals.⁵ A *directional goal* refers to when a “person is motivated to arrive at a particular conclusion” (Kunda, 1999, p. 236). As defined in Table 1, *directional motivated reasoning* causes people to view evidence as stronger when it is consistent with prior opinions and dismiss information inconsistent with prior beliefs regardless of its objective accuracy (e.g., see Druckman, Peterson, & Slothuus, 2013; Kunda, 1990, 1999; Lodge & Taber, 2000; Slothuus & de Vreese, 2010).⁶

To understand the consequences of directional motivated reasoning, consider Druckman and Bolsen’s (2011) two-wave study on the dynamics of opinion formation toward two emergent scientific technologies. At wave 1, respondents reported their support for genetically modified (GM) foods or CNTs following exposure to a pro or con frame on each issue. Then, about 10 days later, respondents received three types of information about GM foods or CNTs in a follow-up survey: in the case of GM foods, positive information about how GM foods combat diseases, negative information about the unknown and potentially harmful long-term health consequences of GM foods, and neutral information about the economic consequences of GM foods. They find that opinions formed at wave 1 in response to exposure to positive or negative frames strongly conditioned evaluations toward novel scientific information presented in wave 2. Individuals exposed to positive or negative information about an emergent technology at wave 1 evaluated directionally consistent evidence at wave 2 as more effective, directionally inconsistent evidence at wave 2 as less effective, and neutral evidence as consistent with the direction of the opinion formed at wave 1. The authors report virtually identical results with the same design but on the topic of CNTs (also see Kahan et al., 2009).⁷

Directional motivated reasoning seems to be pervasive on political and scientific issues where individuals have little incentive to exert great effort in processing competing arguments and technical information (see Taber & Lodge, 2006, p. 767).⁸ Nyhan and Reifler (2010) state, “humans are goal-directed information processors who tend to evaluate information with a directional bias toward reinforcing their pre-existing views . . . ” (p. 307). Dietz (2013) adds, “this process of biased assimilation

of information can lead to a set of beliefs that are strongly held, elaborate, and quite divergent from *scientific consensus*” (p. 14083, italics added).

However, directional motivated reasoning also suggests that one can counteract politicization by communicating to people—prior to encountering politicization—that a scientific consensus indeed does exist and that future politicization claims should be dismissed. This establishes an initial attitude that people later use to evaluate subsequent information a la directional motivated reasoning—i.e., that consensual scientific information is credible and politicization should be dismissed. Put another way, when individuals receive a warning to dismiss future claims about politicization with regard to an emergent energy technology, directional motivated reasoning will lead people to discount politicization and trust consensual scientific information. We thus predict that individuals who receive a warning that a scientific consensus exists and should not be politicized will become less threatened and anxious and more supportive of an emergent technology, relative to those who receive no information (hypothesis 3).⁹

In contrast, directional motivated reasoning implies that corrections to dismiss prior claims about politicization are likely to fail. In this case, individuals form an initial opinion that information related to an emergent technology is the subject of scientific disagreement and thus, due to directional motivated reasoning, view later corrective messages as less credible. Consequently, politicization prevails leading to depressed support a la hypothesis 2: Individuals who are exposed to a correction to dismiss prior politicization will thus become more threatened and anxious and less supportive of an emergent technology, relative to those who receive no information (hypothesis 4).¹⁰

Directional motivated reasoning may drive information processing in some contexts; however, in other contexts, individuals instead pursue an accuracy motivation in processing information and forming an opinion. As described in Table 1, *accuracy motivated reasoning* involves evaluating new information/evidence with the goal of holding a “correct,” or accurate, belief by attempting to engage in an “objective,” or evenhanded, assessment of relevant information (Taber & Lodge, 2006, p. 756; also see Druckman, 2012; Kunda, 1990). Instead of defending a prior belief, identity, or worldview, an accuracy motivation leads individuals to assess all available information objectively, even if it runs counter to one’s existing beliefs or identities (Lavine, Johnston, & Steenbergen, 2012). For example, Bolsen, Druckman, and Cook (2014b) find that, in forming an opinion about aspects included in the *2007 Energy Independence Act*, when respondents were prompted to process information with an accuracy motivation—that is, they were told they would have to justify their opinions—the bias stemming from directional motivated reasoning disappeared. Respondents’ opinions were not driven by the Act’s perceived sponsor but rather reflected an assessment of the policy content with which they were provided (also see Nir, 2011; Prior, Sood, & Khanna, 2013).

The implication, for us, is that individuals will not dismiss a correction a la directional motivated reasoning when motivated to form an accurate belief; rather,

individuals will consider all relevant information and give weight to consensual scientific information previously encountered in forming their overall opinion toward an emergent energy technology. Consequently, when individuals *who are induced to process information with an accuracy motivation* receive a correction to dismiss prior claims about politicization, it will elevate the impact of consensual scientific information. Individuals will thus become less threatened and anxious and more supportive of an emergent technology, relative to those who receive no information (hypothesis 5).

For reasons we will later discuss, this prediction—although perhaps not capturing the motivation of the majority of people when it comes to processing scientific information—may become increasingly relevant in the future as debates about energy evolve and come to have a more direct impact on an individual's everyday life (e.g., as energy debates become more localized) (Sinatra, Kienhues & Hofer, 2014). We summarize our hypotheses in Table 2.

Experimental design and measures

We tested the hypotheses listed in Table 2 with experiments embedded in a nationally representative survey in the United States (implemented over the Internet) with a total of 2,484 participants across both studies.¹¹ We focus, as mentioned, on two emergent energy technologies. One experiment focused on CNTs, which are tiny graphite tubes that efficiently convert sunlight into electricity and thus offer a novel method to obtain energy from an alternative source. National surveys suggest that nearly half the population knows virtually nothing about CNTs (e.g., the 2010 General Social Survey, see also Druckman & Bolsen, 2011). The other experiment focused on a novel way to obtain energy from a conventional energy source: hydraulic fracturing—a method to obtain energy that “involves drilling horizontally through a rock layer and injecting a pressurized mixture of water, sand, and other chemicals that fractures the rock and facilitates the flow of oil and gas” (Boudet et al., 2014, p. 58). Hydraulic fracturing—which is commonly called “fracking”—fundamentally differs from conventional drilling (<http://www.cleanwateraction.org/feature/fracking-explained>). Although this method receives greater media coverage than CNTs, the public is “largely unaware and undecided about this issue” (Boudet et al., 2014, p. 63). We opted to use the term “fracking” in the experiment, as opposed to hydraulic fracturing, because of its familiar use in news coverage and in academic work (e.g., see Boudet et al., 2014). We note that the focus on two relatively novel technologies means that most respondents will not have developed strong opinions, which means that any results we uncover potentially tap the upper bounds of movement in terms of the magnitude of the effect of competing communications on opinion formation.

We used an identical experimental design to test our hypotheses for both CNTs and fracking. We randomly assigned half of the participants in our sample to an experiment about CNTs (N = 1,256) and the other half to an analogous experiment about fracking (N = 1,228). For each technology, we randomly

Table 2 Experimental Conditions and Hypotheses

Condition	Scenario/Stimuli	Hypothesis ^a
1	No information	Baseline condition
2	Consensus scientific information	Consensus scientific information in support of a technology causes individuals to become less threatened and anxious and more supportive of its use. (<i>hypothesis 1</i>)
3	Politicized scientific information	Politicization renders the impact of positive consensus scientific information impotent by generating doubt about its credibility. There is an increase in threat and anxiety and decrease in overall support. (<i>hypothesis 2</i>)
4	Warning to dismiss politicized information → politicized scientific information	The warning that a scientific consensus exists and that politicization should be dismissed causes people to dismiss politicization and remain open to consensual scientific information, leading to a decrease in threat and anxiety and an increase in overall support. (<i>hypothesis 3</i>)
5	Politicized scientific information → correction	Politicization renders the impact of consensual scientific information impotent. The correction has no counteractive effect, due to directional motivated reasoning, leading to increased threat and anxiety and decreased overall support. (<i>hypothesis 4</i>)
6	Accuracy motivation → politicized scientific information → correction	Inducing a motivation to form an accurate opinion will cause the correction to have an effect in counteracting politicization. It will thus overcome directional motivated reasoning and elevate the impact of consensual scientific information, leading to decreased threat and anxiety and increased overall support. (<i>hypothesis 5</i>)

^aPredictions are relative to the baseline.

assigned participants to one of six conditions, as captured in Table 2, that we next discuss.

Individuals randomly assigned to Condition 1, which served as a baseline for assessing the hypotheses, received no information about either technology and were simply asked to respond to the key dependent measures. This included questions that gauged: (1) the extent of support for the use of either CNTs or fracking (on a 7-point

scale with higher scores associated with greater support), (2) the extent to which the government should decrease or increase investments into research that advances this approach for obtaining energy (on a 7-point scale with higher scores associated with increases in investments), and (3) the extent to which the technology would help ensure long-term energy sustainability (on a 7-point scale with higher scores associated with greater sustainability). We also included measures to test our hypotheses about the impact of the experimental interventions on respondents' perceived levels of threat and anxiety. We measured perceived anxiety by asking respondents, "As you think about [fracking/CNTs] as an approach to obtain energy, how much anxiety do you feel?" (on a 5-point scale with higher scores indicating greater anxiety). We measured perceived threat by asking respondents, "Indicate how dangerous or safe you think it is to use [fracking/CNTs] as an approach to obtain energy" (on a 7-point scale with higher scores indicating greater perceived threat). These central dependent variables followed all of the experimental conditions.

As Table 2 illustrates, Condition 2 allows us to test hypothesis 1 by providing respondents with consensual scientific information from a study published in the *Proceedings of the National Academy of Sciences (PNAS)* about either CNTs or fracking and later assessing support for the respective technology. For example, in the case of CNTs, we provided respondents with a definition of CNTs and informed them that CNTs "offer a novel method to obtain energy that is fundamentally different from conventional approaches and allows for the production of a substantial amount of energy. A recent study published in *PNAS* shows that CNTs can be safely produced on a large scale (and do not pollute the environment). A professor of chemistry at Stanford referred to recent developments as 'good and needed.' The fracking study offered analogous information.¹² We confirmed via a pre-test (with participants not in the main experiment) that individuals viewed the source as highly credible. Again, we anticipate (see hypothesis 1, Table 2) decreases in threat and anxiety and an increase in overall support for each technology in this condition, relative to respondents who receive no information.

Condition 3 added a statement that has been employed in exactly the same way in prior related work (see Bolsen et al., 2014a) that accentuates politicization, "... Yet, importantly, politics nearly always color scientific work, with advocates selectively using evidence. This leads many to say it is unclear whether to believe scientific evidence related to debates over CNTs. Some argue the process leads to pollution that harms the environment, while others disagree, pointing to evidence that there are minimal or no negative environmental consequences..." We reference contrary arguments because they are more realistic insofar as they raise uncertainty about the existence of scientific consensus without offering specific factual evidence—e.g., by citing a competing scientific study or conclusion.¹³ We anticipate that politicization will increase threat perceptions and anxiety and stunt overall support for each technology by rendering consensual scientific information impotent (see hypothesis 2, Table 2).

Condition 4 added a warning that preceded the politicized scientific information stating, “Some say that it is difficult to assess the benefits of this process because people only point to evidence that supports their position. However, the assessment of CNTs should not be politicized; a consensus of scientists believes CNTs are better for the environment than other energy production methods.” Thus, the warning explicitly provides respondents with a message that a consensus of scientists believes CNTs are positive relative to alternative energy production methods and that their assessment should not be colored by politicization. We later debriefed these participants and informed them whether “a consensus of scientists” actually believes this is debatable. We expect the warning will cause respondents to reject future politicization due to a directional motivation to uphold the initial opinion and be open to consensual scientific information—thereby decreasing individuals’ perceptions of threat and anxiety and increasing overall support for an emergent technology (see hypothesis 3, Table 2).

Condition 5 included a correction nearly identical to the just described warning, but it was presented to participants after they had already been exposed to politicization. Therefore, due to directional motivated reasoning and the initial opinion toward the technology formed in the presence of politicization, we expect that a correction will not be effective at counteracting politicization, resulting in increases in threat and anxiety and decreases in overall support for an emergent technology (see hypothesis 4, Table 2).

Condition 6 coupled the correction with a widely used method for inducing a motivation for accuracy. Participants were informed at the start of the survey, “At some point in this survey, we are going to ask your opinion about an approach related to energy production in the United States. When thinking about your opinion, try to view the approach in an evenhanded way. We will later ask that you justify the reasons for your judgment—that is, why the technology is more or less appealing” (see Lerner & Tetlock, 1999; Lord, Lepper, & Preston, 1984; Tetlock, 1983). We later asked participants to justify their opinions. Prior work demonstrates that inducing accuracy-motivated reasoning causes individuals to consider information in a more evenhanded fashion with the goal of arriving at an opinion that is correct, rather than one that upholds existing beliefs or protects existing identities (e.g., Bolsen et al., 2014b; Kunda, 1990). We thus expect that corrections to dismiss politicization coupled with an accuracy motivational inducement will decrease threat and anxiety and increase overall support for each technology, relative to those who receive no information (see hypothesis 5, Table 2). As mentioned, the dependent measures followed exposure to the experimental stimuli in all conditions.¹⁴

Results

As noted, we measured support for each technology with the three aforementioned items (support, investment, sustainability); we created scaled measures, using these three items for each technology, to gauge support for CNTs and for fracking. The items scaled together for each technology, coincidentally, with alphas of .94. We evaluate

Table 3 Determinants of Support, Anxiety, and Threat Perceptions Toward Fracking

	Support	Anxiety	Threat
Scientific information	2.14*** (0.08)	-1.44*** (0.10)	-1.98*** (0.14)
Politicized scientific information	-1.75*** (0.08)	0.66*** (0.10)	0.79*** (0.14)
Warning + politicized scientific information	1.79*** (0.08)	-1.31*** (0.11)	-1.11*** (0.14)
Politicized scientific information + correction	-0.05 (0.08)	-0.07 (0.10)	0.17 (0.14)
Accuracy motivation + politicized scientific information + correction	0.95*** (0.08)	-0.72*** (0.11)	-0.21* (0.14)
R^2	0.73	0.35	0.30
Number of observations	1,164	1,154	1,148

Note: Entries are ordinary least squares (OLS) regression coefficients with standard errors in parentheses.

*** $p \leq .01$. ** $p \leq .05$. * $p \leq .10$ (one-tailed tests).

Table 4 Determinants of Support, Anxiety, and Threat Perception Toward CNTs

	Support	Anxiety	Threat
Scientific information	2.26*** (0.09)	-1.48*** (0.10)	-2.40*** (0.11)
Politicized scientific information	-1.40*** (0.09)	1.16*** (0.10)	0.72*** (0.11)
Warning + politicized scientific information	1.59*** (0.09)	-1.18*** (0.10)	-1.08*** (0.11)
Politicized scientific information + correction	0.20** (0.09)	0.23*** (0.10)	0.20** (0.11)
Accuracy motivation + politicized scientific information + correction	0.80*** (0.09)	-0.53*** (0.10)	-0.36*** (0.11)
R^2	0.64	0.46	0.46
Number of observations	1,203	1,176	1,168

Note: Entries are OLS regression coefficients with standard errors in parentheses.

*** $p \leq .01$. ** $p \leq .05$. * $p \leq .10$ (one-tailed tests).

the impact of the experimental conditions on overall support, anxiety, and threat by regressing each dependent variable on the experimental conditions, omitting the pure control condition as the baseline (condition 1, Table 2).¹⁵ We present the results for fracking and CNTs, respectively, in Tables 3 and 4.¹⁶ (In supporting appendices available online, we report the means, standard deviations, and Ns for each condition for overall support, perceived threat, and level of anxiety for both technologies.)

The first column in Table 3 and Table 4 reports the impact of the experimental conditions on overall support for the technology. All reported p -values are from one-tailed hypothesis tests given our predictions are directional (Blalock and Hubert, 1979). First, in support of hypothesis 1, support for fracking and CNTs increases significantly when consensual scientific information is presented relative to the baseline

of no information. Also in support of hypothesis 1, the second and third columns in Table 3 and Table 4 show that anxiety and threat perceptions toward the use of the technologies significantly decrease as a result of exposure to positive consensus scientific information. This shows that, sans politicization, consensual scientific information is impactful in shaping opinions toward emergent energy technologies.

Of course, the impetus for the study is to explore what often occurs in political contexts: politicization. We find, in support of hypothesis 2, that anxiety and threat perceptions increase significantly in the presence of politicization and overall support significantly decreases for each technology (see Tables 3 and 4). Although this result accentuates that politicization undermines consensual scientific information, the results reported below demonstrate ways to counteract it.

We find strong support for hypothesis 3—that is, that a warning vitiates politicization and opens individuals to consensual scientific information. Indeed, Tables 3 and 4 show that the warning generated significantly higher levels of overall support for each technology relative to the baseline of no information. A warning, as Tables 3 and 4 illustrate, also reduces anxiety and perceptions of threat that stem from politicization for both fracking and CNTs. This is the first empirical evidence that we know of that demonstrates a way to counteract politicization. A warning establishes an initial attitude and causes individuals to dismiss subsequent politicization and attend to consensual scientific information.

Recognizing that one cannot always anticipate politicization, hypothesis 4 focused on the impact of a correction. It posited, however, that a correction to dismiss politicization after an opinion has already been formed in its presence, due to directional motivated reasoning, would not be successful at counteracting it, leading to increased anxiety and threat perceptions and decreased support. We find little support for this hypothesis. Table 3 shows that, in the case of fracking, the correction neutralized politicization, leading to no change in support relative to the baseline. This neutralizing effect is also apparent, in the case of fracking, with no significant difference relative to the baseline for measures of anxiety and threat perception. Table 4 shows that the correction, again counter to hypothesis 4, significantly increases overall support for CNTs; however, the correction did not counteract the increased anxiety and threat that stems from politicization in this case. We suspect that these mixed findings with regard to the effect of corrections across technologies sans an accuracy motivation reflect the inclusion of strong consensual scientific information on a topic where citizens lack much prior information. This may explain why we found a larger counteractive effect resulting from the correction on CNTs relative to fracking, as citizens know even less about CNTs than fracking. One intriguing question is whether under certain conditions citizens are willing to support emergent energy technologies—e.g., that offer alternative sources of energy—even if they feel some threat and anxiety simply because the counterfactual is a continued reliance on traditional energy sources (Bolsen, 2011; Bolsen & Cook, 2008).

To evaluate hypothesis 5, we assess the impact of a correction in the context of an inducement to form an accurate opinion. We find that an accuracy inducement along

with a correction counteracts politicization and increases support for both CNTs and fracking (see column 1, Tables 3 and 4). We also find, in support of hypothesis 5, that a correction along with the accuracy motivation reduces anxiety and threat perceptions toward each technology (see columns 3 and 4, Tables 3 and 4). This result demonstrates that an accuracy motivation can play a powerful role in counteracting politicization in the context of competitive communication efforts to open people to consensual scientific information.

We illustrate the substantive impact of the experimental conditions on overall support for each technology in Table 5 by reporting the percentage of respondents in each condition who express support above the neutral point (i.e., greater than 4) on the 7-point-scaled dependent measure. This may exaggerate the magnitude of the treatment effects given a tendency, sans information, for individuals to gravitate to the midpoint on the scale in the baseline condition. Moreover, we recognize that the size of the treatment effect is due, in large part, to the fact that most people had scant information on which to base their opinion across conditions and are captive to our survey treatments (Barabas & Jerit, 2010). The percentage of respondents expressing support for each technology is significantly higher in the presence of consensual scientific information relative to the pure control baseline (as previously demonstrated in Tables 3 and 4)—an increase in support from 17% to 95% for fracking and from 22% to 94% for CNTs. Politicization increases anxiety and perceived threat associated with the use of each technology, and this undermines the positive impact of consensual scientific information. In line with previous work (Bolsen et al., 2014a), politicization significantly *decreases* overall support for each technology relative to the pure control baseline. In the case of fracking, as Table 5 shows, only 4% of respondents support its use in the presence of politicization as compared to 17% in the baseline. In the case of CNTs, the decrease is smaller (5% decline) but remains statistically significant. The decline in support generated by politicization is substantial relative to the support generated by consensual scientific information in condition 2 (a decline from 95% to 4% support for fracking and from 94% to 17% support for CNTs, see Table 5). Perhaps equally striking is the impact of the warning that a scientific consensus exists and that politicization should be dismissed. In this case, as shown in Table 5, 95% of respondents in this condition express support for both fracking and CNTs.

A correction that follows politicization, counter to hypothesis 4, does have a significant effect in increasing support for CNTs relative to the baseline of no information (an increase from 22% to 32%); however, the increase in support for fracking relative to the pure control baseline (an increase from 17% to 20%) is not statistically significant. Nonetheless, in both cases, the correction has some effect at overcoming or neutralizing the negative effects stemming from exposure to politicization. Finally, as Table 5 shows, an accuracy inducement coupled with the correction has a sizeable impact on support for the use of each technology. For fracking, the motivation for accuracy increases the impact of the corrective information by 65% (from 20% support in the corrective condition alone to 85% support when the same information is coupled with an accuracy motivation; see Table 5). The sizeable impact of the accuracy

Table 5 Percentage Expressing Support for Each Technology

	Fracking	CNTs
Pure Control	17%	22%
Scientific information	95%	94%
Politicized scientific information	4%	17%
Warning + politicized scientific information	95%	95%
Politicized scientific information + correction	20%	32%
Accuracy motivation + politicized scientific information + correction	85%	76%

Note: The data above report the percentage of respondents in each experimental condition who express support greater than the midpoint on the 7-point scale (i.e., >4) for each technology.

motivation is also apparent in the results from the CNT study. The accuracy motivation coupled with the correction increases support for CNTs by 44% above the correction sans the accuracy motivation (from 32% support in the corrective condition to 76% when the same information is coupled with an accuracy inducement).¹⁷

To summarize, our central findings are:

- The politicization of science undermines the impact of positive consensual scientific information, increases anxiety and threat, and significantly decreases support for emergent energy technologies. Thus, as many have worried, politicization appears to have significant negative implications for new technologies in the absence of counteractive efforts—e.g., by individuals and scientific organizations.
- The impact of politicization can be counteracted by warnings, or corrections, which increase the impact of consensual scientific information and decrease anxiety and perceived threat stemming from politicization. As we anticipated, warnings are more effective than corrections at counteracting politicization given the prevalence of directional motivated reasoning in this domain.
- Corrections to dismiss politicization can be effective at combating politicization, especially in the presence of an accuracy motivation; however, a correction by itself does not always eliminate the threat and anxiety generated by politicization.
- Overall, warnings appear to be the most effective method to counteract politicization; however, should that not be possible, a correction can counteract politicization, particularly in cases where there is a scientific consensus and individuals pursue accuracy motivational goals in processing scientific information.

Conclusion

We offer a conceptual framework and empirical evidence on how the politicization of science operates in a competitive rhetorical environment. In doing so, we also put forth a research agenda with at least four pressing issues. First, scientists are an obvious potential source of counteractive communications. Yet, to date, scientists generally have not been active in policy debates. Uhlenbrock et al. (2014) explain, “scientists

shy away from being part of this dialogue because some science policy issues have become polarized ... [yet] however ominous it may seem for scientists to venture into the communication world, there is a great need not only for dissemination of the information but also for science to have a regular voice in the conversation" (p. 95) (also see Lupia, 2014). Scientists cannot do this alone, however, and thus some of the responsibility falls on scientific organizations: "Scientific societies and organizations can play a central role in science policy discourse in addition to an individual scientist's voice" (Uhlenbrock et al., 2014, p. 98; also see Newport et al., 2013). This is critical if scientific disciplines hope to present consensus or near consensus statements about varying scientific issues. As mentioned, the NAS serves this role as part of their mission, but, given the challenge of the current and changing media landscape, other disciplinary organizations need to complement the NAS both in identifying areas of consensus and in making a concerted effort to communicate findings to broader segments of the population. Promoting such communication is important to ensure not only adequate public understanding but also scientific funding. As Lupia (2014) makes clear, "*Congress is not obligated to spend a single cent on scientific research*" (p. 5) (italics in the original). He continues, "Honest, empirically informed and technically precise analyses of the past provide the strongest foundation for knowledge and can significantly clarify the future implications of current actions" (p. 5).

A second central issue involves citizen motivation. Given that, in most circumstances, communications attempting to counteract politicization come after it has occurred (i.e., a correction), our results highlight the importance of developing methods to motivate citizens to process information in an evenhanded fashion with the goal of forming and holding an accurate belief. Although the bulk of Americans may not currently be particularly motivated to process information on science-related issues in this manner, this could change as issues about sustainability and energy sources become more localized (i.e., personally relevant to individuals) (Druckman, 2013). For example, the use of novel approaches to obtain energy (e.g., fracking) becomes the subject of debate as they are implemented in local communities. Localization stimulates individuals to process information with an accuracy motivation (Dietz, 2013; Leeper, 2012; Lupia, 2013). Sinatra et al. (2014, p. 131) suggest that with sustainability issues, individuals who have a vested interest in understanding the best local outcome are *less likely* to engage in directional motivated reasoning (i.e., processing information with the goal being to protect one's existing beliefs) (also see Leeper, 2012). In addition to localizing issues, motivation can be induced when information comes from varying sources with ostensibly different agendas (e.g., a mix of Democrats and Republicans) (Bolsen et al., 2014b) and/or when individuals anticipate having to explain their opinions to others (akin to our experimental manipulation). This latter method can be pursued by increased usage of participatory engagement/deliberations where people have to justify their opinions and beliefs publicly (Dietz, 2013; Druckman, 2012, 2014; Klar, 2014; Sinclair, 2012).

Third, our results accentuate the importance of the quality rather than the quantity of political information. Social scientists often focus on "how much" individuals

know (for a detailed discussion of the normative criteria scholars have used to judge the quality of citizens' opinions, see Druckman, 2014)—this is captured in the scientific literacy framework of opinion formation (e.g., Miller, 1998). More information *per se*, though, does not generate opinions that cohere with extant scientific consensus (Kahan 2012; 2015; Kahan et al., 2011). What is more important is the type of information that is conveyed, with the key being communicating the existence of a consensus when it exists. This of course raises another perplexing issue, however. That is, whether scientists in this day and age can in fact arrive at a consensus and successfully communicate this in a way that informs public dialogue. As mentioned, we focus on situations in which positive consensual scientific information exists and the communications are in support of a technology's usage, but we acknowledge that arriving at this consensus in the first place can itself be difficult. Here, the obstacle is not communication *per se* but the need for scientists and scientific organizations to work toward arriving at consensual viewpoints and then, when not possible, highlighting points of consensus and areas of uncertainty (Dietz, 2013).

A fourth question for future work, in terms of studying communication effects, concerns what occurs when there is not a clear scientific consensus. It is critical to explore ways to credibly communicate alternative perspectives and the accompanying inherent uncertainty that accompanies scientific consensus statements. Identifying effective communication tactics and understanding how citizens process various forms of scientific information is of utmost importance to ensure science works to enhance human well-being.

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Notes

- 1 Frames are distinct from facts insofar as they prioritize a consideration that may—but need not—include factual content. Although frames sometimes include factual content, in practice, most frames are “fact free” (i.e., do not report a verifiable and reproducible observation stemming from the scientific method) (e.g., Berinsky & Kinder, 2006; Nelson, Oxley, & Clawson, 1997).
- 2 Interestingly, Bolsen et al. (2014a) also report that politicization does not undermine consensual scientific information *opposed* to the use of an emergent technology, likely reflecting the disproportionate weight of negative information (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001). We thus focus on situations where there is positive consensual scientific information regarding an emergent technology's societal benefits and where counter efforts are necessary to combat politicization.
- 3 This prediction is orthogonal to work on scientific literacy, which focuses on how accumulated knowledge about basic science influences opinions. Recent work suggests that those with more basic knowledge about science hold more polarized attitudes (e.g., Scheufele & Lewenstein, 2005, p. 660; Kahan, 2012, p. 735; Kahan, 2015). The critical distinction between our research and research on scientific literacy is that we focus not on

- the *quantity* of basic scientific information, as in prior work, but rather on the impact of high *quality* and specific information on opinion formation.
- 4 A National Research Council (1994, p. 4) report implicitly recognizes how politicization can undermine the impact of scientific information: “Decision-making based on risk assessment is also bogged down. Uncertainty, an inherent property of scientific data, continues to lead to multiple interpretations and contribute to decision-making gridlock.”
 - 5 Motivated reasoning encompasses a range of distinct goals, including defending prior opinions and behavioral impression motivation (see Kunda, 1999, Chapter 6); however, we follow political communication work to date focusing on directional and accuracy goals.
 - 6 The theory also suggests people seek out information that confirms prior beliefs (i.e., a confirmation bias), but that is not relevant to our focus (see Druckman, Fein, & Leeper, 2012). Also, Lodge and Taber (2013) explain, “The fundamental assumption driving our model is that both affective and cognitive reactions to external and internal events are triggered unconsciously, followed spontaneously by the spreading of activation through associative pathways which link thoughts to feelings, so that events that occur very early, even those that remain invisible to conscious awareness, set the direction for all subsequent processing. . . . A stimulus event triggers the stream of processing, proceeding through affective and then cognitive mediators, and perhaps leading to the construction of evaluations of political objects and conscious deliberation” (p.18). Lodge and Taber then depict the psychological process such that the emotional aspects are largely contained in the unconscious part of the processing that precedes the formation of stated attitudes. Along these lines, they point out that “absent from [our Figure] is any mention of emotions” (2013, p. 21). In short, emotions play an important role in motivated reasoning, but—because this occurs unconsciously and we do not explore unconscious processes—our focus is on the cognitive aspects of opinion formation.
 - 7 Druckman and Bolsen’s (2011) study is distinct from our focus because they explore the impact of a single piece of evidence that contains factual information (i.e., citing the results of a study) compared to a similar frame that lacks factual content (see endnote 1); they also do not study the impact of politicization or the impact of efforts to counteract it.
 - 8 Lodge and Taber (2013, pp. 35–36) explain that motivated reasoning, such as this, entails “systematic biasing of judgments in favor of one’s immediately accessible beliefs and feelings. . . . [It is] built into the basic architecture of information processing mechanisms of the brain.”
 - 9 Most past work on motivated reasoning focuses on how initial opinions with regard to a certain attitude object (e.g., an emergent technology, a political issue) shape subsequent attitudes and information-seeking behavior. Yet, the basic psychological processes apply straightforwardly to beliefs about politicization. Our hypothesis also coheres, to some extent, with inoculation theory, which suggests that warnings can shape the impact of subsequent attempts at persuasion. The difference is that the focus in inoculation theory is on how to prevent future persuasion, whereas our focus—based in motivated reasoning theory—is on how communications can allow individuals to dismiss politicization and be open to persuasion (Compton & Pfau, 2005; Ivanov et al., 2012; McGuire, 1964; Pfau, 1997).
 - 10 The expectation that warnings will have a greater impact than corrections is consistent with research in different domains that shows warnings exhibit stronger effects than

- corrections (Compton & Pfau, 2005, p.117; Einwiller & Johar, 2013, p.119; Pfau & Burgoon, 1988; also see Cobb et al., 2013, p. 308).
- 11 We hired the firm *ResearchNow* to conduct the survey. They collected the data from a non-probability-based but representative (on all key census demographics) sample of the United States. When it comes to experimental research, such a sample is sufficient to ensure generalizable causal inferences (Druckman & Kam, 2011). Supplemental appendices are available online that report the sample compositions.
 - 12 We used quotes from actual articles reporting the findings from studies on CNTs and fracking (Strehlow, 2005; Wines, 2013) that focused on evidence in favor of each technology's usage. As explained, this is a fruitful starting point given prior work suggesting that politicization renders positive information about the usage of an emergent energy technology impotent (Bolsen et al., 2014a). Other than identifying the source of the information as credible, we opted not to vary the source given that we believe this offers an important initial test. Future work should explore source dynamics but doing so would have at least doubled the number of experimental conditions in our large studies. The complete wording of the stimuli for all experimental conditions we discuss in the main text is available in supplementary appendices online.
 - 13 We found, in pretests, that politicization induced a belief that political considerations affected the presentation of scientific information. We also opted, in this initial study, not to present an explicit political agenda as motivating politicization so as to avoid confounds of political leanings. Clearly, future work is needed to isolate the impact of the political sources that use such communications.
 - 14 Both experiments included two additional conditions that we do not discuss in the main text. The first condition included the accuracy prompt along with politicization. The second included the accuracy prompt along with politicization preceded by a warning. We included these for exploratory purposes; we do not present them here because we had no clear expectations. Details reporting the exact wording of the stimuli for those conditions and all results are reported in supplementary appendices available online.
 - 15 We confirmed the success of random assignment, and thus, the results we report to assess the effects of the experimental treatments on our dependent measures are robust to the inclusion of a host of demographic variables. Additionally, we asked respondents, as a manipulation check, the extent to which political considerations affect the nature of the information that the public receives about the technology. As expected, individuals in the conditions where politicization was present viewed political considerations as significantly more salient than those in other conditions. These results are available in supplementary appendices available online.
 - 16 The Ns in the tables are slightly lower than the overall N due to non-response on specific items. Although it is implicit that anxiety and threat mediate the impact of the communications on overall support, the design of our experiment precludes testing for mediation (see Bullock & Ha, 2011).
 - 17 Two other findings are of note that we do not address in the main text. First, we asked respondents if they would like to be re-contacted with more information about either fracking or CNTs. The results—available in supplementary appendices online—show that the desire to obtain more information *decreases* in conditions where anxiety and threat decrease and support for the technology *increases*. For example, when positive scientific information is presented only 7% to 9% of respondents requested to receive more information about fracking or CNTs, respectively, whereas the percentages

requesting information in the presence of politicization ranged from 56% to 73%. A warning or correction with an accuracy motivation significantly reduced perceptions of threat and anxiety associated with each technology's usage and reduced the associated information seeking that anxiety and threat induce, with the warning generating a greater reduction than the correction. We anticipated these results given that it is well established that anxiety generates information-seeking behavior (e.g., Briñol & Petty, 2005, p. 298–299; Marcus, Neuman, & MacKuen, 2000, but see Case, 2012, Chapter 5, p. 115, on contexts where anxiety can lead to information avoidance). Nonetheless, they raise a perplexing challenge for science communication because efforts to reduce the impact of politicization when consensual scientific information exists cause individuals to be less interested in learning about emergent scientific technologies. Second, as mentioned in a prior note, we asked respondents the extent to which they believe that political considerations affect the nature of the information that the public receives when it comes to fracking or CNTs. Although we find that these scores significantly correlate with a different question that we asked about whether respondents believe political considerations affect the nature of the information that the public believes when it comes to science in general (for fracking, $r = .29$; $p \leq .01$; for CNTs, $r = .23$; $p \leq .01$), given the similarity of the questions, the modest size of the correlations suggests that politicization is a domain-specific dynamic.

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Supporting Information

Additional supporting information may be found in the online version of this article:
Appendix S1. Experimental Material and Additional Results