

UNDERSTANDING THE DEBATE: THE LIMITS OF SCIENTIFIC KNOWLEDGE

By

Jason Anthony Kalmbach

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ABSTRACT

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Jason Anthony Kalmbach

Policy debates feature conflicting causal arguments offered by political opponents in order to explain ongoing events. This characteristic is present in the current policy debate over climate change, with conflicting arguments emerging in an attempt to explain changes in global temperatures. Despite assertions by scientists that climate change is anthropogenic, disagreement remains within public opinion over the primary cause of climate change as well as the perceived threat if change continues unchecked.

A two-step process is introduced as a way to understand the polarization within public opinion. Utilizing a proprietary public opinion dataset, the analysis first considers how the public comes to understand the causal arguments relative to climate change. The acceptance of causal arguments, in turn, influence whether respondents are concerned about the phenomenon. In effect, a two-step process exists, where the public must understand the causal arguments before demonstrating an elevated level of concern for the problem.

The dissertation emphasizes the role of scientific knowledge and political values in shaping public opinion. Results support the argument that scientific knowledge guides the public's understanding and acceptance of the causal arguments associated with climate change, with most (but not all) high-knowledge individuals agreeing to even the most politically contested claims. Political values, however, also guide the acceptance of causal arguments and moderate the effect of knowledge. Once respondents accept the causal arguments offered by climatologists, however, they demonstrate an elevated level of concern. The dissertation concludes with a discussion of the

implications of the analysis, with consideration given to whether the polarization within public opinion can be mitigated through meaningful policy action.

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CHAPTER 1: INTRODUCTION

In the fall of 2010, a group of leading scientists and climate change advocates met to discuss the ramifications of “Climategate” for the scientific community in a webinar sponsored by the American Association for the Advancement of Science (AAAS).¹ During the discussion, the panel referred to growing polarization within the American public about whether climate change is occurring. While the public was already polarized on the issue to some extent, the gap between “believers” and “contrarians” grew during the first decade of the 21st Century.² Reports from climatologists working with the Intergovernmental Panel on Climate Change (IPCC) suggest that there is a “very high confidence that the net effect of human activities ... has been one of warming” – a claim that resonates with “believers,” who, for a variety of reasons to be discussed, agreed with the scientific findings (IPCC 2007, p. 37). The “contrarians” did not respond to the information within the IPCC report, with the allegations of fraud associated with “Climategate” perhaps reinforcing skeptical attitudes toward climatologists working with the IPCC.

The AAAS panel was alarmed by the growing disconnect between the “best” scientific information and beliefs of the public. In response, the panel discussed strategies to promote both the science supporting arguments for anthropogenic climate change and remedial policies that would mitigate greenhouse gas emissions. To generate increased policy support, the panel

¹ “Climategate” involved the unauthorized release of electronic communications between climatologists. In these communications, the climatologists referred to using statistical tricks in their research while also criticizing climate change skeptics. For some, these communications called into question the objectivity of climatologists. The event corresponded with a decrease in public belief in climate change, as well as a loss of trust in climatologists (Leiserowitz et al. 2013).

² “Believers” refer to individuals who readily accept climate change as ongoing and anthropogenic, while “contrarians” is a term often used by climatologists to describe individuals who call the scientific information into question.

discussed the importance of making climate change a real, meaningful concept to the American population. This meant informing the public about the merits of scientific arguments and connecting the effects of climate change to tangible phenomena in their everyday lives such as pollution and air quality. Both actions, however, assume the growing disconnect between climatologists and public opinion is the result of an unaware, scientifically unsophisticated public. If the public were simply better informed so that they understood the effects of climate change, then perhaps the polarization within public opinion could be reversed or at least minimized.

This argument is referred to in recent literature as the science comprehension thesis (Kahan et al. 2012a).³ These arguments suggest the polarization within public opinion could be mitigated by implementing policies to educate the public on the causes and consequences of climate change. Emphasis, then, should be placed on presenting the science to the American public “in plain English” to simplify the information and arguments presented by the scientific community. Recent studies, however, view the thesis with a degree of skepticism. As an alternative, these studies favor theoretical frameworks that emphasize values and risk perceptions as determinants of climate change beliefs (e.g., Kahan et al. 2011). Collectively, these alternative frameworks that emphasize values are referred to as the value-centered thesis.

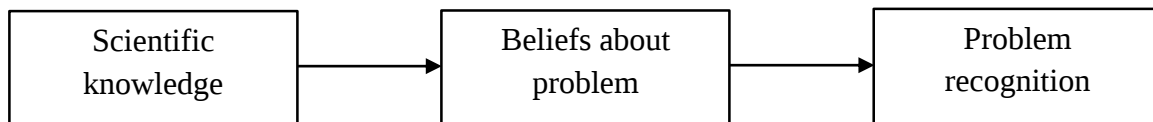
In this dissertation, I argue that the relationship between scientific knowledge and climate change beliefs is best conceptualized as a two-step process. This process envisions “problem understanding” as an intermediate step between scientific knowledge and more specific beliefs about climate change, such as concern and perceptions of a scientific consensus. The first stage of

³ The traditional science knowledge literature refers to the science comprehension thesis as the “deficit model” (Irwin and Wynne 1996; Sturgis and Allum 2004). The core arguments, however, are the same: a knowledge gap is responsible for public attitudes and beliefs that are inconsistent with the scientific community.

the process entails a direct relationship between foundational understanding of science and climate change beliefs (or what might be called climate change knowledge). That is, a basic understanding of molecules, DNA and physics provides a foundation from which individuals can learn about more complex scientific arguments such as the causes of climate change. Consistent with the science comprehension thesis, the expectation is that high-knowledge individuals understand the causal arguments about climate change in a manner consistent with the scientific community, or more specifically, climatologists.

The second step extends the analysis to problem recognition. That is, is the public concerned about climate change? Once individuals understand climate change in a manner consistent with climatologists, then they can determine whether the problem constitutes a threat. This second stage conceptualizes a direct relationship between problem understanding and problem recognition.

Figure 1.1: The two-step process



This two-step conceptualization, diagramed in Figure 1.1, is offered as a means to reconcile the science comprehension and value-centered theses. Prior research suggests each has a degree of merit, but neither research stream has properly recognized differences within the analyses or established the boundaries under which scientific knowledge correlates with climate change beliefs. This is because proponents of the science comprehension thesis have not assessed the thesis in a manner that is consistent with the causal mechanisms and expectations of the thesis itself. Researchers that focus on values inappropriately use the science comprehension thesis as part of a “straw man” argument in order to support arguments championing values as the primary

determinant of climate change opinions. The two-step process presented here is an attempt to assess the core argument of the science comprehension thesis and balance those arguments against research that emphasizes values.

Throughout the analysis, individuals are conceptualized as possessing a variety of orientations that predispose individuals to accept or reject propositions offered by climatologists. Two orientations of interest in this analysis are political- and science-based orientations, both of which are seen as drivers of climate change beliefs. It will also consider interactive effects between these orientations to assess what happens when individuals hold conflicting orientations. Conflict is expected because scientific information is not always compatible with political predispositions. If certain political orientations are given preference over science-based orientations, an interactive effect should emerge – one that shows high-knowledge individuals agreeing with climatologists at different rates, depending on value preferences.

The forthcoming analysis supports the argument that a quality scientific education (i.e., an orientation toward science) leads the public to accept the causal arguments offered by the scientific community, which is the key outcome measure that proponents of the science comprehension thesis have overlooked. This relationship materializes because individuals have the capacity and skillset to process and evaluate the competing causal arguments that emerge from both climatologists and their most vocal critics. This is, arguably, the essence of the science comprehension thesis. Qualifications are in order, however. Political ideology moderates the relationship between high-knowledge individuals and beliefs about climate change, with high-knowledge liberals accepting the causal arguments from climatologists at higher rates than high-knowledge conservatives.

More importantly, the analysis supports the two-step conceptualization. Evidence of a direct relationship between foundational scientific knowledge and specific climate change beliefs emerges. Once individuals understand climate change in a context similar to what climatologists working with the IPCC would suggest, a direct, positive relationship is observed between climate change knowledge and elevated levels of concern. A “profile” of an individual concerned about climate change is one who accepts the causal arguments from climatologists and is knowledgeable about science. Given the two-step process, the relationship between basic scientific knowledge and climate change concern, then, is perhaps best understood as an indirect relationship.

Assessing the merits of the science comprehension thesis is essential to understanding the prospects for remedial policies, such as those noted by the AAAS panel. If public opinion is dominated by political orientations, then the polarization within public opinion on climate change might appropriately be construed as permanent. However, if multiple orientations emerge, and if there is some “give and take” between an individual’s conflicting views, then perhaps the polarization can be mediated through purposeful action.

The discussion proceeds as follows: the remainder of this introductory chapter will discuss the status of climate change policy development within the United States, followed by a proposal that the lack of policy advancement in the United States, compared to other countries, is the result of polarization within American public opinion. Acknowledgement is then given to the larger literature about attitude formation before turning attention in Chapter 2 toward both the science comprehension and value-centered theses. The second chapter develops multiple hypotheses in an attempt to identify a proper understanding under which foundational scientific knowledge might lead to changes in public opinion. The third chapter summarizes the data and offers supplementary details about the construction of the science knowledge index. The fourth chapter offers an

empirical assessment of the first stage of the two-step process. Knowledge should help the citizenry understand the causal arguments coming from the scientific community. This relationship materializes because knowledge provides a foundation and skillset to talk and acquire information related to science issues (see Appendix A). The fifth chapter looks specifically at concern – the typical outcome variable in numerous climate change studies – and specifies a two-step relationship under which a basic foundational understanding of science might lead to higher levels of concern. Finally, the last chapter reviews the empirical results and their implications for policy change. It concludes by specifying a research agenda that extends the research presented here.

Climate Change Policy in the United States

The United States and other countries demonstrate a high degree of faith in the “miracle of science” because of the perceived benefits derived from a scientifically knowledgeable public, such as the discovery of advanced technologies that will improve society’s quality of life. The perceived economic benefits of technological advancement are sufficient to drive developing countries to focus their energy on building an internal capacity to pursue scientific advancements (Alberts 2011; Lawler 2011). Given this reverence toward science, one might expect countries to adopt policies designed to correct problems identified by scientists such as mercury-laced water supplies, acid rain and even anthropogenic climate change. This is not the case, however: several notable discrepancies exist. Despite being a global leader in science over the years, the United States continually fails to pass meaningful legislation – in the eyes of climatologists – to mitigate the effects of greenhouse gases in the eyes of climatologists (e.g., Schneider 2010). Meanwhile,

the United States' counterparts in Asia and Western Europe ratified the Kyoto Protocol and have taken steps to implement a cap-and-trade program for carbon emissions.⁴

These divergent policy responses are of note given the relative consensus among climatologists that the Earth is indeed warming due to human activity. One study (Oreskes 2004) suggests 75% of scholarly research either directly or indirectly supports the consensus view of the IPCC that climate change is anthropogenic. The remaining portion of scientific research takes no position on the issue of anthropogenic climate change. Another survey – directly of scientists and their opinions – finds 84% of scientists see global warming as the result of human activity (Kohut et al. 2009).⁵ The same study, however, found only 56% of the public claimed scientists agree global warming is the result of human activity.⁶

This public-expert disconnect, however, should be expected in some situations, contingent on the salience of the issue. When issues are complex and when the solution (or range of solutions) threatens core political values, there should be little expectation that policy outputs match the best available information. Because of value differences, competing interpretations of scientific

⁴ One related issue where the global community did pursue policy action is in the context of chlorofluorocarbons (CFCs). The Montreal Protocol, ratified by all member states of the United Nations, represented a collective attempt to reduce CFCs, which were blamed for destroying the ozone layer. The issue is fundamentally different from climate change on two fronts. First, ozone depletion has imminent health consequences. This increased the salience of the issue for the public, making it an issue that demanded attention. Second, there were technological solutions available or on the immediate horizon that would mitigate CFC emissions (Schneider 2010; Pielke 2009).

⁵ The Pew Research Center conducted the survey in cooperation with the AAAS. Pew drew 9,998 names from the AAAS membership rolls to solicit participation in the survey. Approximately 2,500 scientists took part in the survey.

⁶ This is not to say notable scientists do not disagree with the arguments of the IPCC. Richard Lindzen (2008) and Nir Shaviv (2006) argue the IPCC has overestimated the Earth's sensitivity to greenhouse gases and conclude natural variations are responsible for any observed change.

information emerge. Political leaders and media personalities attempt to frame the information in a manner consistent with their values (Jones and Baumgartner 2005). Because of this prolonged struggle, a gap emerges between existing policies and the additional remedial policies that advocates contend are necessary in order to mitigate the problem.

Conversely, when salience is low, information is more accurately used in policy debates (Mucciaroni and Quirk 2006). These are largely issues where bipartisan support for an action exists. Bipartisanship, in turn, exists when there is no value-conflict among partisans. Thus, issues with low-salience are areas where policy change can be anticipated. In this sense, science and policy are not entirely disconnected.

Climate change, however, is not a low-salience issue. A combination of interest group competition, continuous political commentary, and a sequence of alarmed discoveries work to keep the issue at the forefront of the public's consciousness. The range of solutions, which involve incentivizing or enforcing behavior change, lead to value-conflict. Many of the remedial policies proposed (which focus on greenhouse gas reductions) would reshape the existing energy market and are likely to have notable effects on both lifestyles and the price of consumer services (Brown and Sovacool 2011). In short, extensive government regulations would be required to achieve significant reductions in greenhouse gases. Historically, such extensive regulatory oversight is often contested in the American political system.⁷ Individuals valuing limited government and personal choice will view arguments for new regulatory policies with greater skepticism. However, other individuals value environmental protection and embrace the precautionary principle. In this

⁷ The exception, perhaps, is during times of perceived crisis, such as the New Deal under the President Roosevelt in the 1930s or the explosion of federal environmental regulations in the 1970s.

way, scientific information resonates with the ideological orientations of decision-makers and the public. As such, the ideological divide that occurs in the context of climate change should not be terribly surprising given the political polarization in America (Abramowitz and Saunders 2008; but see also Fiorina et al. 2005).

Resistance to remedial policies can also occur because elected leaders will protect their electoral district. If legislators wish to be re-elected, they must look out for the interests of their district (Fenno 1977; Mayhew 2004). Many districts rely heavily on the fossil-fuel industry, such as oil-, coal-, and gas-mining operations. These operations tend to overlap with conservative districts (e.g., in Texas, Oklahoma, Wyoming, and North Dakota) or districts that prefer conservative Democrats (e.g., in West Virginia). These districts may face economic hardships if new environmental regulations require greater use of renewable technologies such as wind and solar. What appears to be an ideological divide among decision-makers in Washington may alternatively be the result of legislators defending the economies of their respective districts (Roberts). Political tension and legislator self-interest, then, make it difficult to align policy with what might be perceived as the best available information.

Because of these differences, there has been little advancement in climate change policy since it became a prominent issue for climatologists in the 1980s. The last notable air policy passed by the United States Congress occurred in 1990, in the form of amendments to the Clean Air Act. This legislation implemented a cap-and-trade policy on sulfur dioxide emissions but did little to address rising greenhouse gas emissions. The Environmental Protection Agency (EPA), however, has considerable discretion to implement remedial policies, particularly after the United States Supreme Court in *Massachusetts vs. EPA* (2007) interpreted the language of the Clean Air Act to permit the EPA to regulate greenhouse gas emissions. At the time of this writing in mid-2013, the

EPA under President Obama has begun to initiate plans to regulate greenhouse gases more stringently.

Over the past few years, the EPA has taken small steps toward enacting policies that would mitigate greenhouse gas emissions. Two policies of note include an increase in fuel economy standards (Corporate Average Fuel Economy standards, determined in cooperation between the Department of Transportation and the EPA) and new regulations on power plants (Mercury and Toxic Air Standards, or MATS). While MATS' primary focus is on mercury emissions, it also includes restrictions on particulate matters, which have varying degrees of impact on climate change. The EPA's cost-benefit analysis anticipates MATS will reduce carbon dioxide emissions from coal-fired power plants by 1% annually (2012b) while the CAFE standards will lower the United States' total carbon emissions by 4% by 2030 (EPA 2012a). While these are significant efforts, they fall short of the Kyoto Protocol's call for an 18% reduction in carbon emissions from a 1990 baseline.

The bulk of climate change policy in the United States, however, has occurred at the state level (Gamkhar and Pickerill 2012; Rabe 2010). In the New England area, several states have pursued a regional cap-and-trade program referred to as the Regional Greenhouse Gas Initiative (RGGI) while 29 states have pursued renewable portfolio standards that require energy sold within the state to be produced by varying mixtures of renewable technologies. Meanwhile, California has used its exemption within the Clean Air Act to pursue higher, more rigid air quality standards than those set by the EPA for the rest of the nation. One of the themes of state variation is that, reflective of the political characteristics of the United States, liberal states often lead in terms of adopting climate change policies (Liang and Fiorino 2013; Matisoff 2008).

Public Opinion & Policy

Multiple avenues exist to understand this lack of policy development within the United States. Interest groups, mass media outlets, and political elites all receive and interpret scientific information. An additional explanation that cannot be ignored is the role of public opinion in the policy process. In a democratic society, elites who are elected by the public make decisions. If decision-makers deviate too far from the preferences of their constituents, voters potentially hold them accountable in the next election cycle. Indeed, if reelection is a primary goal of legislators as Mayhew suggests, then decision-makers should approve policies that conform to the opinions of the public. This link between public opinion and Congressional behavior has been termed responsiveness (Achen 1978), with scholars tending to find support for the idea that policy outputs follow public opinion (Page and Shapiro 1983; Wright et al. 1987). This relationship occurs because both public opinion and elite behavior tend to move in the same direction (Ansolabehere et al. 2001; Griffin 2006), with legislators adapting to changes in the opinions of their constituents (Stratmann 2000). This relationship occurs both at the federal and state level, with state policy scholars estimating that, on average, policy and public opinion are aligned 48% of the time across all states (Lax and Phillips 2012). A meta-analysis of research assessing the connection between public opinion and policy adoption suggests “public opinion affects public policy three-quarters of the time” (Burstein 2003). Scrutinizing public opinion, then, is one way to understand the lack of policy development within the United States.

Sources of Climate Change Attitudes

While the discussion here is focusing on science and political orientations, it is useful to acknowledge that there other concepts said to influence public opinion – both in general and with respect to climate change. What is important to note is that scientists are not alone in offering

information to the public. Media outlets, political parties and other trusted personalities assess the information from scientists and offer their own interpretation of the information to the public. Thus, it is difficult for new information to bring about belief change precisely because more often than not, groups are consulting with others and offering their own interpretation on the information. Thus, beliefs may or may not be consistent with the original information as offered by scientists. Despite the prestige afforded to science, the ability of scientists to influence public opinion (and subsequently policy) is not guaranteed. Although Miller (1983) reports the general public views scientists as the group most capable of solving complex societal problems, there appears to be a partisan dimension as well. Partisans are more likely to follow party leadership than defer to experts, although non-partisans appear more likely to align their views with those of experts (Kuklinski et al. 1982). While the purpose here is not to develop or test an exhaustive list of factors that may influence opinions, a few are worth mentioning since there is an opportunity for non-experts to mute the influence of scientists and thus increase the expert-public disconnect.

Media Effects

First, the mass media, whether through the Internet, newspapers, or radio talk shows, have the capability of “priming” information. Under this conceptualization, the media are a powerful influence that can shape beliefs by controlling the amount or degree of information made available to the public. If a media outlet wants to make the public aware of an issue, it can bombard audiences with news about the particular issue. If an issue is consistently discussed, then there is more information available for the public to develop views based on that information (Krosnick and Kinder 1990; Zaller 1992; Barker and Knight 2000). While advocates, such as some climatologists, may be involved in “hammering home” their research to the public through the media, the above studies suggest it is just as easy for a contrarian to fight against climatologists by delivering a

strong, consistent message that questions the scientific evidence. Generally, exposure to science via media reports appears to correlate with positive feelings about scientists. However, exposure to negative images of science via the media correlates with increased levels of reservation about scientific advancements (Nisbet et al. 2002).

In addition to flooding the information environment with news and letting the public absorb the content, the media (as well as other elites) can frame issues in a particular manner that stresses certain characteristics of a story that can alter public support for a given issue. Under this conceptualization, a single belief held by an individual is formed by multiple underlying beliefs. These underlying views are weighted by some unknown factor. By emphasizing some themes over others, media outlets can alter the weights associated with a given belief. This shift in weights produces the observable changes in public opinion during framing experiments (Chong and Druckman 2007).⁸

To illustrate in the context of climate change, individuals hold some baseline opinion about the tradeoffs between environmental regulations and economic prosperity. Framing maneuvers by media personalities emphasize one of these two aspects when discussing remedial policies that would reduce greenhouse gas emissions. A frame that emphasizes the cost of a cap-and-trade program on carbon emissions pushes receptive listeners to place considerably more weight on economic prosperity, thus shifting some public support away from the cap-and-trade program. Alternatively, emphasizing the dangers of climate change can push some (but not all) media consumers toward support for improved environmental regulations. These frames thus alter the

⁸ The framing literature argues the context of the story influences attitudes, while the priming literature refers to the frequency with which the story is presented to the public.

weights associated with the underlying beliefs used by individuals to make decisions about climate change, such as whether climate change is anthropogenic.

Framing does have its limitations, especially when media consumers question the credibility of the news source or the quality of the frames (Druckman 2001). If there is no trust in the person doing the framing, the frame is likely to have a minimal impact. Generally, scientists are seen as trusted sources of information, although even then that trust varies by who exactly is carrying out the research. For instance, Critchley (2008) argues the public is more likely to trust public scientists compared to corporate scientists. Greater trust in scientists leads to more support for scientific research. In the context of climate change, there is considerable polarization in the level of trust held for the IPCC – especially after “Climategate” (Leiserowitz et al. 2013). Some individuals, then, will inevitably tune out the work of scientists, and the resulting arguments, from the IPCC.

In fact, divergent messages have emerged from the media in the context of climate change in an attempt to frame the issue in a preferred manner. Conservatives, especially, have made efforts to frame the debate in a manner opposed to climatologists. A study of the divergent views offered by conservative think tanks suggest a coordinated theme, consisting of two claims: (1) “the science of global warming appears to be growing more and more uncertain; ” and (2) “the harmful effects of global warming policy are becoming increasingly certain” (McCright and Dunlap 2000, p. 499). These arguments are inconsistent with those of the IPCC, which emphasize areas of scientific consensus and discuss the consequences of inaction.

The idea of trade-offs from this framing discussion is worth emphasizing. Pielke (2010) refers to the perceived trade-off between economic prosperity and environmental protection as the “iron law of climate change.” Whether the trade-off is real or not, advocates must be prepared to

respond to claims by opponents that a new policy will adversely affect the economy. This is even though a majority of the public appears to think economic success and environmental protection (broadly defined) are not mutually exclusive (Guber 2003). Still, a specific, targeted frame that emphasizes economic costs does appear capable of swaying public opinion. In the context of expanding nuclear power and wind energy, frames emphasizing economic costs have rallied the public against the expansion of these alternative technologies (Pralle and Boscarino 2011).

Framing is also an issue in the context of the survey questions used to explore opinions of climate change. One study (Schuldt et al. 2011) finds, through a survey experiment, that whether the problem is referred to as “global warming” or “climate change” produces dramatically different results. Republicans are more likely to agree that the problem is real if it is referred to as climate change rather than global warming. This pattern was also found to reflect the way conservative think tanks discuss the issue, with references to the problem as climate change rather than global warming. No such differences emerge with Democrats. Thus, part (but not all) of the polarization within public opinion might be the result of survey wording.

To reiterate, how issues are framed can shape how the public approaches the issue. Conservatives are strategically framing the problem in a manner that is inconsistent with the IPCC, which in turn can potentially shape broader public opinion. It is important to note that an examination of the public’s level of concern over a nine-year period (2002 to 2010) does not find a substantively powerful relationship between media activity and fluctuations in climate change concern (Brulle et al. 2012).

Self-Interest

A second path worth noting is self-interest. Science can be complex, and something “special,” such as self-interest, might be required in order for the public to align their views with

scientists. This is especially true when the problem is distant and invisible, as is climate change. The political science literature has generally found little or weak evidence of self-interest correlating with public attitudes (Sears and Funk 1990). Symbolic attitudes, such as partisanship, are argued to be the root source of attitudes in all but a few cases. In their review of the literature, Sears and Funk argue self-interest contributes to beliefs under only three circumstances: (1) when high levels of magnitude and clarity make the personal stakes clear, (2) when the consequences of the policy are ambiguous, and (3) when politicians press, or perhaps prime, the self-interest issue. Furthermore, they suggest these relationships are minimal and might even be exaggerated due to survey design issues. Follow-up work supported these conclusions, noting “neither greater political sophistication or emotions, nor social identifications or political values, nor perceiving an issue to be a serious national problem, have been sufficient to make self-interest salient” (Lau and Heldman 2009, p. 527-528).

The conditions of influence found by Sears and Funk (1990) suggest that if self-interest has any potential to promote congruence between scientists and the general public, such effects are most likely be found when considering issues where the health or safety of the population is at stake. When scientists raise alarms about consumer products causing cancer or the dangers of toxic fumes, they send a signal to the population that their well-being is endangered and that precautionary actions should be taken. However, the political battle to interpret the information can muddle the signal received by the population about whether a danger truly exists. Despite scientific studies citing smoking tobacco as a cause of lung cancer, segments of the public have bought into the counter messages from the tobacco industry, (which, naturally, has denied the claim), and continue to smoke.

Some limited evidence suggests – at least in the context of environmental policy – that a form of self-interest can alter individual beliefs. This evidence comes from a specific area of research that looks at whether local environmental conditions correlate with environmental views. Directly experiencing poor environmental conditions helps individuals recognize environmental problems and align their beliefs with scientists. The experience makes the science “real” for them, giving them a context that helps them adjust their beliefs accordingly.

When looking at climate change, both Hamilton and Keim (2009) and Egan and Mullin (2012) find a pattern of regional variation in beliefs that correlates with the weather conditions those regions experience. That is, warmer winters increase the probability of respondents perceiving a personalized effect from climate change. In this situation, the observed temperature provides a signal to individuals that climate change is a meaningful phenomenon with real implications. The analysis is expanded in a separate article where the authors find that place effects are not just limited to beliefs about climate change but also speak to larger environmental perceptions (Hamilton et al. 2010). However, it has been suggested “experiential learning” is limited to individuals not already engaged in the climate change debate or committed to beliefs on climate change (Myers et al. 2013)

Borick and Rabe (2010) ask why individuals believe climate change is real. They find that experiencing local weather phenomena may facilitate affirmative climate change beliefs. In this instance, residents of Mississippi were more likely to report violent hurricanes as the source of their beliefs regarding climate change. Furthermore, the occurrence of hurricanes seems to have encouraged Republicans in the state to overcome their partisan predispositions by leading them to believe in climate change at rates higher than Republicans in other states.

Further illustration comes from Brody et al. (2008), who find detectable variations by community when considering perceptions of climate change risk. Localized measures, such as residing in a floodplain and experiencing economic damage from natural events, produce variations in the level of the public's perception of environmental risks, even after controlling for demographic and partisan measures.

Disputed evidence exists that the public is capable of identifying their own self-interest when it comes to more subtle problems such as air quality.⁹ Work by Jacquemin et al. (2007) finds a positive correlation between self-reported annoyance with outdoor air pollution and actual measures of air quality (particulate matter and sulfur) in European communities. This suggests that individuals are capable of gauging the quality of their air, whether through independent means or relying on reports from European environmental regulatory agencies. Brody et al. (2004), however, found no relationship between perceptions of air quality and actual pollution levels in a study focusing on Texas. Furthermore, Brody and Zahran (2007) note the wording of the question used by Jacquemin and colleagues adds a degree of bias to the analysis. Consequently, it remains unclear as to whether individuals can identify whether there are pollution issues with their local air quality.

Still, it is worth recognizing that individuals are not ignorant when it comes to the dangers of burning fossil fuels. Outdoor, rural communities are generally associated with a pristine, uncontaminated environment. Power plants, factories and congested streets – typical of urban settings – are not associated with clean air. At the very least, individuals seem aware of the

⁹ Compared to thoroughly understanding all the risks associated with climate change, it might be easier for individuals to identify areas with substandard air quality. Smokestacks, smog, and foul odors provide simple cues that can be used to gauge local air quality.

potential negative effects associated with power plants operating on fossil fuels (Ansolabehere and Konisky 2009). This suggests individuals maintain at least a minimal capacity to identify problems in their community and recognize, based on self-interest, that such conditions are undesirable for their health and well-being. It also underscores the importance of the ability of individuals to personally experience environmental problems when evaluating the merits of specific causal arguments (Stone 2002).

Partisan Cues

One final concept is political partisanship, which functions as a heuristic utilized by the public when forming opinions on contemporary policy issues. Partisanship is a social identity, in that individuals identify with the party that best matches their interests or “speaks” to them (Green et al. 2002). One who places a premium on moral values or identifies with moral issues will favor the Republican Party under this conceptualization. However, this does not mean that individuals care about or are concerned with all the views of the party. In some areas, an individual may have no initial preferences on a given issue. When they need to make decisions (or answer a survey question), they look at the stance of their preferred party on the issue. Since the party leadership is trusted, partisanship functions as a heuristic and guides individuals toward the views they “should” adopt as a member of that party. They drift toward the party’s position because they trust the party leaders to offer a valid interpretation. Self-identifying Republicans who are not concerned about the environment, for instance, are not going to spend time attempting to understand climate change. Instead, they look to the party and receive a reinforcing message that anthropogenic climate change is either false or at least highly contested among scientists (Feldman et al. 2011; McCright and Dunlap 2000). Conversely, Democrats with little knowledge or interest in science receive a reinforcing message from party leaders that anthropogenic climate change is ongoing. Thus,

acceptance or rejection of climate change beliefs comes from a signal provided by trusted political elites, not necessarily from one's level of knowledge or value preferences.

Evidence seems to suggest that as political parties adopt clear positions on an issue, the public molds their opinions to match their preferred party's platform (Carmines and Stimson 1986). This is one potential explanation for the increased polarization between Republicans and Democrats regarding beliefs about climate change (Dunlap et al. 2001; Dunlap and McCright 2008; McCright and Dunlap 2011). Both Republicans and Democrats battled for the "green vote" in the 1970s, but ultimately President Nixon was not willing to go as far as some of the citizenry desired. Over time, Republican elites developed an anti-regulatory approach to environmental issues while Democrats incorporated environmentalists into their party's base. Today, the Republican Party rejects the idea that corrective policies, such as cap-and-trade, are required to mitigate carbon emissions because the dangers of climate change are either false or exaggerated by scientists. Meanwhile, the Democratic Party has long been seen as the party of environmental concern.

In short, a strong Democrat does not need to be familiar with the science in order to support the position of his or her party, nor does a Republican need to know what the IPCC says in order to reject claims that climate change is anthropogenic. Partisans with no opinion or knowledge regarding climate change can turn to their preferred party for signals about what position they should adopt on the issue. The use of political heuristics is consistent with Zaller and colleagues' (Zaller 1992; Zaller and Feldman 1992) conceptualization of public opinion, where individuals have a tendency to mimic attitudes they are familiar with from the information environment. As such, individuals are likely to rely on other sources of information besides expert commentary.

Next Steps

In the next chapter, I pursue a theoretical framework to identify a more accurate understanding of the relationship between scientific knowledge and climate change beliefs. The discussion will first offer a framework to understand public opinion. It then elaborates on the historical development of the science comprehension thesis and the expected role of knowledge in the public's decision-making process. The second step explores the limits of scientific knowledge and develops an understanding for why information – even information offered by the best and brightest scientists – may be dismissed. The discussion suggests that while there is support for the science comprehension thesis, there is also reason to suspect the relationship between science knowledge and beliefs is not uniform for all ideological groups. The motivated reasoning theory is used to reinforce the expectation that the effect of knowledge is conditional, based on one's political orientations. The two-step model is then proposed as a means to understand the relationship between science knowledge and climate change beliefs. Chapter 3 presents the survey data utilized in the analysis and discusses the operationalization of key concepts. Chapter 4 examines just the first stage of the two-step process while Chapter 5 assesses the entire model. The last chapter reviews the results and discusses the implications of the research.

CHAPTER 2: SCIENTIFIC ORIENTATIONS & THE LIMITS OF KNOWLEDGE

Over the last three decades, the scientific community has emphasized the value of a scientifically knowledgeable public. By accumulating knowledge and understanding scientific processes, the public will be in a position to understand complex policy debates because they have the skill and capacity to evaluate competing causal arguments about alleged problems and, in the end, make informed decisions about whether the problem merits attention.¹⁰ It is often presumed knowledge ultimately leads the citizenry to accept the causal arguments offered by the scientific community. For instance, a panel assembled by the AAAS (noted earlier) speculated that the scientific community should work on increasing the public's awareness of scientific information as a means to persuade the public about anthropogenic climate change (2010). The panel's discussion occurred in the aftermath of "Climategate," when doubts about the validity of climate change rose noticeably. Discussion points included how the scientific community should respond to increasing doubt as well as how policies should be framed in order to generate public support. The assumption is that once the public understands the scientific merits of an argument, then the citizenry will come around to the idea of anthropogenic climate change and accept remedial policies designed to mitigate greenhouse gas emissions.¹¹ Oddly, as will be noted in the forthcoming section, this is a relationship in the literature rarely explored by proponents of the science comprehension thesis.

¹⁰ Boosting scientific knowledge also creates an additional benefit in that exposure to science inspires young minds, which will help draw promising students to STEM (Science, Technology, Engineering, and Mathematics) careers.

¹¹ These arguments are not exclusive to climate change. Evolutionary scientist Richard Leaky, for instance, predicted an end to the public debate over evolution (Eltman 2012). The accumulating scientific information is so convincing that in 15-30 years Leaky believes no one will be able to reject Darwin's basic theory of evolution given information derived from the fossil record.

Recent research, however, casts doubt on whether those possessing elevated levels of scientific knowledge think differently about issues compared to their low-knowledge counterparts. This evidence is particularly notable in the context of climate change. For instance, scholarship suggests there is no relationship between one's level of scientific knowledge and concern over climate change (Kahan et al. 2012a). Instead, values – specifically cultural values – are the optimal predictor of climate change beliefs (Kahan et al. 2011; Kahan et al. 2012a). With this conceptualization, there is little to no opportunity for information to shape beliefs regarding contemporary policy issues such as climate change. Thus, information offered by the IPCC or other science agencies that details the extent of a problem or underscores the need for corrective policies is unlikely to have a meaningful impact on how the public views the phenomenon. These frameworks that emphasize values are collectively referred to as the value-centered thesis.

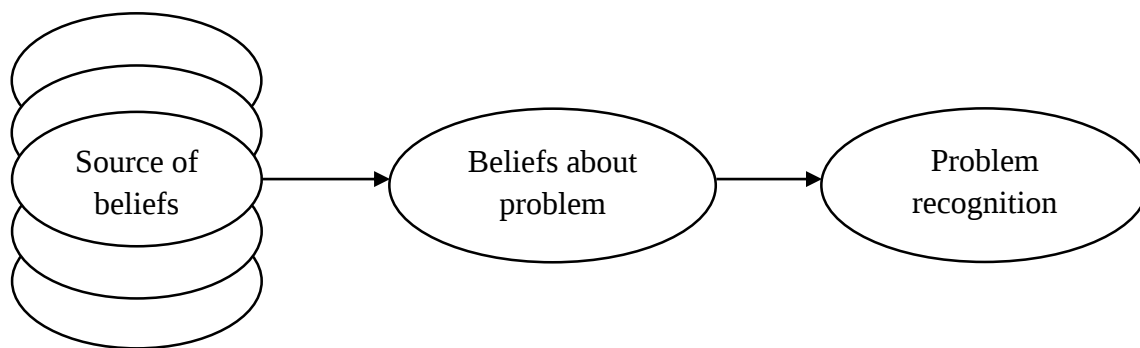
This discussion attempts to reconcile these competing views about the relationship between scientific knowledge and climate change beliefs. While accepting the basic tenants of these two theses, I argue neither conceptualizes the appropriate conditions under which scientific knowledge might guide or otherwise influence public opinion. Both views are discussed in more detail in the following sections, with hypotheses offered as part of an attempt to reconcile the two views. Both views are understood as having a degree of merit, yet careful consideration is required toward the causal mechanisms at work and the use of proper dependent variables given those causal arguments. In the end, a two-step process is conceptualized as one way to reconcile these competing theses.

A Framework of Public Opinion

The foundation for the proposed two-step process is rooted in a framework of public opinion that conceptualizes a sequence of steps utilized by the public to understand policy debates.

The discussion focuses on three related aspects of public opinion: sources of beliefs, beliefs about a problem, and problem recognition. Conceptually, they are diagrammed in Figure 2.1, with a natural progression between the three concepts. The multiple rings on the far left represent the various sources of beliefs often discussed in the literature. As noted earlier, partisan cues are one source of beliefs, as are self-interest and information from various media sources. Knowledge, cultural values, and risk perceptions fall under this grouping as well.

Figure 2.1: The two-step process, general framework



With this progression in mind, I start with the proposition that individuals possess a belief system that they utilize to navigate contemporary policy debates. This belief system is similar to a blueprint as it provides a guide to understanding the competing causal stories that are offered by policy advocates, decision-makers, and media pundits. For purposes here, a belief system is a collection of orientations individuals rely on when formulating specific beliefs that are relevant to political discussions.

At any given time, individuals have basic beliefs and assumptions about the world. These include views about appropriate government activity, the trustworthiness of select actors, how to handle risk and uncertainty in decision-making, as well as the nature of the relationship between humans and their environment. An orientation is a collection of beliefs and assumptions on a broad subject matter. For instance, individuals can possess orientations toward government, science,

religion, and the environment. A political orientation might include views about proper government activity, how collective decisions should be reached, the degree to which society should defer to experts, and whether decision-makers are inherently trustworthy.

For some individuals, there might be patterns as to how these orientations are bundled together. That is, a sizeable portion of the public may share a belief system with similar orientations toward government and science. For others, their belief system might resemble a seemingly random or complex mix of orientations. Sabatier and Jenkins-Smith (1993), as well as others, argue belief systems are well organized, with a clear structure and interrelationship between the various orientations. However, they argue higher levels of organization are mostly reserved for political leaders and the well-educated. The belief systems held by the public, on the other hand, are not as organized. However, others (Carmines and Stimson 1986; Zaller 1992; Zaller and Feldman 1992) have pointed out that the public tends to mimic elite discourse, using it as a heuristic for the formation of their own beliefs. A reasonable expectation exists that the belief systems of the public should feature similar organizational patterns as opinion leaders, if they receive a clear signal.

Regardless of how well they are structured, belief systems are utilized to understand contemporary policy debates. At any given time, an individual, advocacy group, or politician might declare that a problem is at hand – something that requires a solution in order to improve society. The public makes sense of these claims by deferring to their belief system. Decisions about whether to accept anthropogenic climate change as fact, believe in evolutionary theory, or support stem cell research, all flow from some mixture of orientations that assign a sense of “right” and “wrong” to the propositions that work their way into policy debates.

Sources of Belief Systems

One's belief system is the product of a socialization process. Developing and assimilating multiple orientations to form a coherent belief system starts at an early age, where parents imbue their children with a set of values and beliefs as part of the childrearing process. For children, relying on parents is an easy, convenient heuristic to developing a belief system (Achen 2002). A lack of parental guidance, however, is not an obstacle to developing a coherent belief system, as other resources are also available to help guide youth. These other socialization processes include primary and secondary education, social interaction with friends and teachers within the local community, and even consumption of basic news. In this socialization process, adolescents are also accumulating knowledge – from parents, family and teachers in the classroom. Adolescents match newly obtained knowledge with the preexisting beliefs and values they learned at a younger age. Sometimes the knowledge is incorporated into the belief system, stored for later use as part of the master blueprint utilized for guidance. Other times, the knowledge is rejected.

This socialization process is ongoing. At an early age children develop beliefs as well as a willingness to express adult-like opinions (Sears 1975), although those beliefs may or may not be firmly held until overt political action such as voting is taken. By the time individuals can participate formally in the political process, they have developed the beginnings of an ideological framework that filters political events (Beck and Jennings 1982; Jennings and Markus 1984; Niemi and Jennings 1991). This ideological framework is the primary lens utilized by the citizenry to navigate policy debates (Converse 1964). Other concepts have been argued on occasion to guide specific beliefs and policy attitudes, such as self-interest, personal experiences and knowledge, yet ideology and partisanship are often found to be the strongest predictor of beliefs and policy preferences (Sears and Funk 1990; Lau and Heldman 2009).

Once individuals have developed a belief system (the first column of Figure 2.1), they are in a position to make decisions about specific beliefs that arise during policy debates. Are the poor deserving of welfare? Does hydraulic fracturing contaminate the water supply? Do vaccinations have deadly or life-altering side effects? Policy advocates offer competing causal stories to the public in order to shift opinion toward the advocates' preferred answer. Individuals rely on their belief system in order to navigate the competing causal arguments that emerge. Once deciding on what to believe about an alleged problem, the individual is in a position to decide whether the problem warrants a degree of concern.

This conceptualization offers a logical progression from a starting point (belief system) to an end point (problem recognition). Intuitively, this series of relationships is appealing. There is a reasonable expectation that individuals who are concerned about climate change also possess various beliefs about climate change. In turn, these specific beliefs about climate change come from some belief system that might include one's technical understanding of climate change, ideological preferences for what constitutes appropriate government activity, or general beliefs about the relationship between humanity and the environment.

Climate Change Context

In the context of climate change, there are at least two orientations that help individuals navigate the policy debate. Political orientations guide beliefs, which involve ideas about the proper role of government. Scientific orientations also provide a basis for belief formation, guiding how information provided by scientists is interpreted. These orientations are used to form specific beliefs about climate change. Figure 2.2 offers further details about the basic components associated with these two orientations. How individuals respond to the items listed in Figure 2.2 determine their precise orientations toward politics and science, respectively.

Table 2.1: Sample of the views associated with political and scientific orientations

<i>Political orientations</i>	<i>Scientific orientations</i>
• the proper role of government; • how collective decisions should be reached; • the degree to which society should defer to experts on complex decisions; and • the definition of a public problem.	• the veracity of claims from analyses adhering to the scientific method; • the trustworthiness of scientist; • the appropriateness of evidence required to justify beliefs; and • the benefits of scientific advancement.

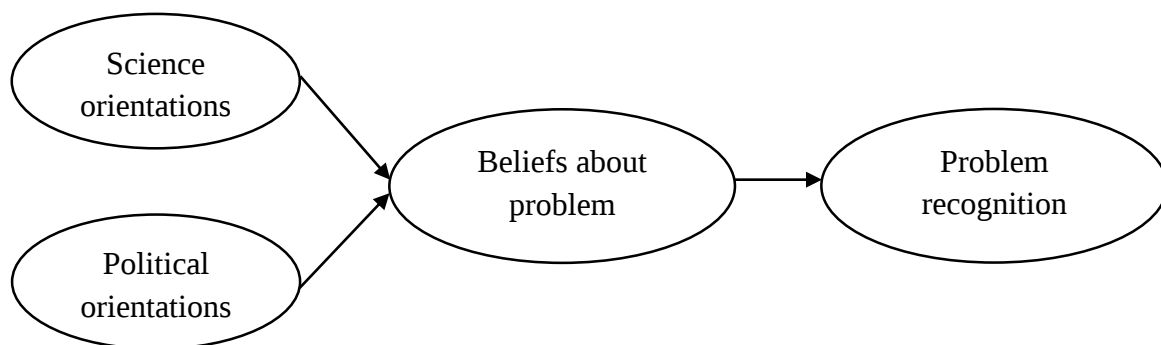
In the policy debate over climate change, there are at least three contested issues of interest in this study. In each area, policy advocates offer conflicting causal arguments. Individuals must rely on their belief system (that is, their mix of political and scientific orientations) to make sense of the conflicting arguments. First, disagreement exists about whether the Earth is warming. Are temperatures increasing? If individuals have researched the question, they might be familiar with temperature records produced by the IPCC and other agencies. They also have their own experiences with local weather conditions. Scientific orientations can guide individuals in terms of understanding the systematic processes of collecting data, and whether they trust scientists to accurately report the data. Political orientations can guide individuals by predisposing them to either outright reject or accept the information.

Second, disagreement exists about the sensitivity of the Earth to human influence, and whether society can even engage in activities that would contribute to a warming climate. In other words, how sensitive is the Earth to the burning of fossil fuels, the release of toxic compounds, the destruction of ecosystems, the harvesting of natural resources, and many of the other activities society engages in on a daily basis? Again, one's belief system provides a roadmap to answering these questions. A scientific orientation might lead some to accept the physics behind the arguments of climatologists while a political orientation may lead them to accept or reject the arguments out of disdain for relying on experts.

Third, disagreement exists about the cause of changes in the Earth's temperature. Since the 1970s, satellites have provided a modern temperature record for climatologists to analyze while various other proxies such as tree rings and ice cores provide temperature readings going back even further, to hundreds of thousands of years ago. These temperature readings can be used as a dependent variable in elaborate time-series analyses in an attempt to parse out explanations for changes in temperature. Disagreements occur over which explanatory concepts are driving observed temperature change, or even whether the statistical models include appropriate assumptions that fit the data. This is perhaps the most contested component of the climate change policy debate. The two orientations guide individuals in terms of informing them of whom to trust and what constitutes appropriate processes to justifying knowledge.

The model tested in the forthcoming analyses is consistent with Figure 2.3, where specific beliefs about climate change derived from both scientific and political orientations. These orientations guide individuals as they make decisions about whether to accept or reject the causal arguments offered by climatologists. Once the problem is understood, individuals are in a position to make an informed decision about whether climate change is a problem. In the following sections, both science and political orientations are discussed in more detail, with specific hypotheses offered in order to assess the science comprehension and value-centered theses.

Figure 2.2: The two-step process for climate change beliefs



The Science Comprehension Thesis

For some time, possessing various types of education or knowledge has been recognized as a key characteristic of individuals demonstrating higher levels of civic responsibility. In the political context, knowledge strongly correlates with the retention of political information (Price and Zaller 1993), which in turn helps the citizenry identify preferred political candidates (Gelman and King 1993), assess political performance via merit rather than personal factors (Popkin and Dimock 1999), and participate in elections (Popkin and Dimock 1999). Those with higher levels of knowledge also maintain more stable attitudes (Delli Carpini and Keeter 1996). Once knowledge is obtained, the citizenry appears to retain that knowledge throughout the remainder of their life (Jennings 1996). In short, political knowledge is a key component in understanding civic behavior. Putnam referred to education as “one of the most important predictors – usually, in fact, the most important predictor – of many forms of social participation – from voting to associational membership, to chairing a local committee to hosting a dinner party to giving blood” (2000, p. 186) while Converse (1972) referred to education as a “universal solvent” that correlates with socially desirable outcomes.

Similar arguments exist as to the value of scientific knowledge. The influence of science specific knowledge on behavior and opinions has been referred to as either the deficit model (Irwin and Wynne 1996) or science comprehension thesis (Kahan et al. 2012a). The premise, however, is the same, in that variations within public opinion on science-based issues can be explained via a lack of understanding scientific research. Just as political knowledge is required to assess the success of incumbent candidates, scientific knowledge is required to assess claims regarding the necessity of new public policies for issues such as climate change.

An early report by the Royal Society in London argued for the importance of public understanding of basic scientific concepts. The report argued that a more scientifically knowledgeable public “will not automatically lead to a consensus about the best answer, but it will at least lead to more informed, and therefore better, decision-making” (Bodmer 1985, p. 10). The report observed that science is a critical component of the policymaking process. In several areas, scientists are offering critical information relevant to policy debates. Given their advisory role on contemporary policy issues, scientists have been described as an additional branch of government (Jasanoff 1990).

However, scientists cannot avoid the political conflict inherent to the policy process as they fulfill their role as advisors to elected decision-makers. While some scientific domains such as nanotechnology research may be relatively bipartisan, other domains – particularly in the environmental context – possess clear partisan boundaries where Republicans and Democrats have established opposing positions on issues. These positions, which are based on political orientations, inform the range of policy options partisans are willing to consider. In the environmental context, issues such as climate change raise questions about whether government intervention is necessary and the extent to which regulations are required in order to minimize the risk associated with greenhouse gas emissions.

Whatever information the scientific community offers, there is a strong likelihood those findings will either support or contradict the established positions of the political parties. As noted in the opening chapter, issue evolution provides at least one explanation of how the political parties developed different positions on environmental issues. Because of the political dimension embedded within contemporary policy issues such as a cap-and-trade program or a carbon tax, partisan actors are expected to interpret and frame information about climate change in a context

compatible with the pre-existing values and beliefs of their respective political coalition (Jones and Baumgartner 2005; Schattschneider 1960).

Thus, for the public to understand the policy debate between politicians (and sometimes between politicians and scientists), the citizenry requires a minimal understanding of science (Trefil 2008; Prewitt 1983). By possessing some common or basic understanding of the scientific process, the citizenry can interpret scientific news reports and better evaluate the causal arguments offered by partisan actors. This interpretation process is inherently a social process, given the diverse range of backgrounds and preferences held by the public. Understanding of the scientific process (via accumulated scientific knowledge) is one way for the public to interpret information and understand the problem. Once the problem is understood, the public can then make informed policy decisions and even participate in the debate itself.

Embedded within this process is the notion that knowledge is necessary in order for the public to pay attention and mobilize around a given issue (Almond 1960; Miller 1983). To create the momentum necessary to enact policies designed to correct a given problem such as climate change, the citizenry needs to know something about the problem in the first place. That is, they need to understand the alleged causes of a problem and the potential consequences if the problem is left unchecked. Only after comprehending these two components can the citizenry mobilize and place serious pressure on elected leaders for policy change. Once a critical level of awareness of a problem is achieved within public opinion, the conditions become ripe for policy change (Page and Shapiro 1983). With this conceptualization, how the public comprehends the cause of the problem (i.e., are observed temperature changes the result of burning fossil fuels or some natural cause?) and its consequences (i.e., are rising seas and stronger storms a main result?) will dictate

the pace of policy change. Of course, the scientific community and specifically climatologists have information to offer on both of these fronts.

This discussion leads to one hypothesis that speaks directly to science comprehension thesis. If the thesis has any merit, at a minimum those individuals possessing a foundational understanding of science should think differently about the causal arguments related to climate change compared to their low-knowledge counterparts. Specifically stated:

Hypothesis 1: Individuals with higher levels of scientific knowledge accept the causal arguments from climatologists at higher rates than their low-knowledge counterparts, holding all else constant.

This hypothesis refers to an expected relationship within the first stage of the two-step model. As individuals are socialized to accept beliefs supported by scientific processes, they accumulate basic scientific knowledge. During this process, individuals also develop attitudes about the reliability of experiments and scientific analyses, as well as the trustworthiness of scientists executing the research. Thus, scientific knowledge is an indicator of how individuals are orientated toward science.

What makes high-knowledge individuals stand out in their beliefs? If individuals are going to make sense of the causal arguments pushed by climatologists, they must engage in information acquisition activities. To that end, knowledge is seen as providing the skills necessary to process technical reports (Jerit et al. 2006) and ask critical questions of the claims that surface in the policy debate. They also develop the confidence to engage others in the debate, as their familiarity with science mitigates fears of sounding ignorant during interpersonal communications. In other words, knowledge provides the capacity to engage in information acquisition activities, which in turn lead to more refined and specific beliefs about issues such as climate change (Trefil 2008).

This argument forms what I call the core of the science comprehension thesis. The arguments of climatologists (and scientists in general) are publically contested at various times. To understand the public debate, the thesis suggests individuals need the capacity to engage in information acquisition activities in order to evaluate scientific claims. If they are confident in the work of scientists, they will accept their arguments. Possessing a foundational understanding of scientific knowledge provides the capacity for this process to unfold. Note again that there is no requirement that individuals believe the scientific information implies a problem. As specified in the two-step model, problem definition and understanding scientific arguments are conceptually different stages of public opinion. If the relationship specified in the first hypothesis does not materialize through empirical analyses, then perhaps there is no merit to the arguments offered by the scientific community. Education and knowledge would not be a “universal solvent” when it comes to climate change beliefs and perhaps science or policy issues more broadly. This first hypothesis, the relationship between knowledge and specific causal arguments, constitutes the first step of the two-step process noted earlier.

Development of Empirical Assessments

The aforementioned Bodmer (1985) report occurred in the context of increasing skepticism over science, with the hope that greater scientific understanding would translate to a greater appreciation for scientists (Lewenstein 1992). That is, “science itself would be a beneficiary of increased scientific literacy” through increased research support, newfound faith in technology, etc. (Miller 2001, p. 116). In other words, training and educating adolescents about the scientific process and the work of scientists would orient individuals to think favorably of the scientific community. The first steps for scholars interested in these relationships, then, was to (1) develop

a battery of questions that accurately capture scientific knowledge and (2) execute a research agenda to examine the outcomes associated with a scientifically knowledgeable public.

Constructing the Modern Knowledge Assessment Questions

In constructing a valid measure of science knowledge, researchers had to first ask what type of knowledge informed individuals should possess. On this front, Miller (1998; 2004) argues scientifically knowledgeable persons should be able to identify basic scientific terms and possess an understanding of the scientific process. These are said to represent two dimensions of scientific knowledge. Evans and Durant (1995) argue, however, that these two dimensions have merged together and are, for all intents and purposes, a single dimension. Respondents who can identify basic scientific constructs also understand scientific processes, such as probability and experimental design.

The modern knowledge questions are the product of collaboration between Thomas and Durant, and Miller (1998), who elected to focus on the core scientific constructs. Knowledge should include an understanding of basic scientific concepts, such as DNA and molecules – terms that apply to a wide range of research issues. These basic constructs are building blocks that provide the capacity for individuals to read and comprehend more in-depth media reports. For instance, it is difficult to comprehend an article about genetically modified food if one does not understand basic concepts like DNA. The advantage of this conceptualization of knowledge is that it focuses on basic scientific constructs, thus avoiding temporal science issues and allowing for a comparison of science knowledge across generations.

Assessing Outcomes

The initial analyses of the science comprehension thesis were drawn towards empirical tests examining the correlation between knowledge and generalized science attitudes (e.g., Bauer

et al. 1994; Sturgis and Allum 2004; Evans and Durant 1995; Sturgis et al. 2005; Hayes and Tariq 2000); however, the correlation between science knowledge and generalized attitudes is generally considered weak (Allum et al. 2008). These studies with their focus on generalized attitudes as the outcome measure formed the core tests of the science comprehension thesis up until the late 1990s and early 2000s.

Over the last decade, alternative studies have looked beyond generalized science attitudes towards specific policy domains with a focus on other concepts such as problem recognition, perceptions of consensus, and policy preferences. To briefly illustrate, Hayes (2001) finds a positive relationship between scientific knowledge and two environmental specific dependent variables – attitudes favoring environmental protection and overall respect for nature.¹² Meilby et al. (2012) find a correlation between knowledge of basic biology and public support for genetically modified products, with those demonstrating higher levels of knowledge also capable of discriminating between support for the technology via application (e.g., medical versus agricultural). Another study finds knowledge and attitudes towards space policy are positively correlated (Cook et al. 2011).

Some studies, however, identify no meaningful relationship between scientific knowledge and attitudes, such as when considering support for nanotechnology policies (Ho et al. 2010). In some cases, the link between knowledge and opinions may even be negative. Evans and Durant (1995) argue the relationship between knowledge and research support is positive for what they call “useful” science research. The public, for instance, can see the value of publically funded

¹² Note both Hayes (2001) and Hayes & Tariq (2000) argue the science comprehension thesis is found wanting despite a significant relationship between science knowledge and selected dependent variables. See also Sturgis and Allum (2001).

research targeting medical breakthroughs; there is a value associated with developing a cure to cancer. As such, the citizenry support efforts to funnel public resources toward such ventures. If the research may be considered non-useful (e.g., space exploration) or if it impinges on moral issues (e.g., cloning), a negative relationship emerges. This suggests to some extent that high-knowledge individuals do not blindly follow the scientific community's lead, at least when it comes to research support.

The relationships that emerge between scientific knowledge and specific climate change attitudes are weak and, in some cases, puzzling. In the context of climate change, Hamilton (2012) argues education (as a proxy for knowledge) leads individuals to correctly identify the scientific community's arguments about what is driving changes in the arctic region. Wood & Vedlitz (2007) find that their measure of scientific knowledge does not explain concern about climate change. The lack of a positive, significant relationship between science knowledge and climate change concern has been observed elsewhere as well, with the relationship found to be negative (Kahan et al. 2012a; Kellstedt et al. 2008). Looking specifically at environmental knowledge, however, reveals a small but positive relationship with concern for global warming (Wood and Vedlitz 2007).

Others have observed that the role of knowledge, specifically knowledge of climate change, may lead to support for remedial policies, but evidence also suggests knowledge does not function equally for all individuals (Marquart-Pyatt et al. 2011). This inconsistency is perhaps due in part to the use of self-reported knowledge of climate change in some studies (e.g., Malka et al. 2009), which is arguably an inferior measure when compared to actual knowledge of both science and climate change.

The message at this point is that a chain of research contains some support for the idea that possessing scientific knowledge leads individuals to different conclusions about science-related policy issues. Furthermore, the direction of these attitudes appears to be in alignment with positions shared by the scientific community. With only mixed success, though, other factors might be contributing to science-related beliefs and attitudes. The upcoming discussion will consider two alternatives: that there are additional orientations toward science that need to be considered and that values might be supplanting the influence of knowledge in some cases.

Predisposed to Science

Recent scholarship has suggested attitudes toward science vary even among those who are highly knowledgeable (e.g., Gauchat 2011). Understanding this divide relies on the idea that science is a social construct (Wynne 1991; Ziman 1991; Locke 2002). It is important, then, to consider how individuals think of scientists. Because of the transaction costs associated with accumulating knowledge and understanding all aspects of science, alternative concepts such as institutional alienation might play a role in belief formation as well. Just as individuals come to distrust government operations or large bureaucracies (Giddens 1991), individuals may distrust or become discontent with the whole scientific enterprise in general (Yearley 2000).

Specifically, how individuals feel about scientists might have some influence on how the citizenry makes sense of the climate change debate. If citizens feel good about scientists and believe they are working to better humanity's condition, then they are possibly more likely to accept the claims of scientists. Conversely, if one feels scientists threaten the status quo and may be complicating society with unnecessary claims of a problem, then they may feel more inclined to reject the arguments of scientists. This line of thought leads to additional hypotheses that examine normative beliefs:

Hypothesis 2: Individuals perceiving benefits from scientific advancement are more likely to accept causal arguments from climatologists, holding all else constant.

Hypothesis 3: Individuals skeptical of scientists and their work are less likely to accept the causal arguments from climatologists, holding all else constant.

The normative views conceptualized in Hypotheses 2 and 3 constitute an orientation toward science. Positive and negative feelings about scientists in general push the citizenry toward accepting or rejecting causal arguments from climatologists. They can hear the debates about climate change in the media, identify the position of climatologists, and then make decisions about which causal arguments to accept based on their feeling of scientists. These hypotheses make no requirement as to whether they have any factual knowledge about science.

It is important to note that these positive and negative normative views are seen as two distinct concepts. An individual can see positive benefits coming from scientific adventures, yet also be cautious about the pace of technological development or the ethics of select scientists. Thus, two distinct hypotheses are tested. This distinction between positive and negative views is explored further in the Chapter 3.

A second important note is that the science comprehension thesis says nothing about normative science views. Normative views of science were the dependent variables in the original analyses of the thesis. In this analysis, they are conceptualized as an independent variable, a predictor of climate change beliefs. As described above, normative views are a heuristic that can be utilized in the absence of knowledge.

Values as an Alternative Framework

The work by Evans and Durant (1995) noted earlier implies issue context matters, which in turn suggests the link between knowledge and public opinion is not as simple as advocates of

the science comprehension thesis contend. This complexity does not imply that the science comprehension thesis is invalid or somehow compromised; rather, it forces one to consider *why context matters*. Knowledge may matter, but its influence is contingent on the context of the issue and the degree to which the science supports one's preexisting beliefs. The value-centered thesis refers to any framework that emphasize values as providing heuristics to facilitate the public's decision-making process.

An emerging framework that falls under this grouping is cultural cognition (Kahan et al. 2011; Kahan et al. 2012a). Kahan and colleagues have developed a theory that focuses on four cultural values (hierarchy, egalitarianism, fatalism, and individualism) originally identified by Douglas (1983) and others (Douglas and Wildavsky 1983; Thompson et al. 1990; Scharwz and Thompson 1990). The four values are arranged in a matrix (replicated in Figure 2.4) based on views about collectivism and individual autonomy in society. Those holding hierarchical values see the world as highly ordered with little individual autonomy in any decision-making process. Egalitarians also see the world as highly ordered, but value individual thought and believe everyone has an equal voice. Fatalists see the world as fairly random, with no collective organization in the decision-making process and little role for individual choice. Lastly, individualists see a less restrictive decision-making structure, one where it is the individuals who should ultimately be the driver of decisions.

Table 2.2: Dimensions of culture

	<i>Low individual autonomy</i>	<i>High individual autonomy</i>
<i>High collectivization</i>	Hierarchy	Egalitarianism
<i>Low collectivization</i>	Fatalism	Individualism

The important part of this values discussion is that each value is connected to varying beliefs about the environment. Thompson has been instrumental on this front (Scharwz and Thompson 1990; Thompson et al. 1990; Swedlow 2012). For these authors, cultural values shape

one's view of environmental issues. Both hierarchical and individualistic personalities see nature as resilient to the influence of human activity. For instance, they are likely to think that even if all the trees are cut down, the forest can still grow back. Similarly, they might think increasing the amount of total carbon dioxide in the atmosphere by only 0.5% cannot cause detrimental effects because the Earth is resilient to what are perceived as minute human influences.

Conversely, personalities characterized by egalitarianism and fatalism see nature as more sensitive to human activity, that slight disturbances might upset the natural equilibrium of the world – perhaps permanently. For Kahan and his colleagues (2012), it is these cultural values and associated risk perceptions that drive beliefs about climate change. Additional work by Jones (2011) has argued that climate change deniers are largely individualists: personalities who do not desire collective action and seek to preserve individual choice. This emphasis on cultural values has risen in the literature over the last several years as an explanation for the polarization in public opinion over climate change. In the process, their empirical work rejects the notion that scientific knowledge has a role in the public's decision-making calculus.

Why Values Dominate Climate Change Models

Value differences might explain why the public disagrees on issues such as climate change and explain why inconsistent findings emerge when scholars look at relationships between scientific knowledge and key constructs. Still, why, from a psychological perspective, do segments of the public reject scientific arguments when science is often viewed as objective and beyond reproach? One answer found within the theory of motivated reasoning (Kunda 1990; Kunda 1987) considers the motivations of citizens. Individuals retain a preferred outcome in policy disputes and seek a coherent, consistent story to explain the world. As a result, they look to preserve that consistency as new policy information surfaces. A bias, of sorts, results, which affects the entire

decision (or reasoning) process by shaping how individuals reconsider their beliefs and evaluate evidence.

Two types of motivation are considered. Naturally, the citizenry can be motivated by accuracy in the sense that they want their beliefs to be right. There is little incentive to appear out of touch or foolish in the face of undisputable evidence. However, there is also motivation to reach specific conclusions, ones that match the initial predispositions dictated by one's belief system. The two motivations must strike a balance – “people are more likely to arrive at conclusions that they want to arrive at, but their ability to do so is constrained by their ability to construct seemingly reasonable justifications for these conclusions” (Kunda 1990, p. 480). When a high degree of ambiguity exists over an issue, such as with climate change, individuals are prone to favor views that match their initial preferences rather than strive for accuracy (Doherty and Wolak 2012).

As a result, persuading individuals to change their beliefs can be quite difficult. Initial views are anchored to specific positions (Anderson 1981; Kahneman and Tversky 1982) because “citizens are prone to overly accommodate supportive evidence while dismissing out-of-hand evidence that challenges their prior attitudes” (Taber and Lodge 2006, p. 755-756). There also appears to be a tendency to overestimate the support for one's preferred position (Nir 2011; Druckman and Bolsen 2011). New information may even have a “backfire effect,” where “unwelcome information” leads individuals to support their original opinions with even stronger conviction (Nyhan and Reifler 2010).

In the context of science-related issues, scholars have noted conservatives tend to dismiss research findings that support liberal conclusions, contributing the results to the biases of liberal researchers (MacCoun and Paletz 2009). In respect to climate change specifically, a boomerang effect is observed where media reports discussing the consequences of climate change reduce

policy support among those predisposed to reject climate change (Hart and Nisbet 2012). These results suggest it is difficult to alter the beliefs of individuals.

The possibility remains that new information is accepted despite value conflict. At some point, the accuracy of new information can no longer be denied. However, the amount or quality of information required can be quite large. Even when presented with a scenario where conclusive evidence of the consequences of climate change is available, segments of the public still remained unconcerned over the issue (Wood and Vedlitz 2007). It seems individuals with a developed belief system are going to resist altering their views even if the scientific community suggests definitive evidence exists of a problem.

Reconciling the Two Views

There appears to be only a small window of opportunity for information to influence beliefs. The Kahan et al. (2012) work that specifies a limited relationship between basic scientific understanding and climate change beliefs is reinforced in other research as well (e.g., Wood and Vedlitz 2007; Malka et al. 2009). Based on their research, Kahan and his colleagues are comfortable asserting that “[s]imply improving the clarity of scientific information will not dispel public conflict so long as the climate change debate continues to feature cultural meanings that divide citizens of opposing world-views” (2012, p. 734). Still, advocates of the science comprehension thesis insist there must be something about knowledge that helps guide public opinions on climate change (McCaffrey and Rosenau 2012).

Are these two theses mutually exclusive, or is there an opportunity to reconcile the two views? Emphasis is placed on two points in an attempt to understand this apparent conflict. First, the science comprehension thesis requires qualification, in that not all individuals respond to scientific information. It is appropriate to model science knowledge as interacting with or being

moderated by values. Second, the focus on climate change concern as one of the dependent variables is a misrepresentation of the science comprehension thesis. Nothing in the aforementioned discussion of the thesis suggested knowledge makes individuals more risk averse. The argument was that knowledge allows individuals to understand the causal arguments from scientists and then, using that information, make informed decisions. While it is certainly difficult to measure what constitutes an informed decision, efforts can be made to offer a more precise assessment of the science comprehension thesis.

A Moderating Effect

The emphasis of the value-centered thesis was that values moderate or condition the interpretation of information. Certainly, then, there is an expectation that the relationship between science knowledge and climate change beliefs might be moderated by political values or other theoretically important concepts. It does appear that partisans tend to be better educated (Taber and Lodge 2006), and as suggested earlier, there is a partisan dimension to opinions about climate change (Dunlap et al. 2001; McCright and Dunlap 2011). Research also suggests that the educated are less likely to follow the advice of experts, electing to rely more on their predispositions and political preferences (Kuklinski et al. 1982). As such, it should not be surprising if high-knowledge individuals think differently about climate change, with liberals (Democrats) more likely to embrace the scientific claims and conservatives (Republicans) more willing to call the information into question.

There is support for this argument in the literature. For instance, Malka et al. (2009) proposed only select individuals who possess higher levels of scientific knowledge are likely to stand out in empirical analyses. Specifically, among those with knowledge, only Democrats were more likely to perceive climate change as a serious problem. It was argued that climate change

research coincides with the environmental orientation of the party. This suggests that any potential relationship between scientific knowledge and beliefs is likely to be conditional, based on prior beliefs. Since ideologues receive reinforcing messages from ideological leaders that openly question or support the scientific community's claims, this ideological or partisan divide is not surprising (McCright and Dunlap 2000). Conservatives, with their focus on fiscal restraint and limited regulation (Zumbrunnen and Gangl 2008), tend to be more skeptical of climate change. Meanwhile, liberals have been identified as demonstrating strong environmental support since the 1970s' environmental movement (Jones and Dunlap 1992; Dunlap and McCright 2008) and tend to receive reinforcing messages that the environment needs to be protected.

Further support for interactive effects occurs in Hamilton's work when looking at climate change concern (2011), but such effects are more limited when looking at climate change beliefs (2012). This latter study comes the closest to the analysis proposed here. The key difference is in how the interaction effect is operationalized. Hamilton utilized a measure of education and partisanship while this study uses a more nuanced and precise measure of science knowledge. The use of science knowledge in the interaction term offers a different conclusion than that found in Hamilton's work – an issue that is taken up further in the discussion.¹³

The justification for including an interaction term in the analysis is based on the value-centered thesis, which creates an expectation that a subclass of high-knowledge individuals will think about climate change in unique ways compared to their other high-knowledge counterparts.

¹³ Also see McCright (2011) for additional commentary on the moderating effect of political ideology and partisanship. Society is divided into groups that either “attack” or “defend” industrial capitalism, according to the argument. These groups map along current political cleavages in the United States, which might help to understand why conservatives think differently about climate change compared to other ideologues.

Three specific expectations, then, are anticipated in the analysis, depending on the ideological beliefs of the survey respondents:

(1) Moderates without a firmly held political ideology rely on knowledge to guide beliefs when ideas are contested. With, presumably, no strong value bias, they are more willing to accept information from scientists and incorporate that information into their existing beliefs.

(2) If new information supports an ideological position, this ideological partisan will more readily accept new beliefs into his or her pre-existing belief structure (compared to moderates). That is, the information is a tool to bolster or support one's original position.

(3) If new information threatens an ideological position, this ideological partisan will more readily reject the information and defend those values. This ideologue will more likely question the accuracy of the information and rally around his or her core beliefs.

This discussion suggests a hierarchy should emerge in the data when applying this conceptualization to climate change. Liberals should be more likely to agree with climatologists, conservatives the least likely to agree, and moderates should be somewhere between the two ideological extremes. From this breakdown, the following hypotheses are proposed:

Hypothesis 4: Liberals (conservatives) are more likely to agree (disagree) with causal arguments consistent with the IPCC, holding all else constant

Hypothesis 5: Ideology moderates the relationship between scientific knowledge and climate change beliefs.

Evidence of a moderating effect would include differences between high-knowledge liberals and conservatives emerging with respect to the rate at which they accept the causal arguments of climatologists. This observation would also support the value-centered thesis. The evidence would

not suggest, however, that the science comprehension thesis is somehow compromised. Rather, the moderating effect reveals the conditional nature of the science comprehension thesis as it only applies to a targeted group of the population. Whether high-knowledge moderates are more or less likely to accept causal arguments about climate change will be critical to assessing the veracity of the science comprehension thesis. Given the discussion of ideological differences with respect to climate change, it is necessary for models to account for potential interactive effects between knowledge and beliefs. Failure to do so may lead to inappropriate conclusions about the science comprehension thesis. It also potentially explains why there is disagreement in the literature about the veracity of the thesis.

Different Outcome Expectations

An additional measure to understand the conflict in the literature is the result of a focus on climate change concern as the dependent variable of interest (e.g., Kahan et al. 2012b; Kellstedt et al. 2008; Wood and Vedlitz 2007). Problem recognition, however, is rooted, in part, in individual risk perceptions (Leiserowitz 2005; Lorenzoni et al. 2005). It is difficult to imagine a causal process where simply knowing basic foundational science leads individuals to change their level of risk aversion, although new information might make the risks clearer to individuals, thereby causing changes in risk perceptions. Still, it is likely individuals possess varying degrees of risk acceptance or aversion before any new information is received. There are valid reasons individuals might acknowledge a phenomenon such as climate change yet not be concerned with the problem. Perhaps the consequences are not viewed as entirely negative, or perhaps they feel scientists will eventually develop technological solutions before severe problems emerge. However, nothing about the science comprehension thesis (at its core) suggests higher levels of knowledge should lead to greater recognition of a problem. Rather, as indicated earlier, knowledge should help

individuals understand the problem, from which point they can decide on their own whether they should be concerned about the alleged problem.

In a sense, prior scholarship has misconstrued the essence of problem definition. One has to understand the problem in a manner similar to climatologists before exhibiting the scientific community's expected level of concern. Wood and Vedlitz (2007) hint at (but do not develop) this distinction when they briefly observe that basic scientific knowledge does not correlate with concern over claim change, but a domain specific construction of environmental knowledge does positively correlate with concern. The Wood and Vedlitz observation provides a basis for conceptualizing the two-step process noted at the beginning of the chapter.

Figure 2.3: The two-step process for climate change beliefs

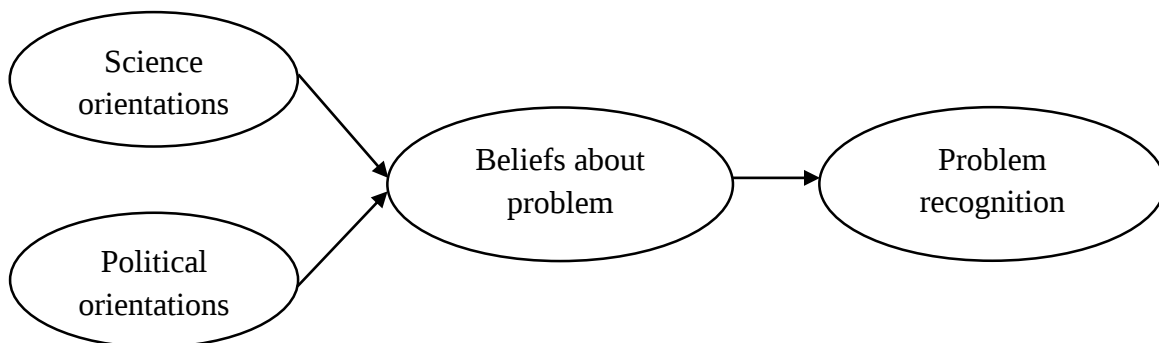


Figure 2.5 presents the two-step process introduced earlier. The figure shows a proper conceptualization of the science comprehension thesis and how it is expected to “connect” with climate change concern (i.e., problem recognition). Individuals are oriented toward science, a process that includes exposure to science and the scientific process. This includes accumulating basic scientific knowledge and developing the skills to properly evaluate scientific arguments. Once this knowledge accumulates, individuals are in a position to evaluate causal arguments offered by the IPCC, political leaders and other policy advocates. The thesis suggests possessing higher levels of scientific knowledge provides the skill set and capacity to make sense of the causal

arguments offered as part of the climate change debate. Basic scientific knowledge, then, facilitates the understanding of contemporary problems like climate change.

With an understanding of climate change, individuals are then in a position to make informed decisions about whether climate change is a threat. Again, the science comprehension thesis does not specify whether understanding climate change in a manner similar to climatologists should increase concern. It simply says individuals are in a position to make an informed decision about the accuracy of the claim. However, a link is expected between climate change concern and how one understands the problem. Climatologists, for one, believe remedial policies are required, and the public can certainly reach similar conclusions.

Properly understood, then, the role of scientific knowledge in this conceptualization and its relationship with climate change concern is best understood as an indirect effect. Knowledge helps individuals understand what climatologists are saying, and if they reach this point they are then more likely to be concerned about the phenomenon. This discussion leads to two additional hypotheses as part of an assessment of the two-step process just described:

Hypothesis 6: Individuals who understand climate change in a manner consistent with climatologists are more likely to demonstrate higher levels of concern.

Hypothesis 7: Individuals concerned about climate change are knowledgeable about basic scientific principles.

These last two hypotheses are assessed through path analysis to show the causal relationship developed in the two-step approach. If scientific knowledge possesses an indirect effect on climate change concern when assessing the causal argument in Figure 2.2, then there is arguably support for Hypothesis 7. That is, those with scientific knowledge are more likely to be concerned about

climate change, but this relationship emerges due to the prior effect of science knowledge on problem understanding and acceptance of arguments from climatologists.

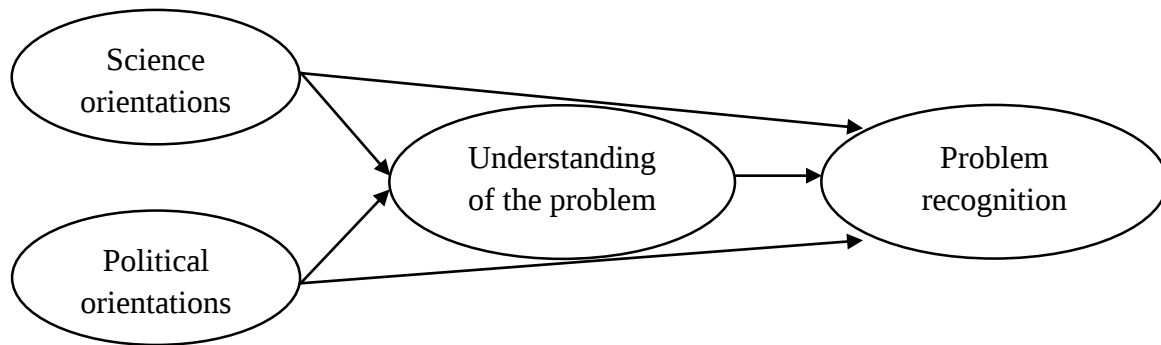
These hypotheses outline the expected relationships of the two-step process. Again, the suggestion is that individuals have some understanding of climate change, which in turn directly influences problem recognition. That understanding, however, hinges on the belief systems of individuals. This discussion is primarily interested in whether science knowledge can guide individuals toward understanding climate change in a manner consistent with climatologists, but at the same time, other orientations are important as well in determining climate change beliefs.

To be clear, this is not an argument that cultural values or other factors such as affect (e.g., Leiserowitz 2006) and risk perceptions (e.g., Lorenzoni et al. 2005) are not essential to the public's decision-making calculus. Indeed, concern over an issue is an inherently subjective process and a variety of non-objective factors (i.e., those not related directly to knowledge) should be expected to problem understanding and problem recognition as well.

As noted earlier, however, there is the possibility that individuals accept the arguments of climatologists but may simply not be concerned about the problem. This is because they have risk accepting personalities (Brody et al. 2008; Leiserowitz 2005; Lorenzoni et al. 2005; Pidgeon and Butler 2009; Searle and Gow 2010; Spence et al. 2012) or perhaps feel technological solutions will be available if the problem does get out of hand many years down the road. These potential relationships are consistent with the value-centered thesis in that predispositions and not knowledge are utilized to assess the severity of a problem. Consequently, the two-step process does not explain all the variation in public opinion. As such, the proposed diagram presented earlier should be modified as seen in Figure 2.6, with direct connections between orientations and concern

to represent these other unexplored relationships. This figure provides the final model to be tested in the forthcoming chapters.

Figure 2.4: A two-step process for climate change beliefs, tested model



Summary

The preceding discussion attempts to reconcile conflicting results in the literature by paying closer attention to the core expectations of the science comprehension thesis. In the process, careful attention is given to the dependent variable selection and the potential for moderating effects. The hypotheses are tested with a public opinion dataset that features an extensive battery of questions that allow an assessment of the science-orientated concepts discussed above. The next chapter will speak more about the data to be utilized in the analysis, how the variables are operationalized, and the methodologies to be incorporated in future chapters.

CHAPTER 3: DATA & OPERATIONALIZATION

Assessing the relationships identified in the previous chapter requires a public opinion dataset that not only inquires about climate change attitudes, but also includes detailed questions about science attitudes. The forthcoming section discusses such a dataset and offers details about how the operationalization of the key concepts identified in Chapter 2. A descriptive analysis of the science concepts is offered, followed by an outline of the planned approach for the empirical chapters.

Survey Data

The survey utilized in the analysis was collected by Dr. Jon D. Miller and is referred to as the *Science News Survey*. The survey is a nationwide three-wave panel survey that was originally designed to assess whether exposure to local television news reports of science-related issues influenced public opinion. Throughout the survey, questions were asked about attitudes toward science, including specific inquiries into the beliefs and policy preferences of the respondents.

The first wave of the survey was conducted in September 2007. During this wave, the survey focused on the beliefs and attitudes of respondents on science issues. Included in this wave was a self-assessment of how informed respondents claimed to be on a variety of science issues, including global climate change and space exploration. Also included was a battery of questions to assess scientific knowledge. The questions were in true or false, as well as multiple choice, formats. The content of the questions covered a range of topics. Several concepts utilized in the analysis come from the first wave of the survey, including science knowledge, generalized science attitudes, and beliefs about climate change. The second wave of data collection occurred in November 2007 and asked about scientific concepts that appeared on local television news

broadcasts over the preceding month. The forthcoming analysis does not utilize data from the second wave of the survey.

The third wave occurred in March 2008, with the purpose of assessing respondents' political attitudes during the 2008 presidential primary campaign season. Included in the third wave was a battery of declarative policy statements that asserted a clear position on contemporary political issues. Respondents were asked about their level of agreement with each policy statement. This wave of the survey also included questions specific to climate change, such as one's level of concern, how often they interacted and discussed the issue with others, and whether they sought out additional information about the issue. This information is summarized in Table 3.1.

Table 3.1: Summary of Science News Survey

	Wave 1 (September 2007)	Wave 2 (November 2007)	Wave 3 (March 2008)
N=	1407	1166	960

Notes: The first stage of the analysis (Chapter 4) relies primarily on survey questions from the first wave of the survey. No analyses utilize questions from the second wave. The third wave of the survey is utilized in analyses presented in Chapter 5, as well as Appendices A and C.

Knowledge Networks, a polling service that utilizes a random sample of the United States adult population to distribute online surveys, collected the data. Once respondents are in the Knowledge Network survey population (the so-called "Knowledge Panel"), they complete two to four surveys per month, delivered by Knowledge Networks through the internet.¹⁴ The *Science News Survey* was randomly assigned to 1407 individuals comprising the Knowledge Panel. The

¹⁴ Knowledge Networks built a probability-based random sample of the U.S. population. Households were strategically recruited to participate in periodic monthly surveys, with provisions to account for non-internet populations. They claim the Knowledge Panel accurately represents 97% of U.S. households and argue results are comparable to random-digit dialing procedures. Scholars have argued probability-based online surveys are an optimal form of data collection, as procedures like those used by Knowledge Network reduce error and provide more accurate results (Chang and Krosnick 2009).

size of the sample did fluctuate by wave, with the sample size dropping to 1116 and 960 on the second and third waves, respectively. A weight is included in the dataset to account for the loss of survey respondents over the seven-month timeframe, which also serves to keep the survey sample weighted to the national adult population.

Why Climate Change?

The advantage of the *Science News Survey* is its wealth of science questions, including specific inquiries about climate change beliefs and attitudes. Climate change is an ideal context for an analysis assessing the science comprehension thesis for multiple reasons. First, as noted earlier, a high degree of consensus exists among scientists that the Earth is warming and that these changes are the result of anthropogenic activities. The idea of a consensus is essential to the science comprehension thesis as those familiar with the scientific process and the general work of scientists should be able to identify the causal arguments made by scientists. If there is genuine disagreement within the scientific community, then it is doubtful those with elevated levels of knowledge should stand out in analyses. Thus, the expectations outlined in Chapter 2 should materialize in this context.

Second, despite the scientific consensus on climate change (see the first chapter), it is an issue where non-scientists contest the causal arguments from climatologists. Senator James Inhofe, a Republican from Oklahoma, argues that the idea of anthropogenic climate change is a hoax (Inhofe 2012) while the broader Republican Party and its allies coordinate a counter-narrative to the work of climatologists that emphasizes growing uncertainty about the scientific community's understanding of the problem (McCright and Dunlap 2000). These counterarguments from non-scientists might appeal to segments of the public, depending on the mix of one's political and cultural orientations. These counterarguments provide another voice in the public debate, and a

reason to suspect the relationship between knowledge and beliefs is weakened by ideological predispositions.

Given the above, there is reason to suspect the relationships outlined in the Chapter 2 should emerge in the context of climate change. It is important to note, however, that the relationships outlined in the Chapter 2 may not emerge in other contexts. If there is no strong counterargument by an organized interest to a scientific issue, then (1) the relationship between science knowledge and specific beliefs should be empirically stronger, and (2) no moderating effects (whether by ideology or some other factor) should emerge. However, climate change represents an issue where counterarguments emerge, which means the context offers a challenging test for the science comprehension thesis, especially given the prior research noted earlier.

Operationalizing Key Concepts

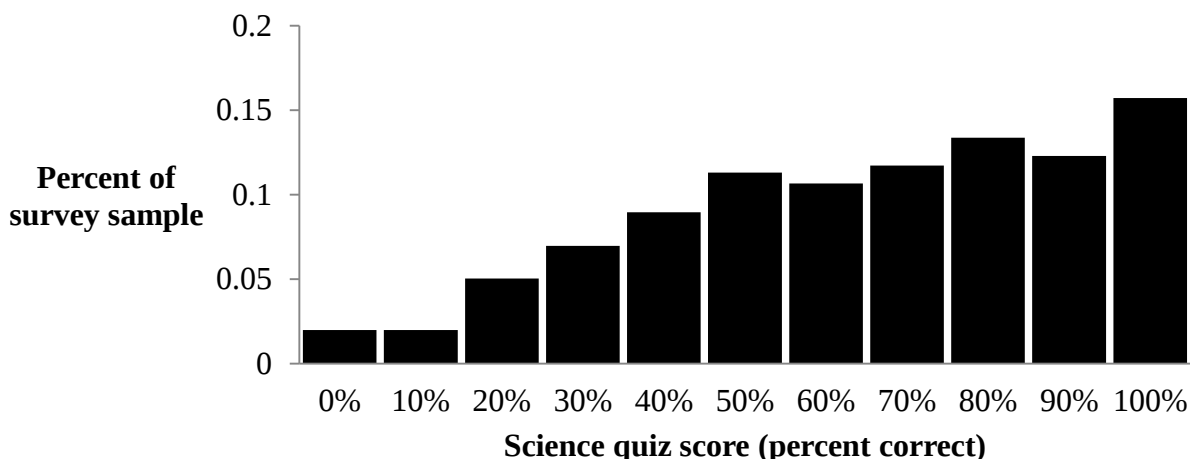
The main theoretical concepts of interest involve the orientation of survey respondents toward the scientific enterprise. These include both one's foundational understanding of science and normative science views. The operationalization of these concepts is discussed below.

Scientific Knowledge

The key concept that predicts agreement with the work of scientists is one's understanding of foundational scientific concepts. This is traditionally captured in the scholarship with some variant of a science quiz. The *Science News Survey* includes a series of quiz-style questions that one might expect to see on a comprehensive science exam, with each question speaking to the core building blocks of science. Scientific knowledge is operationalized as an additive index of responses to ten science questions. Table 3.2 displays the questions utilized to construct the knowledge scale, including eight true or false questions and two multiple-choice questions. These questions were selected due to the lack of controversy surrounding the veracity of the scientific

claims. For each question answered in a manner consistent with the scientific community's position, respondents were awarded one point. Each respondent's score was totaled, producing an index that ranges from zero to ten, with a median score of seven (i.e., respondents correctly answered 70% of the questions). The distribution of the quiz scores is plotted in Figure 3.1.

Figure 3.1: Distribution of science quiz scores



Before proceeding, three points are worth emphasizing when discussing the operationalization of scientific knowledge. First, with respect to question selection, the overall results presented in the following empirical chapters remain consistent when utilizing alternative knowledge questions from the survey or varying the number of questions included in the index.

Second, the data were conditioned to remove respondents who completely ignored or refused to answer the battery of science questions as well as respondents who answered “Don’t Know” (DK) to all 19 of the science knowledge questions. This effectively removed 14 (refused all questions) and 22 (responded DK to all questions) respondents from the analysis, respectively. The rationale was that these respondents were not taking the survey seriously, so their score on the science quiz did not reflect true ignorance to science. Removing these initial respondents did not alter any of the analyses provided in the forthcoming chapters.

Table 3.2: Variable coding & operationalization

Variable	Question wording	Operationalization	Mean	Std. dev.
Science knowledge	○ “The center of the Earth is very hot” (true/false) ○ “Antibiotics kill viruses as well as bacteria” (true/false) ○ “Ordinary tomatoes, the ones we normally eat, do not have genes, whereas genetically modified tomatoes do” (true/false) ○ “Lasers work by focusing sound waves” (true/false) ○ “Stem cells occur only in plants” (true/false) ○ “For the first time in recorded history, some species of plants and animals are dying out and becoming extinct” (true/false) ○ “Electrons are smaller than atoms” (true/false) ○ “All plants and animals have DNA” (true/false) ○ “Which travels faster: light or sound?” (multiple choice; answer options light, sound, and both the same) ○ “Would you say that the Sun is a planet, a star, or something else?” (multiple choice; answer options a planet, a star, something else)	Additive index of the number of correct answers ranging from 0 to 10	6.5	2.6
Faith-in-science index	Ordinal response (strongly agree, agree, disagree, strongly disagree) to the following propositions: ○ “Science and technology make lives healthier, easier, and more comfortable; ○ Because of science and technology, there will be more opportunities for the next generation; ○ Most scientists want to work on things that will make life better for the average person; and ○ Even if it brings no immediate benefits, scientific research which advances the frontiers of knowledge is necessary and should be supported by the federal government”	0 to 4 additive index, averaged; high value equals strongly agree across all issues	3.2	0.6

Table 3.2 (cont'd)

Skeptical-of-science index	Ordinal response (strongly agree, agree, disagree, strongly disagree) to the following propositions: ○ “One of the bad effects of science is that it breaks down people’s ideas of right and wrong; ○ The growth of science means that a few people could control our lives; ○ Science makes our way of life change too fast; and ○ We depend too much on science and not enough on faith”	0 to 4 additive index, averaged; high value equals strongly agree across all issues	2.3	0.6
Ideology	“In talking about politics, the expressions "liberal" and "conservative" are often used. Please think of a scale from 0 to 10 where 0 means very liberal and 10 means very conservative. Where would you locate yourself? If you are not sure, you may check the "Not Sure" box.”	Recoded on -5 to 5 scale; “5” indicates most conservative position, “-5” indicates most liberal	0.5	2.4
Democrat	“Generally speaking, do you usually think of yourself as a Democrat, a Republican, an Independent, or what?”	Dichotomous 1/0 identifier; “1” indicates Democrat	0.3	0.5
Republican	“Generally speaking, do you usually think of yourself as a Democrat, a Republican, an Independent, or what?”	Dichotomous 1/0 identifier; “1” indicates Republican	0.3	0.4
Age	Not available, information from Knowledge Networks	Continuous measure	46.8	17.2
Gender	Not available, information from Knowledge Networks	Dichotomous 1/0 identifier; “1” indicates female	0.5	0.5
Four-year degree	“What is the highest degree or level of education that you have completed?”	Dichotomous 1/0 identifier; “1” indicates bachelor’s degree received	0.2	0.4
Advanced degree	“What is the highest degree or level of education that you have completed?”	Dichotomous 1/0 identifier; “1” indicates advanced degree (master’s, doctoral, professional)	0.1	0.3

Lastly, it is beneficial to emphasize treatment of the DK responses. Mondak (2001) notes that different results emerge when DK responses are encouraged in questions designed to assess the knowledge of survey respondents. Inviting DK response creates a degree of “noise” in the measure, as respondents who might be able to make informed guesses are more likely to be discouraged from indicating an answer. Individuals who are lacking knowledge, however, are more likely to guess (and guess correctly). Encouraging DK responses potentially creates a bias in a knowledge scale, although there is disagreement on this front (e.g., Luskin and Bullock 2011). If there is a bias, however, it appears that the bias is in the direction against the expected relationships outlined in the second chapter. Given that respondents were offered a DK option on the *Science News Survey*, a significant relationship would suggest that the science knowledge scale sufficiently captures a systematic pattern despite the propensity of some groups to guess more than others.

Normative Science Views

The last two measures proposed in the second chapter are the normative views of science. That is, are scientists working for the common good and will society be better off with technological advancements, or are there negative consequences for society’s deference to scientists? Respondents were presented with a variety of questions and asked about their level of agreement on a four-point ordinal scale, ranging from strongly disagree to disagree to agree to strongly agree.

To construct these measures, a principal-component factor analysis was performed on a range of questions assessing normative attitudes about the scientific enterprise (presented in Table 3.2). The factor loadings are presented in Table 3.3 and suggest that the two concepts load on separate dimensions rather than falling along a single continuum. Factor one, which features positive views about science and technological advancements, accounts for 32% of the variance. Factor two,

which includes four questions that express reservations about the scientific process, accounts for 29% of the variance. The two factors cumulatively explain 61% of the variance.

Table 3.3: Principal-component factor analysis results

Questions (from Table 3.2)	Factor 1	Factor 2
#1: Healthier, easier and comfortable	0.84	-0.07
#2: More opportunities	0.84	-0.00
#3: Science advances frontiers	0.70	-0.03
#4: Scientists want to better world	0.75	0.09
#5: Makes life change too fast	0.00	0.77
#6: Breaks down right/wrong	0.04	0.72
#7: Means few control lives	-0.08	0.66
#8: Not enough faith	0.02	0.78

Notes: N=1315. No weights were utilized in the analysis. An oblique promax rotation is utilized due to correlation between the two factors.

Two indices were created, one for each factor. The first factor, which is labeled the “faith-in-science index,” is an average score (rounded) of respondent’s answers to questions one through four. A high score indicates strong agreement with the selected questions. Factor 2 is referred to as the “skeptical-of-science index” and consists of an average score on the last four questions. A high score indicates more skepticism or ambivalence over the effects of science and technological advancement.

The dimensions are likely unique due to a degree ambivalence or conflict among the respondents. That is, one can think science makes life healthier and more comfortable for society but also be skeptical about science due to its tendency to facilitate change or threaten spiritual beliefs. The distributions of these indices are presented in Table 3.4. The patterns suggest that respondents generally look positively on the contributions of science and technological advancements for society as 93% of the survey respondents indicated they agree or strongly agree with the positive statements about science. Meanwhile, only 39% of the sample agreed or strongly agreed with statements expressing skepticism about the actions of scientists. Only a small portion

of the survey respondents, 4.3%, may be considered anti-science in that they agree there are reasons to be skeptical about science while also disagreeing that society has benefited from scientific advancements. The table reveals, however, a degree of ambivalence. A notable number of respondents found a reason to be skeptical about the work of scientists but also held generally positive views about science. Almost 37% of the sample is in the bottom-right quadrant of the table, the area where skeptical and favorable views of science are both expressed. This ambivalence demonstrates the need to break the generalized science attitude measures into two dimensions – faith and skepticism.

Table 3.4: Cross-tabulation of normative science views

		<i>Skeptical-of-science index</i>			
		<i>S. Disagree</i>	<i>Disagree</i>	<i>Agree</i>	<i>S. Agree</i>
<i>Faith-in -science index</i>	<i>S. Disagree</i>	0.3%	-	-	0.1%
	<i>Disagree</i>	0.1%	2.1%	3.7%	0.5%
	<i>Agree</i>	1.0%	33.2%	27.8%	1.1%
	<i>S. Agree</i>	3.4%	18.7%	6.6%	1.3%

Notes: N=1315. Reporting total percentage of the survey population within each cell. Indices constructed using the questions outlined in Table 3.2. Distributions are weighted to the U.S. adult population.

In order to discuss the relationships between normative science views and the outcome measures in the forthcoming analyses, three profiles of individuals have been identified based on the most populated cells in Table 3.4. These three profiles are:

Strong Pro-Science, shaded []: These are individuals who strongly agree that society benefits from scientific advancements (faith-in-science index score of four) and disagree with propositions that there are reasons to be skeptical about the work of scientists (skeptical-of-science index score of two).

Weak Pro-Science shaded : These are individuals who agree that society benefits from scientific advancements (faith-in-science index score of three) and disagree with propositions that there are reasons to be skeptical about the work of scientists (skeptical-of-science index score of two).

Conflicted, shaded : These are individuals who agree with propositions that there are reasons to be skeptical of the work of scientists (skeptical-of-science index score of three) but also agree with propositions that there are benefits to scientific advancement (faith-in-science index score of three).

These profiles are shaded in Table 3.4 and represent the three most populated cells from the table. When discussing the substantive effects of these indices, the analysis discusses differences in the predicted probabilities of these three profiles. All other measures are held at their means during this discussion.

Correlations

These three measures (faith-in-science index, skeptical-of-science index, and scientific knowledge) represent components of the scientific orientations individuals possess. A correlation matrix is presented in Table 3.5 and suggests that while there are some interrelationships between the main concepts identified here, none are strong enough to suggest multicollinearity issues will arise, at least when these three measures are considered.

Table 3.5: Correlation matrix of science measures (Pearson's r)

	<i>Knowledge</i>	<i>Faith</i>	<i>Skepticism</i>
<i>Knowledge</i>	1		
<i>Faith</i>	0.1831	1	
<i>Skepticism</i>	-0.2061	-0.1869	1

Means Analysis

Table 3.6 reveals the difference of means of the three science orientations by select demographic measures. These bivariate relationships suggest there is a knowledge gap between men and women. Males, on average, correctly answer one more question than their female counterparts. This is consistent with prior literature examining gender differences, where this gap is also noted (Hayes 2001; Hayes and Tariq 2000), although females do appear to know more about climate change than their male counterparts despite this gap (McCright 2010). There is an age gap as well, where the elderly (aged 66 and up) average one point lower on the quiz. Also of note is the lack of variation between ideological groups. Conservatives (defined as those selecting the three most conservative positions on an eleven-point ideological scale) are no different from liberals (those selecting the three most liberal positions on the ideological scale). Lastly, there is some overlap between the educational measures and science knowledge, which is expected, given that participation in college science courses is required for a majority of degrees in the United States. With respect to one's level of faith in science, there is little difference in the mean scores of demographic groups. A similar interpretation emerges when considering one's level of skepticism about science, although conservatives are a bit more likely to agree with cautious statements by about one-half of one point on the four-point scale.

Political Ideology

As noted earlier, the citizenry's orientation toward science is not the only dimension within a belief system. The public utilizes other orientations as well. While there are no questions within the *Science News Survey* to assess cultural values, there is a degree of overlap between cultural and political values (Michaud et al. 2009; but see Ripberger et al. 2012). A focus on ideological values is a valid analytical approach given this overlap as well as the political dynamics of climate

change. Policy solutions that seek to mitigate greenhouse gas emissions involve increased government regulation, which may or may not clash with the political orientations of the citizenry.

Table 3.6: Demographic variation across measures of scientific orientation

<i>Category</i>	<i>Science knowledge</i>			<i>Faith-in-science</i>			<i>Skeptical-of-science</i>		
	<i>N</i>	<i>mean</i>	<i>s.d.</i>	<i>N</i>	<i>mean</i>	<i>s.d.</i>	<i>N</i>	<i>mean</i>	<i>s.d.</i>
All	1371	6.6	2.6	1353	3.2	0.6	1335	2.4	0.6
Gender									
<i>Male</i>	675	7.1	2.5	666	3.3	0.6	664	2.3	0.6
<i>Female</i>	696	6.1	2.5	687	3.2	0.6	671	2.4	0.6
Education									
<i>No Degree</i>	952	6.0	2.5	943	3.2	0.6	930	2.4	0.6
<i>Bachelors</i>	280	7.8	2.1	274	3.3	0.6	275	2.2	0.6
<i>Advanced</i>	139	8.2	2.2	136	3.4	0.6	130	2.2	0.6
Age Cohort									
18-25	154	6.8	2.4	154	3.3	0.6	156	2.4	0.7
26-35	241	7.0	2.4	242	3.2	0.6	240	2.4	0.6
36-45	288	6.9	2.5	287	3.2	0.6	284	2.4	0.7
46-55	242	6.8	2.7	240	3.2	0.6	235	2.3	0.6
56-65	226	6.5	2.5	218	3.2	0.6	217	2.4	0.6
66+	220	5.5	2.6	212	3.3	0.5	203	2.3	0.6
Ideology									
<i>Conservative (Top 3)</i>	266	7.1	2.4	257	3.2	0.6	252	2.5	0.7
<i>Moderate (Middle 5)</i>	743	6.8	2.4	733	3.3	0.6	724	2.3	0.6
<i>Liberal (Top 3)</i>	130	7.3	2.6	126	3.4	0.6	129	2.0	0.7

Notes: Values reported in the table, from left to right, are number of observations, mean score on the science knowledge quiz, and the standard deviation (s.d.).

A long line of literature has documented the citizenry view the world through a liberal-conservative ideological lens (e.g., Converse 1964). A measure of political ideology is leveraged to account for this alternative orientation utilized by the public to interpret policy debates. The measure was recoded to a -5 (liberal) to +5 (conservative) scale in order to ease the interpretation of the coefficients in the forthcoming regression. Respondents unsure of their placement on the scale (236 respondents) were removed from the analysis, although supplementary analyses suggest

there are no broad-level interpretative differences if these respondents were recoded as moderates. In fact, in some cases, the inclusion of these additional survey respondents leads to even stronger support for the hypotheses, suggesting that the direction of any omission bias is against the specified hypotheses.

In addition to ideology, a battery of demographic figures is included at times in the analyses. These include age (continuous), gender (dichotomous, female high value), partisanship (two separate dichotomous measures for Republican and Democrat, independents as the reference group), and two alternative education measures (two dichotomous measures for the type of college degree earned, four-year and advanced). These measures are also included in Table 3.2. These measures are included to account for additional explanatory power not captured by orientations. Given the science knowledge gaps noted earlier for age and gender, women and the elderly population may reach conclusions about climate change due to unique viewpoints not captured by science and political orientations. With respect to the education metrics, other educational processes, outside exposure to science courses, may provide the skills necessary for the public to evaluate causal arguments about climate change. The forthcoming analyses considers multiple models that test whether adding these socio-demographic controls account for any unique variation left unexplained by science and political orientations.

Outcome Measures

The two-step model described in Chapter 2 conceptualized two types of dependent variables. The first stage requires measures that represent an individual's understanding of climate change. Three outcome variables were identified within the *Science News Survey* that meet this requirement. The dependent variables selected for the first-stage of the analysis include the following true or false quiz-style questions, all of which come from the first wave of the survey:

- The greenhouse effect causes the Earth's temperature to rise;
- The primary human activity that causes global warming is the burning of fossil fuels such as coal and oil; and
- Global warming is increasing primarily because the level of direct radiation from the Sun is increasing.

Each question represents various stages of the public debate on climate change. The first question covers the basic outcome associated with the greenhouse effect while the second addresses the possibility that human activity can influence the environment. On both issues, there is considerable certainty among climatologists that the greenhouse effect causes warming and burning fossil fuels emits greenhouse gases. The greenhouse effect theory is supported by basic physics, as is the argument that burning fossil fuels can release greenhouse gases and contribute to global warming. The third question taps a more politically- and scientifically-contested issue: whether solar radiation (a natural force) is primarily responsible for global warming. Climatologists at the IPCC do not dismiss the role of solar radiation, but the 2007 report (IPCC 2007) references anthropogenic causes as the primary cause of climate change (but see Shaviv 2006). As such, an answer consistent with the majority of climatologists would be FALSE for the third question and TRUE for the first and second questions.¹⁵ Each question featured three answer options – true, false, and do not know. Consistent with prior studies (Durant et al. 1989; Miller 1998), each measure was recoded into a dichotomous measure so that agreement with the consensus position

¹⁵ A careful interpretation of the question wording is appropriate on this front. The third question only speaks to whether solar radiation is the primary driver of global warming. For those answering FALSE, it cannot be definitively determined whether they view anthropogenic forces as the primary driver or perhaps some other natural variation. It is also possible respondents answered FALSE because they completely reject the idea of global warming.

of scientists is the high value while the incorrect and do not know responses represent a zero value.¹⁶

The second stage of the analysis requires a measure that represents the perceived threat of climate change. In the third wave of the survey, respondents were asked the following question: “How concerned are you about global climate change?” Survey respondents were presented with a five-point scale to indicate their level of concern. The options included: very concerned, concerned, mildly concerned, largely unconcerned, and totally unconcerned. In Chapter 5, this measure of concern is used as an additional dependent variable when testing the two-step process.

Model Presentation & Next Steps

The first empirical chapter considers only the first stage of the two-step process. This initial test focuses on the relationship between orientations and acceptance of causal arguments offered by climatologists. The hypotheses presented in Table 3.7 are tested in this analysis. Each hypothesis is restated and accompanied by the independent variable relevant to assessing the relationship. Figure 3.2 diagrams the expected relationship between these key variables and the three outcome measures noted earlier. The outcome measures, again, represent the causal arguments offered by climatologists.

¹⁶ This coding has potential consequences for the analysis. The rationale for the coding is that the assessment seeks to identify those who agree with scientists. For the science comprehension thesis, there is no fundamental difference between DKs and incorrect answers. Commentary in the literature suggests some DK responses could be randomly recoded with true values to offset any biases due to the propensity of some groups to guess more than others (Mondak 2001). Recent literature has operationalized the DKs as a middle category residing between clear assertions of agreement/disagreement (e.g., Kahan et al. 2011). Other work, however, suggests DK responses do not reveal very much missing knowledge (Luskin and Bullock 2011).

Table 3.7: Hypotheses for first-stage analysis

<i>Hypothesis</i>	<i>Measure</i>
Hypothesis 1: Individuals with higher levels of scientific knowledge accept the causal arguments from climatologists at higher rates than their low-knowledge counterparts, holding all else constant.	Science knowledge quiz score
Hypothesis 2: Individuals perceiving benefits from scientific advancement are more likely to accept causal arguments from climatologists, holding all else constant.	Faith-in-science index
Hypothesis 3: Individuals skeptical of scientists and their work are less likely to accept the causal arguments from climatologists, holding all else constant	Skeptical-of-science index
Hypothesis 4: Liberals (conservatives) are more likely to agree (disagree) with causal arguments consistent with the IPCC, holding all else constant.	Ideology
Hypothesis 5: Political ideology conditions the relationship between scientific knowledge and climate change beliefs, holding all else constant.	Interaction: Science knowledge * ideology

Figure 3.2: Proposed relationships between selected orientations and acceptance of climate change arguments**Science orientations**H₁ Science knowledge (+)H₂ Faith-in-science index (+)H₃ Skeptical-of-science index (-)**Political orientations**H₄ Political ideology (+)**Orientation interaction**H₅ Science knowledge by ideology (-)**Socio-demographic controls**

Age (-)

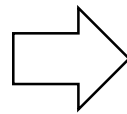
Gender (+)

Democrat (+)

Republican (-)

Four-year degree (+)

Advanced degree (+)

**Understanding of climate change**

- 1) The greenhouse effect causes the Earth's temperature to rise;
- 2) The primary human activity that causes global warming is the burning of fossil fuels such as coal and oil; and
- 3) Global warming is increasing primarily because the level of direct radiation from the Sun is increasing.

Chapter 4 assesses Hypotheses 1 through 5. Each outcome measure – greenhouse effect, fossil fuels, and solar radiation – is considered separately. The analysis presents three logistic regression models for each outcome measure. These models take the following form:

- Equation 1: $\ln\left(\frac{p}{1-p}\right) = b_0 + b_1 * \text{scientific knowledge} + b_2 * \text{faith in science} + b_3 * \text{skeptical of science} + b_4 * \text{political ideology} + \varepsilon$
- Equation 2: $\ln\left(\frac{p}{1-p}\right) = b_0 + b_1 * \text{scientific knowledge} + b_2 * \text{faith in science} + b_3 * \text{skeptical of science} + b_4 * \text{political ideology} + b_5 * \text{scientific knowledge} * \text{political ideology} + \varepsilon$
- Equation 3: $\ln\left(\frac{p}{1-p}\right) = b_0 + b_1 * \text{scientific knowledge} + b_2 * \text{faith in science} + b_3 * \text{skeptical of science} + b_4 * \text{political ideology} + b_5 * \text{scientific knowledge} * \text{political ideology} + b_6 * \text{demographics} + \varepsilon$

The first equation provides a means to test Hypotheses 1 through 4. The second equation adds the interactive measure, allowing for an assessment of Hypothesis 5. The third equation includes the socio-demographic controls. Dividing the analysis into multiple components allows a test of whether the interaction term and socio-demographic measures substantively contribute additional

explanatory power to the core model. Specifically, considering the first and second models separately assesses whether conceptualizing the science comprehension thesis as conditional on ideological values significantly improves the explanatory power of the overall model. Model 3 provides additional analysis as to whether the socio-demographic controls capture significant amounts of unexplained variation, whether through the gender, age, or education gaps noted above.

The last empirical chapter utilizes path analysis to test the causal process outlined in the two-step model. This analysis includes two additional hypotheses, re-stated in Table 3.7. Assessing the full model requires taking the dependent variables of the first stage and using them as independent variables that predict climate change concern (see Figure 3.3). Path analysis is selected because the technique was designed to assess the structural relationships specified within causal processes such as the two-step process described here (Kline 2005). The intent of the analysis is to only show support for the two-step process – not compare a range of competing causal models. The technique will assess whether scientific knowledge has a prior effect on other endogenous measures that, in turn, correlate with higher levels of concern about climate change.

Table 3.8: Hypotheses for full two-step model

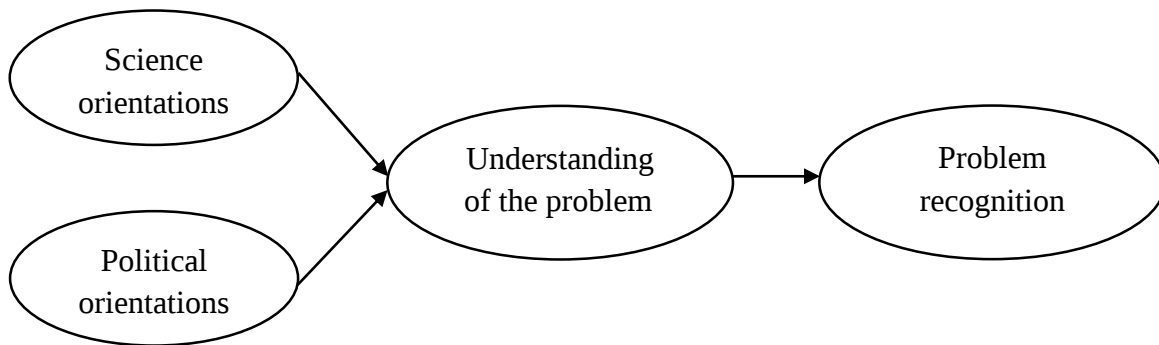
<i>Hypothesis</i>	<i>Measure(s)</i>
Hypothesis 6: Individuals who understand climate change in a manner consistent with climatologists are more likely to demonstrate higher levels of concern.	Solar radiation and fossil fuel beliefs
Hypothesis 7: Individuals concerned about climate change are knowledgeable about basic scientific principles.	Climate change knowledge, scientific knowledge

Summary

The discussion now turns toward assessing the first step of the two-step process developed in Chapter 2. To reiterate, the two-step process is a conceptualization of public opinion that is utilized to assess both the science comprehension and value-centered theses. The two theses have led to inconsistent, and in some cases conflicting, results. The arguments, however, are not

mutually exclusive. Rather, the inconsistencies that have emerged when analyzing climate change attitudes are the result of improper model specification. The two-step process is an attempt at addressing this inconsistency in the literature.

Figure 3.3: The two-step process



CHAPTER 4: ORIENTATIONS AND ACCEPTANCE OF CAUSAL ARGUMENTS

This opening empirical chapter assesses the first stage of the two-step model. The model conceptualizes “problem recognition” as a bridge between basic science knowledge and climate change concern. That is, individuals need to recognize the problem before deciding whether they are concerned about the problem. As policy actors attempt to frame the problem to the public, they offer different causal arguments that can lead to divergent understandings of the problem. This chapter considers, then, the direct relationship between both political and scientific orientations with the acceptance of three specific arguments relevant to climate change: whether the greenhouse effect produces global warming, if burning fossil fuels is the primary mechanism by which humans warm the Earth, and whether warming is the result of increased solar radiation.

The proposed relationships discussed in the prior chapters are diagramed in Figure 4.1. The first hypothesis expects a positive relationship between scientific knowledge and climate change beliefs. Individuals who score higher on the ten-point knowledge scale should demonstrate an increased likelihood of agreeing with the three propositions about climate change. Knowledge, however, only captures one dimension of an individual’s scientific orientation. Predispositions about scientists are potentially important as well. Hypothesis 2 captures the expected relationship between positive normative views of science and climate change beliefs. Those who view society as better off due to scientific advancements and view scientists themselves as working to benefit society are going to demonstrate a greater tendency to agree with scientists on climate change. The third hypothesis assesses relationships related to skeptical normative views, such as those of individuals who question the work of scientists and are open to other methods of justifying beliefs. Such individuals view science skeptically, and as such, they are less likely to agree with scientists in general and climatologists in particular. As shown in Table 3.3, the bulk of the population (94%)

perceives some level of benefits from science and technological advancement. Roughly 35% of these respondents, however, also find reasons to doubt the work of scientists. This group expresses an ambivalent attitude toward the contributions of scientists. In short, individuals can score high on both indices as noted in chapter three. The second and third hypotheses, then, are considered separately due the multi-dimensionality of the two constructs.

Political orientations are the focus of the fourth hypothesis. Due to policy preferences, views of appropriate government activity, as well as a tendency to utilize heuristics offered by ideological leaders, the fourth hypothesis expects conservatives to reject the views of climatologists at greater rates. Meanwhile, liberals are more likely to share the climatologists' beliefs. Moderates will fall somewhere between liberals and conservatives when it comes to their support for a given proposition.

Figure 4.1: Proposed relationships between selected orientations and acceptance of climate change arguments

Science orientations

H1 Science knowledge (+)

H2 Faith-in-science index (+)

H3 Skeptical-of-science index (-)

Political orientations

H4 Political ideology (+)

Orientation interaction

H5 Science knowledge by ideology (-)

Socio-demographic controls

Age (-)

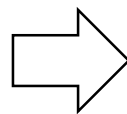
Gender (+)

Democrat (+)

Republican (-)

Four-year degree (+)

Advanced degree (+)



Understanding of climate change

- 1) The greenhouse effect causes the Earth's temperature to rise;
- 2) The primary human activity that causes global warming is the burning of fossil fuels such as coal and oil; and
- 3) Global warming is increasing primarily because the level of direct radiation from the Sun is increasing.

The next point of inquiry (Hypothesis 5) considers the possibility of an interactive effect between scientific knowledge and political ideology. The presumption noted earlier was that high-knowledge individuals are more likely to follow ideological cues and reject expert positions. This last hypothesis considers whether the science comprehension thesis is affected by political values. If individuals rely on values and predispositions as expected, high-knowledge conservatives and liberals should view climate change differently when compared to ideologically neutral moderates.

The earlier descriptive analysis suggested that gender and age gaps exist in respect to science knowledge. Additional literature also notes differences in environmental attitudes according to gender, with females often more concerned about climate change and more knowledgeable about climate change facts (McCright 2010, but also see Hayes 2001). Including age and gender as socio-demographic controls offers additional information as to whether there is something unique about women or age that cannot be explained via scientific knowledge or political values. If scientific knowledge is significant while age and gender both remain insignificant, then perhaps the science comprehension thesis is one means of understanding these demographic gaps in environmental attitudes.

The educational achievement and partisan control measures are included for comparison purposes. Reasonable counterarguments to the model specification might emphasize partisanship and educational values as more dynamic predictors of opinions. Experience with science may not be a necessary condition to sort through the climate change debate. In the absence of science knowledge, individuals with non-scientific knowledge may have sufficient skills to decipher the political debate and evaluate the claims of scientists. Similarly, partisanship may function as the optimal predictor of attitudes – especially if survey respondents were unable to understand the meaning or intent of the ideology question on the survey. The expected directions of the

coefficients for these additional relationships are noted in the diagram, although the science and political orientation measures are expected to explain the majority of the variation.

Climate change beliefs are operationalized with the three previously noted survey questions that speak to different aspects of the causal argument. To reiterate, the first outcome measure asks respondents about the outcomes associated with the greenhouse effect while the second outcome measure considers the relationship between humans and the damage caused by burning fossil fuels. The last outcome measure considers a specific counterargument to the scientific community – that solar radiation is primarily responsible for global warming. These three questions constitute the dependent variables to be considered here. As noted earlier, there is more certainty among climatologists in respect to the first two measures. However, the solar radiation proposition is more complicated and contested, with perhaps less certainty among select scientists. Despite these differences, the initial expectation is that the hypothesized relationships will emerge throughout the analysis, regardless of the outcome measure.

Each measure is coded on a dichotomous scale, with high values (coded as “1”) indicating agreement with the causal arguments from the climatologists working with the IPCC. Low values (coded as “0”) indicate a failure to acknowledge these positions – either an incorrect answer or a “Don’t Know” response. This operationalization tests for explicit acknowledgement by respondents to the arguments of climatologists.

The forthcoming analysis will consider each outcome variable separately. For each outcome, the discussion will first note the extent to which support for the hypotheses is found within the models. This is followed by a comparison of the three equations noted earlier, including how well each explains the variation within climate change beliefs. The substantive effects of key

variables are then discussed. The chapter will close with a comparison of all three issues and a discussion of the implications associated with the results.

Analysis: Greenhouse Effect

The first outcome measure introduced here addresses a core scientific concept in climate change discussions: the greenhouse effect. The question asked respondents whether the following statement is true or false: “The greenhouse effect causes the Earth's temperature to rise.” Table 4.1 presents the logistic regression coefficients and z-score for models one through three. The first model offers an assessment of the first four hypotheses, with the model supporting three of the four expectations. First, a statistically significant relationship emerged between science knowledge and responses to the question. Individuals with elevated levels of scientific knowledge are more likely to identify the outcomes of the greenhouse effect (Hypothesis 1). Second, individuals who scored higher on the faith-in-science index are also significantly more likely to support for the proposition (Hypothesis 2). Third, an ideological divide is observed. The coefficient for political ideology is statistically significant and suggests that conservatives are more likely to reject the proposition compared to moderates while liberals are more likely than moderates to accept the proposition (Hypothesis 4). Lastly, the direction of the relationship between those skeptical of science and the proposition in question is negative (Hypothesis 3). More skepticism corresponds with a lower likelihood of identifying outcomes associated with the greenhouse effect. However, the relationship itself is not significant. The magnitude of these relationships will be taken up later, but for now, there is support for both the science comprehension thesis as well as the value-centered thesis.

Table 4.1: Acceptance of the greenhouse effect argument

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
Scientific knowledge	0.17 (4.59)	0.26 (6.34)	0.24 (5.55)
Faith in science	0.42 (2.48)	0.42 (2.50)	0.42 (2.47)
Skeptical of science	-0.08 (-0.52)	-0.05 (-0.32)	-0.06 (-0.39)
Ideology	-0.23 (-4.87)	0.26 (2.48)	0.28 (2.78)
Ideology X science knowledge	-	-0.08 (-5.16)	-0.08 (-4.97)
Republican	-	-	-0.02 (-0.09)
Democrat	-	-	0.29 (1.13)
Age	-	-	-0.01 (-1.67)
Female	-	-	0.09 (0.49)
4-yr degree	-	-	0.22 (0.91)
Advanced degree	-	-	0.49 (1.45)
Constant	-1.22 (-1.63)	-1.75 (-2.43)	-1.32 (-1.62)
Model 1: N=1082	Log-likelihood -578	Wald Chi ² 70.0	PCP 72.5%
Model 2: N=1082	Log-likelihood -559	Wald Chi ² 83.7	PCP 72.7%
Model 3: N=1082	Log-likelihood -553	Wald Chi ² 91.6	PCP 73.1%

Notes: The first number represents the coefficient derived from a logistic regression. The number in parenthesis indicates the z-score from the significance test. In all models, a weight provided by Knowledge Networks was utilized in order to make inferences from the results back to the U.S. adult population.

The percent correctly predicted by each model was also calculated. This analysis compares the predicted probability that respondents agree with a proposition with the actual observed answer for each respondent. If the model calculates a predicted probability that a respondent agrees with the proposition at a rate greater than 50% and if the respondent actually agreed with the proposition, then it is a successful prediction. Conversely, if the predicted probability was less than 50% and

the respondent did not indeed support the proposition, then it is also a successful prediction. The results of this analysis are displayed in Table 4.2. Overall, the model successfully predicts answers for 72.5% of the respondents. A more nuanced look is obtained by looking at the sensitivity (how many of those who agreed were predicted successfully) and the specificity (how many of those who disagreed were predicted successfully). The sensitivity was 94.6% while the specificity was 16.4%. Many of the incorrect predictions, then, come from people who answered false yet for whom the model predicted a true value. These calculations suggest there is perhaps a missing measure from the model, one that would facilitate better predictions of those disagreeing with the proposition.

Table 4.2: Percent correctly predicted for each model

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
Percent correctly predicted	72.5%	72.7%	73.1%
Sensitivity	94.6%	94.2%	94.7%
Specificity	16.4%	18.4%	18.4%

Model 2 in Table 4.1 adds an interactive term to assess the fifth hypothesis, that ideology moderates the relationship between knowledge and beliefs. Support for an interactive effect is found on multiple fronts. First, the interactive term and its two components are all significant. The coefficients suggest a more nuanced interpretation of the science comprehension thesis is warranted. A high-knowledge moderate (when ideology and the interaction equal zero) is more likely to agree with climatologists (coefficient of 0.26). With the ideology coefficient, there is a sign reversal from negative to positive. This measure is interpreted as representing low-knowledge ideologues (Brambor et al. 2006). Among those with no knowledge (a zero on the quiz score), the coefficients suggest it is conservatives who are more likely to agree with the proposition than both moderates and liberals.

The interactive term is interpreted as high-knowledge ideologues. The negative coefficient suggests high-knowledge conservatives are less likely to agree with the proposition compared to their high-knowledge counterparts while high-knowledge liberals are more likely agree with the proposition at greater rates. The overall effect of ideology remains negative in the second model. The substantive details of this interaction will be taken up shortly after discussing the other models.

Also supporting the fifth hypothesis is the overall improvement in the model's fit. A Wald test was utilized to test whether constraining the interaction term to zero significantly reduces the overall fit of the model. The test indicates that the fit of the model is improved by including the interactive term ($p < 0.001$). A similar analysis was performed with a likelihood ratio test, which compares whether the difference in the log-likelihood between the two models is significant. This statistic is two times the difference in the log-likelihood for each model. The derived statistic is 38.8 with one degree of freedom, which is significant according to the chi-square distribution matrix ($p < 0.001$).

While the Wald and log-likelihood ratio test statistics suggest the second model improves on the first, the overall predictive power of the model is not improved by adding the interactive term. Referring back to Table 4.2, the second model's prediction success rate is only 72.7% - an increase of 0.2%. The second model performs equally well when looking at the sensitivity and specificity. The consistency of this imbalance suggests identifying high-knowledge conservatives as less likely to agree with the proposition does not significantly improve the predictive capabilities of the model.

The third model adds the socio-demographic controls. With respect to the core hypotheses, there is no change in the interpretation compared to model two. In respect to the socio-demographic controls, none of the measures achieve significance in the model. The direction of the relationships,

however, fits with expectations. The strength of the science knowledge coefficient and the lack of a significant age and gender relationship suggests differences along these socio-demographic identities might indeed be the result of differing levels of scientific knowledge. Furthermore, a Wald test of the socio-demographic controls as a block suggests that while the Wald statistic increases with the third model, it did not do so significantly. A similar interpretation is found with the likelihood ratio test. A statistic of 11.8 is derived with the previously noted formula. With six degrees of freedom, the additional variables are not significant at the 95% confidence level. With respect to the model's predictive power, the socio-demographic measures offer little additional explanatory power. The overall predictive power does improve slightly (73.1% correctly predicted), but there is little change in the sensitivity or specificity.

Substantive Effects

The preceding discussion identifies statistically significant relationships within the data, but statistical relationships do not tell the full story (Kline 2013). The next section explores the substantive effects using the coefficients from Model 3 of Table 4.1. Although Model 3 offered no additional explanatory power in this context, the controls do increase performance of the model in later analyses. For consistency purposes, the coefficients from the third model will be utilized throughout all substantive analyses.

As knowledge accumulates, the likelihood that respondents agree with the scientific community increases. The predicted probability of agreement with climatologists for those with medium knowledge (score of 7 on the quiz) is 76.9% of the time – holding all other variables in Model 3 at their respective means.¹⁷ A move to full knowledge increases the predicted probability

¹⁷ All predicted probabilities are derived from Model 3 by using the Delta method, holding all other independent variables at their respective means unless otherwise noted.

of agreement with climatologists to 85.8%. While the nine-point improvement is notable and statistically significant, it is important to stress that the model accurately predicts responses for individuals even at medium levels of knowledge. In fact, an individual who hypothetically guesses on the true and false questions to achieve a 50% knowledge-quiz score would still be predicted to agree with the question 69% of the time. The average marginal effect, which represents the average change in the predicted probability for a one-unit change in knowledge, is 2.6%. On average, then, answering one additional question correctly on the quiz corresponds to a 2.6% increase in the probability that a respondent agrees with the proposition.

Turning attention toward the normative science views, recall there was mixed support for hypotheses two and three. As seen in Table 4.1, those with higher levels of faith in science are more likely to identify the outcome of the greenhouse effect, consistent with Hypothesis 2. However, those who question science do not appear to stand out in their survey responses. To explore this relationship further, the three profiles of normative views noted in Chapter 3 are considered in Table 4.3. The weak pro-science profile provides a baseline to examine an increase on the faith-in-science index from “agree” to “strongly agree” (the strong pro-science profile). A move along this index, holding skeptical science views at “disagree” and all others measures at their respective means, increases the probability of agreement by 8% - an increase that is roughly equivalent to a move from medium to full knowledge on the science knowledge quiz. There is little noticeable difference between the weak pro-science and conflicted individuals, where there is just over a 2% difference in the probability of agreeing with climatologists. Regardless of which profile respondents fall under, there is still a high probability of agreement with climatologists when looking at normative science views.

Table 4.3: Probability of identifying greenhouse effect outcome by normative views of science

	<i>Strong pro-science: Faith science (s. agree), skeptical science (disagree)</i>	<i>Weak pro-science: Faith science (Agree), skeptical science (disagree)</i>	<i>Conflicted: Faith science (agree) skeptical science (agree)</i>
Greenhouse Effect	82.1%	75.1%	72.9%

Notes: Probabilities calculated with coefficients from Model 3 of Table 4.1. All other variables outside those indicated here are held at their respective means.

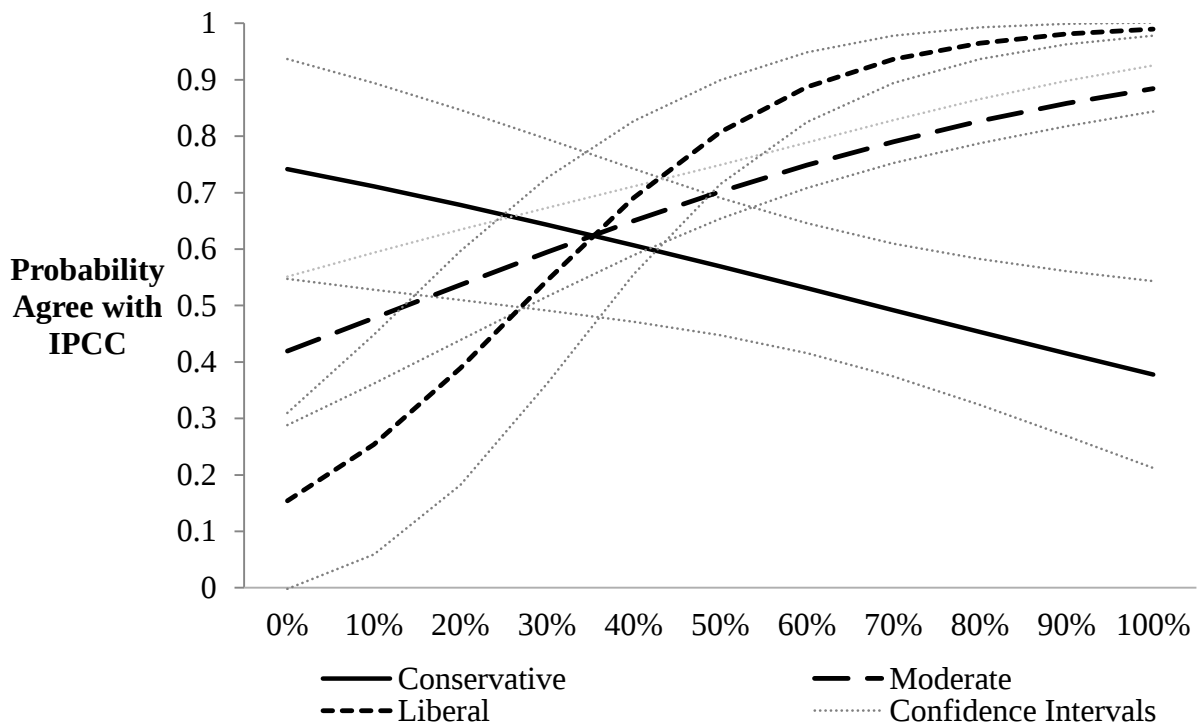
Also consistent with expectations, conservatives are less likely to identify the outcome associated with the greenhouse effect. A strong conservative (at the “5” position on the eleven-point ideological scale) retains a 49.4% probability of accepting the proposition, all other variables held at their respective means. Liberals at the opposite end of the scale retain a predicted probability of 93.4%. Moderates appear closer to liberals than conservatives, all things equal, with a calculated probability of 78.8%. This ideological difference is expected given the divergent political messages offered by political leaders about climate change. Unlike the other hypotheses, the fourth hypothesis that focuses on ideology is particularly notable given the 40-point gap in predicted probabilities for conservatives and liberals (all things equal). The average marginal effect for ideology is approximately 50% larger than that calculated for science knowledge. A one-point movement along the ideological continuum results, on average, in a 4.0% change in probability of agreeing with the proposition. The substantive strength of the relationship suggests political ideology is a potent factor utilized by the public to interpret policy debates that involve scientific information.

While there is support for the science comprehension thesis here, the interactive effects suggest the thesis requires some qualification. The models support the interactive relationship between scientific knowledge and political ideology (Hypothesis 5). The interactive nature of the relationship is displayed in Figures 4.2 and 4.3. The first figure shows the probability respondents agree with the proposition for three types of ideologues – strong conservatives (“5” position on

the ideology scale), strong liberals (“-5” position) and moderates (“0” position). The 95% confidence intervals for each of the groups is included as well. Consistent with the prior interpretation, the figure suggests low-knowledge conservatives are more likely to identify the outcome associated with the greenhouse effect compared to moderates and liberals possessing similar levels of knowledge. However, the slope is at a downward angle, with conservatives becoming less likely to share the beliefs of climatologists as they accumulate scientific knowledge. Meanwhile, as liberals and moderates accumulate knowledge, the probability they associate the greenhouse effect with warming increases.

At low levels of knowledge, the chart suggests there is little difference between ideologues at opposite ends of the scale. Respondents who can correctly answer 30 to 40% of the questions possess approximately the same predicted probability of agreeing with climatologists (around 60%). The ideological differences, however, start to emerge once respondents pass the halfway point on the quiz. For liberals, once medium levels of knowledge are obtained, there is a remarkably high probability that respondents will agree with the proposition. A move from medium to full knowledge increases the probability by almost six points (93.6% to 99%). Moderates who move from medium to full knowledge experience a bit more change in prediction capabilities, moving from a 79.0% to 88.4% probability of agreement. For both moderates and liberals, there is support for the science comprehension thesis.

Figure 4.2: Probability agree with IPCC by science knowledge for liberals (-5), moderates (0), and conservatives (5)



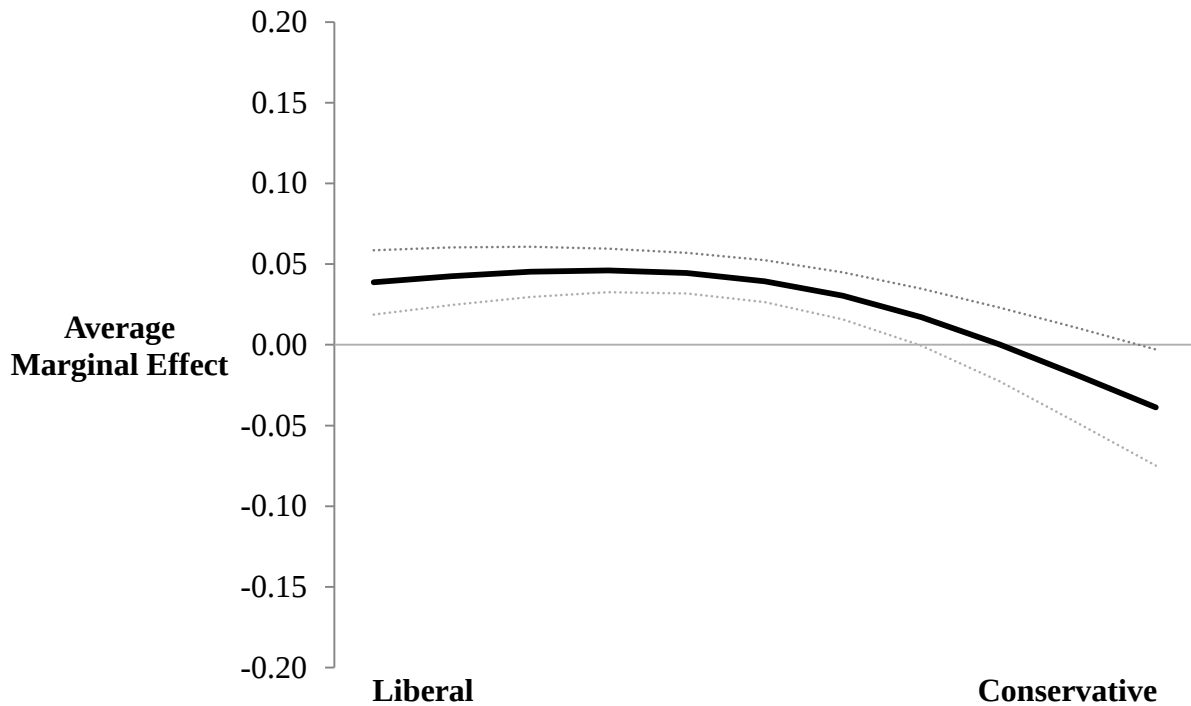
As shown in the figure, the probability of conservatives agreeing with the proposition slowly declines as knowledge is accumulated. There is a double-digit drop in the predicted probability of agreement with the proposition for strong conservatives. A move from medium to full knowledge (a drop from 49.2% to 37.8%). A high-knowledge conservative is almost 50 points away from a moderate and 60 points away from a liberal.

As a whole, this is strong support for Hypothesis 5, as the science comprehension thesis appears to explain climate change beliefs for only two of the three ideological groups. The value-centered thesis finds support due to the apparent reliance of conservatives on other views besides those from climatologists. That high-knowledge conservatives were less likely to agree with low-knowledge conservatives was not hypothesized in Chapter 2, although the finding is consistent with the observation that ideologues are more educated (Taber and Lodge 2006) and that these

ideologues are likely to adopt positions opposite their opponents in policy debates (Nicholson 2012). Furthermore, the s-shaped pattern for strong liberals is of note. They more readily embrace the position of climatologists as scientific knowledge accumulates because they are less likely to question the science since the findings and conclusions generally conform to their predispositions. This pattern supports both the value-centered and science comprehension theses.

Figure 4.3 above shows the average marginal effects of science knowledge by ideology. The figure reveals an increase in the predicted probability of liberals and moderates identifying the outcome of the greenhouse effect as they accumulate knowledge. For each question answered correctly by a strong liberal, the predicted probability increases by 3.6% on average, all things equal. A move from a medium score of seven to maximum knowledge at 10 would produce, on average, a 10.8% increase in the predicted probability. This improvement in prediction increased by an average of 4.3% for moderates, or about 12.9% as one moves from medium to full knowledge. However, all things equal, the probability of predicting the beliefs of conservatives does not improve as they accumulate scientific knowledge. The probability of successfully predicting strong conservatives (ideology=5) drops by an average of 3.4% for each knowledge question answered successfully. A move from medium to full knowledge would result in a 10.2% drop in predictive capability, all things equal. There appears to be no significant benefit from accumulating knowledge for more conservatives in the “3” and “4” positions on the ideology scale. These results from Figure 4.3 are interpreted as continued support for the both theses.

Figure 4.3: Average marginal effect of scientific knowledge by ideology



Summary: Greenhouse Effect

When it comes to understanding the outcomes associated with the greenhouse effect, there is support for four of the five hypotheses. Consistent with the first hypothesis, high-knowledge individuals answered the question differently from their low-knowledge counterparts, suggesting support for the science comprehension thesis. The thesis, however, requires qualifications. The fifth hypothesis, that ideology moderates the relationship between knowledge and beliefs, is also supported. The analysis suggests the science comprehension thesis can explain beliefs of liberals and moderates but not conservatives. This suggests there are some limits to knowledge, given that knowledgeable individuals will defer to their predispositions and values.

The substantive strength of the relationship seems notable at first, but it is important to remember the models retain considerable predictive power regardless of whether individuals possess average or high knowledge. In this sense, there does not appear to be much value

associated with taking extra steps to accumulate additional scientific knowledge. Still, individuals with low-knowledge retained predicted probabilities below 50%, so there is a notable change as knowledge accumulates. The effect of accumulating knowledge occurs as respondents move from low to middle levels of knowledge, rather than from average to high levels of knowledge. Comparatively, a move in ideological views corresponds with a greater change in predicted probability. This suggests that while knowledge is one explanatory concept, ideology is a more powerful predictor of beliefs about the greenhouse effect.

Furthermore, individuals retaining a degree of faith in science were more likely to answer the question in a manner consistent with climatologists. The substantive effects, however, are limited. As noted in Chapter 3, most respondents either agree or strongly agree with the positive benefits of science. A move from “agree” to “strongly agree” improved the probability of agreement by 7%. The substantive effect of such a move is similar to a move on the science-knowledge scale from medium to full knowledge. Those cautious of scientific advancements, however, did not stand out in their beliefs as expected, suggesting no support for the third hypothesis in the context of the greenhouse effect. These results will be compared to the other two issues toward the end of the chapter. For now, the analysis turns to propositions about fossil fuels, followed by solar radiation.

Analysis: Fossil Fuels

The second analysis focuses on whether the burning of fossil fuels is the primary way in which society can cause global warming. Specifically, the question asked the following true and false question: “The primary human activity that causes global warming is the burning of fossil fuels such as coal and oil.” Table 4.4 presents the results from the logistic regression using equations one through three specified earlier.

Table 4.4: Acceptance of the fossil fuels argument

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
Scientific knowledge	0.14 (3.95)	0.19 (5.25)	0.19 (5.07)
Faith in science	0.39 (2.75)	0.41 (2.83)	0.35 (2.44)
Skeptical of science	-0.04 (-0.27)	0.00 (0.01)	-0.00 (-0.00)
Ideology	-0.19 (-5.14)	0.24 (2.56)	0.24 (2.62)
Ideology X science knowledge	-	-0.07 (-4.89)	-0.06 (-4.52)
Republican	-	-	-0.26 (-1.27)
Democrat	-	-	0.33 (1.54)
Age	-	-	0.00 (0.32)
Female	-	-	-0.32 (-1.97)
4-yr degree	-	-	0.08 (0.42)
Advanced degree	-	-	0.03 (0.12)
Constant	-1.70 (-2.44)	-2.12 (-3.00)	-1.93 (-2.45)
Model 1: N=1082	Log-likelihood -671.3	Wald Chi ² 56.6	PCP 64.1%
Model 2: N=1082	Log-likelihood -654.8	Wald Chi ² 76.3	PCP 64.9%
Model 3: N=1082	Log-likelihood -647.6	Wald Chi ² 89.2	PCP 66.8%

Notes: The first number represents the coefficient derived from a logistic regression. The number in parenthesis indicates the z-score from the significance test. In all models, a weight provided by Knowledge Networks was utilized in order to make inferences from the results back to the U.S. adult population.

Within the first model, there is again support for three of the first four tested hypotheses. Individuals with higher performance on the science knowledge quiz were significantly more likely to agree with the proposition (Hypothesis 1). Similarly, individuals who agreed with the positive statements about science were also more likely to express opinions similar to scientists (Hypothesis 2). Empirical support for an ideological gap also emerges. Again, conservatives were significantly

less likely to support the proposition than liberals and moderates while liberals agreed with the proposition at higher rates than moderates (Hypothesis 4). Just as before, the third hypothesis finds no support. Those holding more skeptical attitudes about science were less likely to agree that burning fossil fuels is the primary mechanism by which humans cause global warming.

The proportions of correct predictions are displayed below in Table 4.5. For the first model, 64.1% of the respondents were successfully classified. This is a drop in successful predictions compared to the greenhouse gas analyses. The model does a better job successfully predicting responses for individuals who agreed with the proposition (81.6%) rather than for those who disagreed (39.4%). Compared to the greenhouse effect (specificity below 20%), the models here better predict non-agreement.

Table 4.5: Percent correctly predicted for each model

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
Percent correctly predicted	64.1%	64.9%	66.8%
Sensitivity	81.6%	78.0%	77.6%
Specificity	39.4%	46.3%	51.4%

As before, the second model adds an interactive effect between science knowledge and political ideology to assess the fifth hypothesis. Support is once again found on multiple fronts. First, the interactive components as well as the interactive term are all significant. High-knowledge moderates are more likely to agree with climatologists (science knowledge coefficient of 0.19). Meanwhile, high-knowledge conservatives (the interaction term; coefficient of -0.07) are less likely than high-knowledge moderates and liberals to agree with the proposition. As before, there is a change in the direction of the relations between ideology and the response, suggesting low-knowledge conservatives are more likely than low-knowledge moderates and liberals to accept the proposition (ideology coefficient of 0.24). The overall effect of ideology remains negative in the second model as well.

Including the interaction term also significantly improves the overall fit of the model. A Wald test suggests the interactive term does significantly improve the fit of the model ($p < .001$) while a likelihood ratio test also supports this conclusion. The value of the test statistic is 33, with one degree of freedom – suggesting the improvement is significant ($p < 0.001$) utilizing a chi-squared distribution matrix. The substantive details of this interaction are reported below, but for now, there is continued support for this more nuanced understanding of the relationship between science knowledge and political ideology.

In terms of the model's ability to correctly predict responses, there is little overall improvement between the first and the second model (see Table 4.5). The overall percent correctly predicted remains roughly the same at 64.9% - an improvement of only 0.8%. The sensitivity and specificity statistics suggest the interaction term improves the predictive capabilities for those who disagree with the proposition. For those answering false, the percent correctly predicted improves by nearly 7% (from 39.4% to 46.3%). There is a slight trade-off, however, as the ability to predict agreement with climatologists drops by 3.6%. As before, these differences in Table 4.5 suggest an additional explanatory concept is needed to help better understand why some respondents reject the proposition in question.

The third model adds the same socio-demographic controls noted earlier. The results suggest no change to the interpretations of the core hypotheses offered for the second model. Of the socio-demographic controls themselves, gender is perhaps of the most interest. The relationship is negative and significant at the 95% confidence level. This relationship suggests that the knowledge gap is not entirely responsible for gender differences when it comes to this proposition about fossil fuels. After controlling for scientific knowledge and the other educational measures, there is still something unique about females and their response to the proposition on

the survey. The remaining socio-demographic controls are in the expected direction but do not achieve statistical significance.

As a block, however, there is mixed support as to whether Model 3 is a better fit to the data. A Wald test suggests no additional explanatory is offered by the inclusion of these additional variables as a group. However, the likelihood ratio test suggests the block of socio-demographic controls does improve the overall model fit, with a test statistic of 14.4 with six degrees of freedom – significant at the 95% confidence level. This difference is likely due to the minimal explanatory power offered by the socio-demographic measures. Only gender was significant. The likelihood ratio test indicated the gender relationship was powerful enough to improve the fit of the entire block of demographic controls while the Wald test offered no such indication. An additional Wald test considered gender alone and finds its inclusion significantly improved the fit of the model ($p < 0.05$).

Compared with Models 1 to 2, the third model does slightly improve the overall predictive capability of the model by 2%. This gain is among those who answered false to the proposition. It appears that adding gender to the model improves the predictive capability of false responses by 5% compared to the second model. All together, the third model offers nearly a fifteen-point improvement in predictive capability of false responses by including the interactive term and other socio-demographic controls (notably gender). The discussion now turns to the substantive effects of these identified relationships.

Substantive Effects

With this second analysis, there was once again support for the science comprehension thesis. As before, coefficients from Model 3 are utilized to explore the size of the effects. This is due to the improvement in model fit by including the socio-demographic control (particularly

gender in this case). Focusing in on scientific knowledge, the coefficients suggest that as respondents accumulate more scientific knowledge, the likelihood that they agree society can influence global warming via burning of fossil fuels increases. All things equal, a respondent with average knowledge of science (a score of seven on the quiz) is predicted to agree with the claim 60.9% of the time. As knowledge accumulates to full knowledge, the probability rises to 71.8% - over a ten-point improvement in predictive power. The average marginal effect of science knowledge is 3.1%, which is slightly elevated compared to the marginal effect calculated in the greenhouse effect analysis.

As before, the proposition that normative views of science correlate with beliefs draws mixed support. In the context of fossil fuels, there is again support for Hypothesis 2 but not for the third hypothesis. Individuals who agreed with basic propositions about the merits of scientific advancement were more likely to assert beliefs similar to climatologists (Hypothesis 2). The probabilities based on the three normative profiles (see Chapter 3) are offered in Table 4.6. The results suggest that a move from “agree” to “strongly agree” on the faith-in-science index (holding the skeptical of science index at “disagree” with all other values in Model 3 at their respective means) increases the probability of agreeing with the proposition by eight points – similar the change found when considering the greenhouse effect proposition earlier. As before, there is no difference in probabilities based on whether skeptical views of science are held. The profiles for weak pro-science and conflicted individuals reveal the same probability of agreement with the proposition. The eight-point improvement in the predicted probability is roughly equal to a move from medium to full knowledge on the science quiz score noted earlier.

Table 4.6: Probability agree with IPCC on fossil fuels by normative views of science

	<i>Strong pro-science: Faith science (s. agree), skeptical science (disagree)</i>	<i>Weak pro-science: Faith science (agree), skeptical science (disagree)</i>	<i>Conflicted: Faith science (agree) skeptical science (agree)</i>
Fossil Fuels	66.7%	58.5%	58.5%

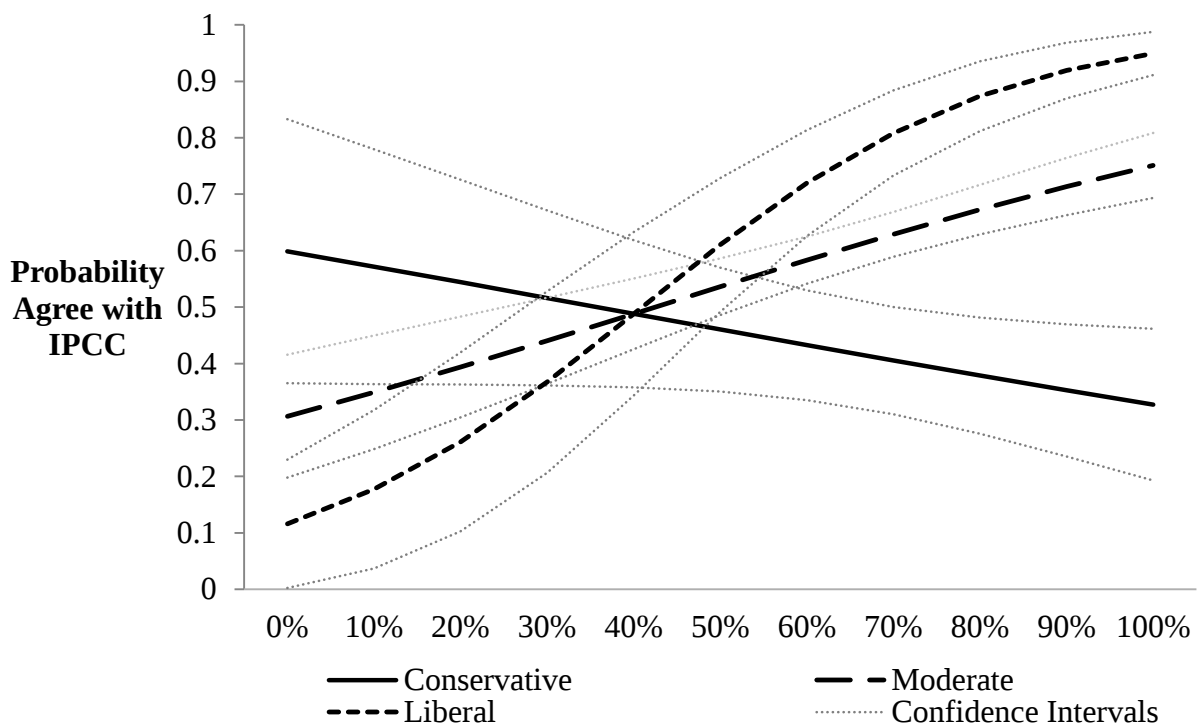
Notes: Probabilities calculated with coefficients from Model 3 of Table 4.4. All other variables held at respective means unless specified in column header.

Again, there was support for the fifth hypothesis – the suggestion that political ideology influences beliefs as well. As respondents grow more conservative in their ideological views, the probability they agree with the fossil fuel proposition declines. A strong conservative is predicted to agree with the proposition 40.7% of the time, all other variables held at their respective means. On the opposite end of the scale, a strong liberal retains a predicted probability of 80.4%. Moderates once again are slightly closer to liberals than to conservatives – agreeing with the proposition 62.6% of the time. These results are consistent with expectations outlined in Hypothesis 4 and are clearly indicative of the well-documented ideological gap within respect to climate change beliefs. There is nearly a 40% swing as one moves across the ideological scale, although the average marginal effect for ideology is approximately -3.5%. This movement is on par with the average marginal effect for science knowledge, but slightly reduced compared to the greenhouse effect analysis earlier.

While the first two models offer support for both the science comprehension and value-centered theses, recall that the interaction term once again suggests qualifications are in order. The second and third models both support the argument for an interactive relationship between scientific knowledge and political ideology (Hypothesis 5). The interactive nature of the relationship is displayed in Figures 4.4 and 4.5. The first figure shows the probability of agreement with the proposition for three types of ideologues – strong conservatives (“5” position on the ideology scale), strong liberals (“-5” position) and moderates (“0” position). The 95% confidence

interval is once again included for each group. As before, at low levels of knowledge there is little difference between ideologues. Respondents who score roughly 40% on the science knowledge quiz possess the same predicted probability of agreeing with climatologists (around 50%). For these low-knowledge individuals, agreement with climatologists is approximately a 50-50 proposition. The ideological gap starts to emerge once respondents can answer at least 50% of the questions. The probability that strong liberals agree with the proposition escalates rapidly but levels off once a medium level of knowledge is reached. A move from average to complete knowledge for liberals increases the probability by just over 14% (80.8% to 94.4%). A similar shift among moderates produces a change from 62.9% to 75.1% in the predicted probability of agreement. For both moderates and liberals, there is once again support for the science comprehension thesis.

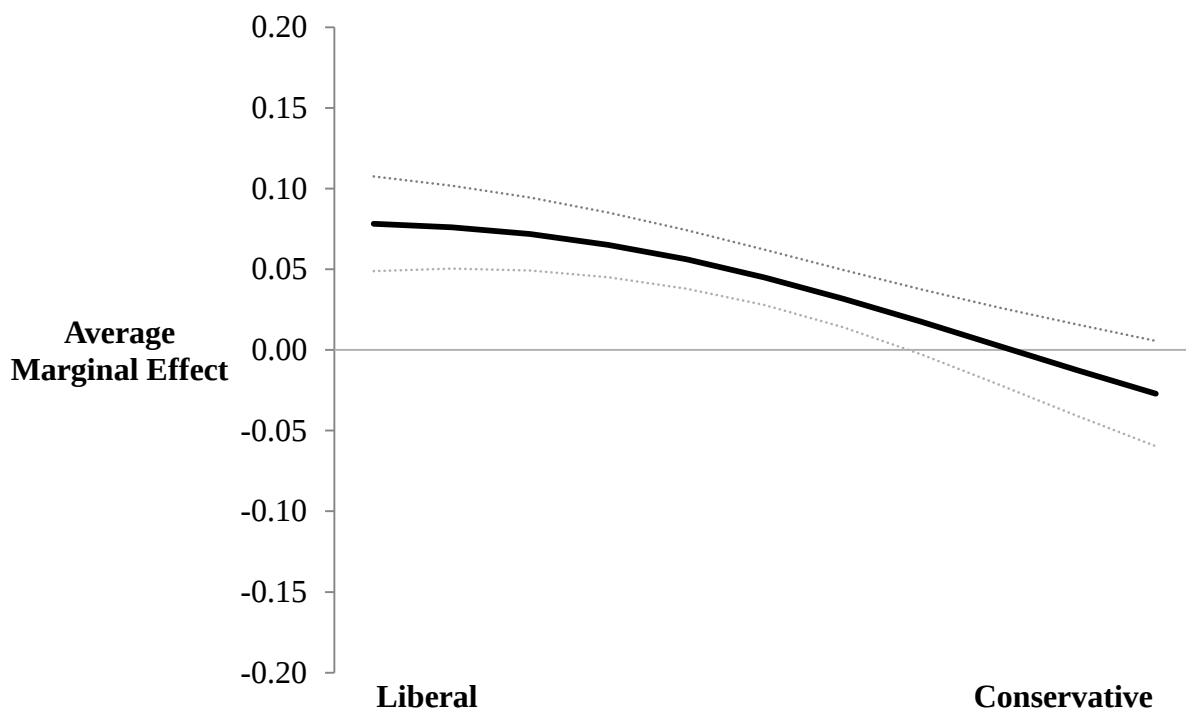
Figure 4.4: Probability agree with IPCC by science knowledge for liberals (-5), moderates (0), and conservatives (5)



Conversely, the probability of conservatives agreeing with the proposition slowly declines as knowledge accumulates. There is a drop in the probability of agreement with the proposition for strong conservatives. The probability of agreement drops from 40.5% to 32.9% for strong conservatives. A high-knowledge conservative is almost 40 points away from a moderate and 60 points away from a liberal.

These relationships offer strong support for Hypothesis 5. The science comprehension thesis finds support when only looking at two of the three ideological groups. Conservatives, meanwhile, appear to rely on other sources of beliefs, which is strong support for the value-centered thesis. The s-shape of the liberal line also suggests support for the value-centered thesis, as liberals appear to more readily accept the proposition as knowledge accumulates due to their environmental predispositions. The negative slope associated with conservatives is consistent with observations that strong ideologues take positions opposite of their political opponents.

Figure 4.5: Average marginal effect of scientific knowledge by ideology



The average marginal effect of science knowledge by ideology is displayed in Figure 4.5, which includes the 95% confidence interval. Knowledge has a positive, significant effect for liberals and moderates. For each question answered correctly, the probability a strong liberal agrees with climatologists increases by 7.6%, on average. A move from average to complete knowledge, then, would increase the probability of agreement by 22.8% on average. The increase in probability for moderates is 4.5%, which corresponds to a 13.5% increase in the probability of agreement with the proposition. For moderate to strong conservatives, scientific knowledge has no significant effect on the probability of accepting the proposition. While the marginal effect is negative, the derived coefficient is not significant. These results support the proposition that the science comprehension thesis offers a means to understand the beliefs of liberals and moderates, but not conservatives.

Summary: Fossil Fuels

The analysis of a second contested component of the climate change debate provides further support for four of the five hypotheses. As before, as individuals accumulate scientific knowledge they demonstrate an increased likelihood of accepting the proposition that fossil fuels cause global warming – a relationship expected according to the first hypothesis. However, qualifications are in order. Political ideology provides an alternative mechanism to understanding climate change beliefs as expected by Hypothesis 4. Furthermore, the interactive effects expected by Hypothesis 5 also emerged. The science comprehension thesis is one mechanism to understand beliefs for liberals and moderates, but it cannot explain the beliefs of conservatives. High-knowledge liberals and conservatives view the proposition differently. Again, there are limits to knowledge – limits that are dictated by the political orientations of individuals.

Substantively, the probability of accepting the proposition is relatively high whether individuals possess medium or elevated levels of knowledge. Those possessing average to full knowledge already possess a high probability of agreeing with climatologists – 60.1% and 71.8%, respectively. Once individuals achieve a quiz score of over 40%, they have a 50-50 chance of accepting the proposition. It is again the move from low to middle levels of knowledge that perhaps bring public opinion into congruence with scientists. Furthermore, in this analysis the average marginal effect of science knowledge and ideology is roughly the same, suggesting similar explanatory power for both concepts.

Expectations about normative scientific views once again find mixed supported. The second hypothesis finds support. Individuals who “strongly agree” with the positive statements were 8% more likely to accept the proposition – all else equal. Substantively, this increase is just behind a move from average to full knowledge on the science quiz. However, those skeptical of science were not significantly less likely to accept the proposition, providing no support for the third hypothesis. The pattern at this point is continued support for four of the five hypotheses specified earlier in the discussion. The analysis will now shift toward solar radiation to examine whether these patterns remain.

Analysis: Solar Radiation

The last outcome measure taps into beliefs about the primary driver of global warming, which again is perhaps the most contested issue within the policy debate. One of the often cited counterarguments to the IPCC is that recent warming is the result of increased solar radiation. Heat output from the sun as well as other cosmic forces are argued to be the cause of warming. The question on the survey asked respondents whether they accept this proposition. Specifically, they were asked the following question: “Global warming is increasing primarily because the level of

direct radiation from the Sun is increasing.” Unlike the prior questions, the answer consistent with climatologists is false. The measure was recoded so that high values are consistent with what the IPCC might advise.

Table 4.7: Rejection of the solar radiation counterargument

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
Scientific knowledge	0.24 (6.70)	0.26 (7.12)	0.24 (6.23)
Faith in science	-0.33 (-2.16)	-0.32 (-2.14)	-0.31 (-2.05)
Skeptical of science	-0.38 (-2.73)	-0.35 (-2.50)	-0.34 (-2.26)
Ideology	-0.04 (-1.26)	0.22 (2.10)	0.23 (2.15)
Ideology X science knowledge	-	-0.04 (-2.64)	-0.04 (-2.76)
Republican	-	-	0.46 (2.16)
Democrat	-	-	0.34 (1.65)
Age	-	-	-0.01 (-1.24)
Female	-	-	0.15 (0.91)
4-yr degree	-	-	0.30 (1.57)
Advanced degree	-	-	0.63 (2.33)
Constant	-0.04 (-0.05)	-0.27 (-0.38)	-0.33 (-0.40)
Model 1: N=1082	Log-likelihood -669	Wald Chi ² 64.9	PCP 65.3%
Model 2: N=1082	Log-likelihood -665	Wald Chi ² 70.9	PCP 65.4%
Model 3: N=1082	Log-likelihood -653	Wald Chi ² 83.1	PCP 65.9%

Notes: The first number represents the coefficient derived from a logistic regression. The number in parenthesis indicates the z-score from the significance test. In all models, a weight provided by Knowledge Networks was utilized in order to make inferences from the results back to the U.S. adult population.

The three models for the analysis are presented in Table 4.7. As seen in the first model, the degree of support for the first four hypotheses is noticeably altered. Consistent with prior analyses,

there is a positive, significant relationship between scientific knowledge and the outcome measure. Individuals who have accumulated greater levels of scientific knowledge are more likely to reject solar radiation as an explanation for global warming – an action consistent with the arguments coming from climatologists working with the IPCC. This is the only one of the four hypotheses supported in the first model.

Shifting focus to normative views reveals support for the third hypothesis, which had not materialized in the prior analyses. Those more skeptical of scientists and their work fail to express positions similar to those of climatologists working with the IPCC, which is consistent with the third hypothesis. Meanwhile, those who view science more favorably are also *less likely* to assert beliefs consistent with climatologists. This relationship reflects a reversal in the sign of the relationship between favorable views of science and climate change beliefs when compared to the prior analyses. The second hypothesis, then, fails to find support. This suggests that a more sophisticated understanding of climate change deniers is warranted given what appears to be selective rejection of a particular component of the climate change debate. The change in direction is explored in greater detail in the discussion.

Lastly, the first model reveals no support for the fourth hypothesis. The ideological gap does not emerge as in the prior analyses, although the direction of the relationship is consistent with expectations. The discussion section will explore this relationship further by looking at the differences within beliefs along the eleven-point ideological scale. Currently, conservatives are not significantly less likely to accept the argument of climatologists compared to their moderate and liberal counterparts.

The percent correctly predicted metric is presented in Table 4.8. For the first model, the model correctly predicts responses for over 65% of the survey respondents. Compared to the prior

models, the first model performs better predicting respondents who disagree with climatologists working with the IPCC (76%) but only correctly predicts approximately half of those agreeing with climatologists.

Table 4.8: Percent correctly predicted for each model

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
Percent correctly predicted	65.3%	65.4%	65.9%
Sensitivity	50.8%	46.0%	48.9%
Specificity	76.0%	79.8%	78.7%

The second model includes an interactive term to assess the proposition that ideology moderates the relationship between knowledge and beliefs. The results suggest that while ideology was not a significant predictor of beliefs in Model 1, there is still continued support for the more nuanced expectations of the fifth hypothesis. Moderates with elevated levels of knowledge were indeed more likely to reject the solar radiation counterargument (knowledge coefficient of 0.26). High-knowledge conservatives were less likely to reject the solar radiation proposition compared to their high-knowledge counterparts (interacted coefficient of -0.04) while low-knowledge conservatives were more likely to accept the causal arguments from climatologists (ideology coefficient of 0.22). These significant relationships support the expectations of the fifth hypothesis. The interpretation of the other coefficients remains the same as in the first model.

The interactive effect does provide a slight variation, however. While high-knowledge conservatives are less likely to reject the solar radiation counterargument compared to moderates and liberals, the coefficients suggest all ideologues are likely to accept the proposition as knowledge accumulates (a positive relationship). For instance, the coefficient for a high-knowledge strong conservative is 0.04 (derived from adding the ideology and interaction coefficients). Recalling the discussion earlier, the difference with this issue is that there is more uncertainty and confusing rhetoric about what is driving global warming. This effect along with

the overall interaction between ideology and science knowledge is taken up further in the substantive effects discussion.

In addition, model fit diagnostics support the proposition that this more nuanced understanding of the relationship between scientific knowledge and ideology is appropriate. A Wald test suggests the interaction term adds explanatory power to the second model ($p < 0.01$). A likelihood ratio test supports this conclusion as well. With a test statistic of nine and one degree of freedom, the difference between the first and the second model is significant ($p < 0.01$).

The interaction term does not improve the overall predictive capabilities of the model. The overall percent correctly predicted is the same between Model 1 and Model 2 (approximately 65%). As with the other outcomes measures, there is a slight shift in the model's ability to predict respondents who answered true and those who answered false. Among those who disagreed with the claim that solar radiation drives climate change, there is a five-point drop in the percent of respondents correctly classified. For those agreeing with the proposition, there is a four-point increase in the model's predictive capabilities. This trade-off between the sensitivity and specificity metrics is consistent with the prior analyses.

The third model includes socio-demographic controls as a means to assess whether there is anything unique about gender, age, and education not captured by values and knowledge. The age and the gender gaps in environmental beliefs disappear in this context after controlling for scientific knowledge. However, the educational achievement measures suggest science knowledge is not the lone educational metric with predictive capabilities. Recall a portion of respondents reported obtaining college degrees yet performed poorly on the science knowledge quiz (see Chapter 3). The coefficients for Model 3 suggest those obtaining advanced degrees are significantly more likely to reject the solar radiation counter argument compared to those without

a college degree. There is also a similar but not significant relationship between those achieving at least a four-year degree and those who have not.

Lastly, the partisan metrics are of interest. Both Republicans and Democrats were more likely to identify the argument from climatologists than Independents. The relationship for Democrats makes sense as partisan cues provide a basis for beliefs. The direction and significance level ($p < 0.05$) was unexpected for Republicans, however. The reference group is perhaps key to understanding this relationship. If partisans are more educated and education partially explains the response of survey respondents to the question, then the partisan metrics may be capturing some of this variation.

Turning to the goodness of fit statistics, the block of socio-demographic controls significantly improves the explanatory power in the third model. The Wald test suggests the controls explain additional variance ($p < 0.05$). The likelihood ratio test produces a similar conclusion. The test statistic of 23.2, with six degrees of freedom, is significant ($p < 0.001$). With respect to the predictive performance of the model, the third model correctly predicts responses for 65.9% of the respondents – less than a 1% improvement compared to the other two models. There is also only slight movement in the specificity and sensitivity. Overall, then, there is no dramatic improvement in the success rate of prediction by adding the socio-demographic controls.

Substantive Effects

To examine the substantive effects, the analysis moves to a discussion of the predicted probabilities for the independent variables of interest in the hypotheses. Coefficients from the third model are utilized for this analysis given the improved explanatory power achieved by adding the socio-demographic controls. Turning attention first toward science knowledge, the analysis suggests that individuals possessing an average knowledge of basic scientific concepts (average

score of seven on the quiz) agree with climatologists roughly 42.1% of the time. Individuals with full knowledge retain a predicted probability of 58.8%. The average marginal effect suggests each additional question answered correctly increases the probability of accepting the proposition by 4.7% - almost double the effect found in the first analysis. This change in predictive capabilities merits further commentary later in the discussion.

Shifting focus toward normative views of science, recall the analysis found support for the third hypothesis yet no support for the second. The predicted probabilities for the three main profiles are presented in Table 4.9. Holding all other variables at their respective means, those demonstrating weak pro-science attitudes were the most likely to agree with scientists at 46.9%. This profile can provide a baseline for comparison to the other two profiles. The pro-science profile represents a one-unit increase in the faith-in-science index compared to the weak science profile. The analysis revealed a negative relationship between faith in science and beliefs about solar radiation. Consequently, a one unit change from “agree” to “strongly agree” – holding skeptical science views at “disagree” and all other values at their means – corresponds to a decrease in the predicted probability by nearly eight points. A similar drop in probability occurs when considering the skeptical-of-science index. Here, a one-unit increase from disagree to agree on the skepticism scale corresponds to an eight-point drop in the probability of agreement with climatologists. Taking the analysis a step further in order to explore this counterintuitive result, an additional profile (strongly conflicted) was added to Table 4.9. This position represents individuals who average strong agreement with the science attitude questions for both indices. Such individuals, while only a small portion of the overall sample, possess a 24.8% probability of agreeing with climatologists.

Table 4.9: Probability of rejecting solar radiation counterargument by normative views of science

	<i>Strong pro-science: Faith science (s. agree), skeptical science (disagree)</i>	<i>Weak pro-science: Faith science (agree), skeptical science (disagree)</i>	<i>Conflicted: Faith science (agree), skeptical science (agree)</i>	<i>Strongly conflicted: S. agree on both indices</i>
Solar Radiation	39.3%	46.9%	38.7%	24.8%

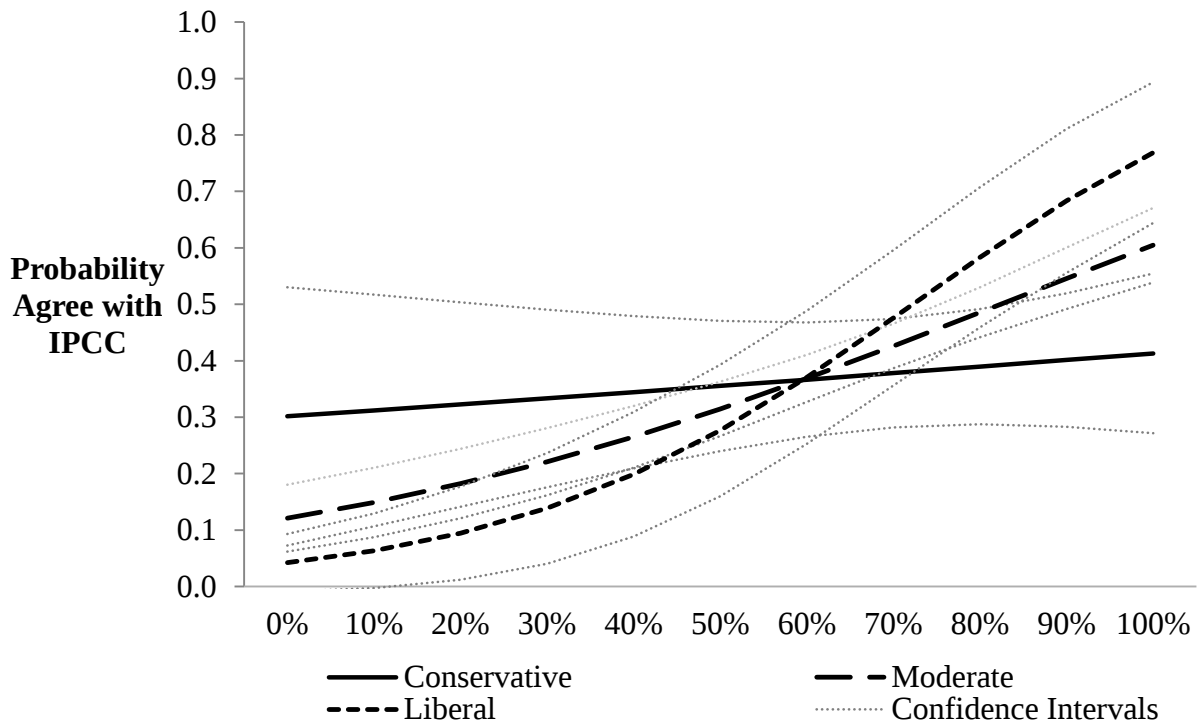
Notes: Probabilities calculated with coefficients from Model 3 of Table 4.7. All other variables held at respective means unless noted in column heading.

The fourth hypothesis, again, finds no support in the models although there is slight movement in the predicted probabilities. Holding all other measures at their respective means, a strong conservative has a 37.7% probability of agreeing with climatologists on the issue. A moderate possess at 42.3% probability, and a strong liberal retains a 47.0% probability. All ideologues, then, are within a ten-point range of each other in respect to their predicted probabilities. The average marginal effect is -1%, which is the weakest effect for ideology across the three outcome measures.

A key difference in the solar radiation analysis is the interactive effect. Figure 4.6 below illustrates the change in predicted probabilities for the previously used profiles of strong liberals, moderates, and conservatives. The figure reveals similar conclusions to the prior analyses with respect to liberals and moderates. The probability of both groups rejecting the solar radiation counterargument increases dramatically as knowledge accumulates. As noted earlier, the coefficients from Model 3 suggest high-knowledge conservatives are also more likely to reject the solar radiation counterargument, although compared to moderates and liberals the probability increases at a much slower rate as knowledge accumulates. The relationships suggest there are still indeed differences between high-knowledge ideologues: high-knowledge conservatives think differently about science compared to their colleagues. This is consistent with the fifth hypothesis

despite the positive slope calculated for strong conservatives in the figure. The fifth hypothesis speculated only that differences should emerge between ideological groups, but how high-knowledge conservatives compare to low-knowledge conservatives was not specified.

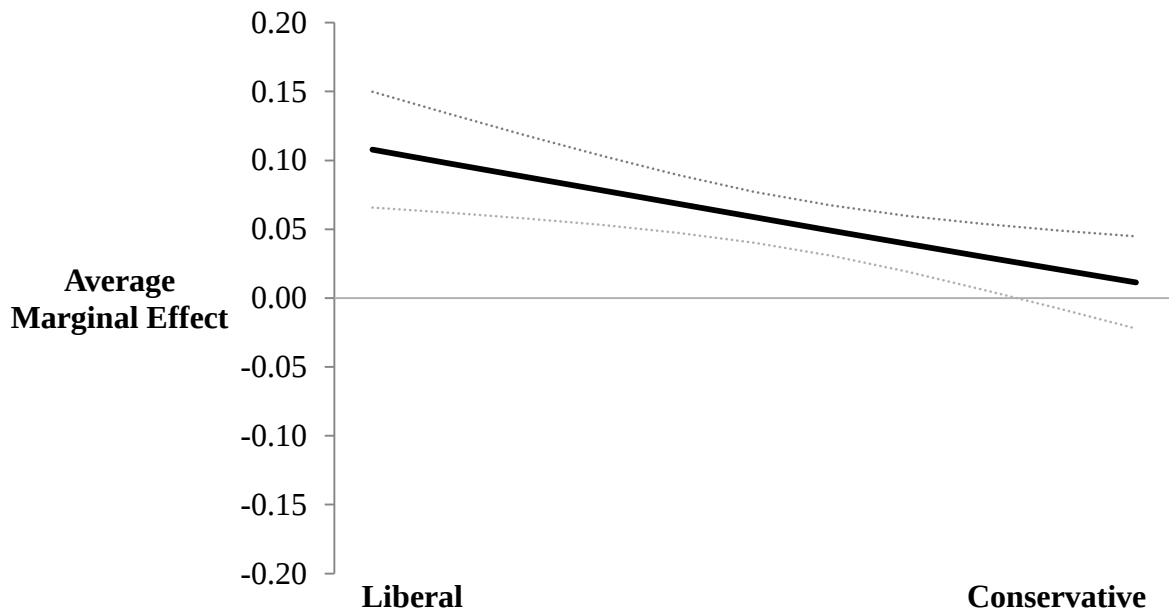
Figure 4.6: Probability agree with IPCC by science knowledge for liberals (-5), moderates (0), and conservatives (5)



It is important to emphasize, however, that for strong conservatives knowledge has no significant effect. Figure 4.7 displays the marginal effects of knowledge by ideology. For strong liberals (ideology=-5), the average change in probability for each accumulated level of knowledge is 10.8%. A move from average to full knowledge, then, would on average increase the probability of rejecting solar radiation by 32.4%. For moderates (ideology=0), there is an average change of 5.9% in the predictability for each quiz score answered correctly, corresponding to a 17.7% change in predicted probability on average. The average marginal effect remains positive for moderate conservatives (ideology=3) while knowledge has no significant effect for strong conservatives

(ideology=5). This is taken as support for the fifth hypothesis and suggests a notable, significant relationship between science knowledge and beliefs.

Figure 4.7: Average marginal effect of scientific knowledge by ideology



Summary: Solar Radiation

This last analysis further suggests support for the science comprehension thesis. The first hypothesis is again supported by the analysis as high-knowledge individuals are more like to share the views of climatologists even when considering the most complex, divisive issue in the climate change debate tested here. The improvement in prediction capabilities with a move from average to full knowledge was the highest out of all three outcome measures. Meanwhile, ideology was not a significant predictor of beliefs as proposed in Hypothesis 4. The interactive effect expected by Hypothesis 5, however, did emerge. High-knowledge liberals, moderates and conservatives all accepted the proposition at different rates. The unexpected result in the third analysis was that high-knowledge conservatives were more likely to accept the proposition compared to low-knowledge conservatives, although the relationship is not significant. The strength of not only

scientific knowledge but also the other education measures suggest that educational metrics are a powerful predictor of beliefs when the issue is highly contested, as is the case here.

For the first time, a significant negative relationship emerged between those skeptical of science and a specific climate change belief. A move from the weak science to conflicted profile produced an 8% change in the probability of agreement with climatologists. This change is on par with a move from average to full knowledge as well as a move from the weak to strong pro-science profile in prior analyses. In this context, the magnitude is roughly half that of the approximate seventeen-point movement caused by a similar move. This disparity reinforces the importance of knowledge in guiding beliefs, but also suggests scientists need to tread carefully and not give the public additional reasons to doubt their work (as was the case with “Climategate”).

The lack of an ideological relationship is somewhat curious, as is the sign reversal in the faith-in-science index. Both findings are taken up in more detail in the discussion since the identified relationships do not match the pattern of the prior analyses. Final judgment on the second and fourth hypotheses, then, are reserved for the discussion in the following section as there is some suggestion that both still might have support.

Discussion

The regression analyses revealed strong support for four of the five hypotheses. The results are quickly summarized in Table 4.10. The following section discusses the key observations for the three analyses above, as well as notes the implications of the results.

Table 4.10: Summary of support for hypotheses

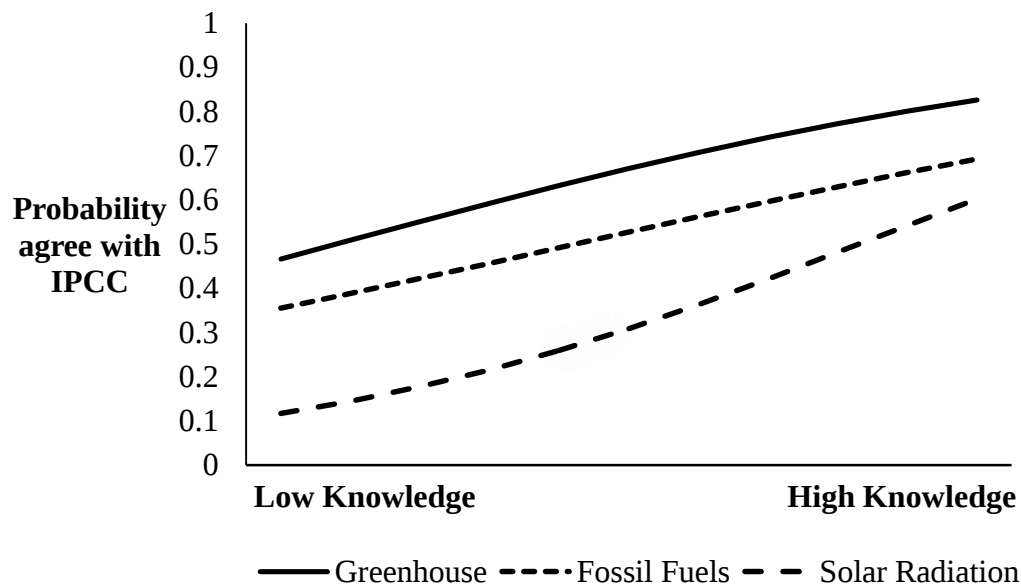
<i>Hypothesis</i>	<i>Greenhouse effect</i>	<i>Fossil fuels</i>	<i>Solar radiation</i>
Hypothesis 1: Individuals with higher levels of scientific knowledge accept the causal arguments from climatologists at higher rates than their low-knowledge counterparts, holding all else constant.	Yes	Yes	Yes
Hypothesis 2: Individuals perceiving benefits from scientific advancement are more likely to accept causal arguments from climatologists, holding all else constant.	Yes	Yes	No
Hypothesis 3: Individuals skeptical of scientists and their work are less likely to accept the causal arguments from climatologists, holding all else constant	No	No	Yes
Hypothesis 4: Liberals (conservatives) are more likely to agree (disagree) with causal arguments consistent with the IPCC, holding all else constant.	Yes	Yes	Yes
Hypothesis 5: Political ideology conditions the relationship between scientific knowledge and climate change beliefs, holding all else constant.	Yes	Yes	Yes

Knowledge by Issue

Across all the three issues, there is solid support for the science comprehension thesis. In all cases, individuals with higher levels of scientific knowledge were more likely to offer answers that are consistent with the causal arguments offered by climatologists working with the IPCC. There are some differences across issues, however. The predicted probabilities by science knowledge are offered in Figure 4.8, again using coefficients from Model 3 of the prior analyses and holding all other values at their means. The substantive effect of knowledge was perhaps the most notable for the first two issues. In both cases, the beliefs of individuals mastering the science knowledge quiz could be predicted with a high degree of power – 85.8% (greenhouse effect) and

71.8% (fossil fuels). In each case, a move from average knowledge to full knowledge increased the predicted probability by between 9 and 11%.

Figure 4.8: Probability of agreement with IPCC by science knowledge for all three outcome measures



It is this last issue, solar radiation, which is perhaps of the most interest to proponents of the science comprehension thesis. On one hand, scientific knowledge does not do as well of a job explaining the variance within public opinion. The overall predicted probabilities for low-knowledge individuals do not stand out. This makes sense given that the political debate over climate change often includes discussions of whether warming is the result of anthropogenic or natural causes. The outcome measure in the survey taps into this debate, and it seems intuitive that the relationship between scientific knowledge and beliefs would be reduced as political claims are escalated. Non-scientific actors also attempt to influence opinions and offer alternative causal arguments. The result is the growth of polarization within public opinion since some high-knowledge individuals are motivated to reject scientific information that threatens their work.

On the other hand, solar radiation is also the issue where a move from average to full knowledge reveals considerable improvement in predictive power – a seventeen-point increase in overall predictive capabilities. Of the three issues, solar radiation is the issue where a move from average to full knowledge produces the most value in terms of changing the predicted probabilities of agreement with climatologists. This jump speaks to the value advocates of science education expect to realize by educating the public on basics scientific concepts. In this case, the scientifically knowledgeable appear able to sort through the noise and identify the core scientific arguments in respect to the causes of climate change.

This is robust support for the first hypothesis. Science benefits from a perception that it is an objective process that can be used to justify knowledge. Once individuals accept the scientific process as a means to justify their beliefs, they begin to develop a pro-science framework that guides their approach to understanding and interpreting policy debates. At a general level, this framework seems to lead the population to accept the causal arguments offered by climatologists. Claims by advocates that knowledge does lead individuals to accept basic scientific findings do find support in this analysis. Specifically, they come to understand climate change in a manner similar to climatologists.

Normative Views

Possessing a foundational understanding of science, however, is only one component of understanding the climate change debate. As noted earlier, there has been some emphasis in the literature that science is a social construct and normative views of science require consideration. This analysis found mixed support for generalized science attitudes as a predictor of climate change beliefs. The third hypothesis, which focused on individuals with a skeptical view of science, did not find support in two of the three models. Only in the most contested issue – solar

radiation – did a relationship with beliefs emerge. The overall effect is rather limited, however. There was only a net decrease of 8% in the probability of agreeing with climatologists as skeptical views of science increase (a move from the “weak science” to “conflicted” profile). Given that this move between these two points represents a sizeable majority of survey respondents, the overall influence of cautious science views in the models seems limited.

More noteworthy is the second hypothesis, which focused on the level of faith respondents place in science. The expected relationship materialized in the first two analyses, although the overall effect was limited. The change in probability of agreeing with climatologists did not exceed double-digits for individuals moving from the “weak science” to “strong science” profiles, which again are among the three most common positions on the normative scale matrix (see Table 3.3). Across all issues, the changes that did occur as respondents moved between the three profiles was comparable to changes in science knowledge from medium to full knowledge on the scale (with the exception being solar radiation).

Also of interest is the result of the third analysis, where a significant negative relationship emerged between favorable science views and the proposition about solar radiation. The switch in sign suggests a more nuanced understanding of climate change deniers might be in order.

The first point of inquiry is to assess whether a bivariate relationship exists between the faith in science index and the three outcome measures (presented in Table 4.10). In respect to solar radiation (last two columns), there is a slow, minor increase in the proportion of respondents who agree with the IPCC as positive feelings of science increase. This increase is minimal compared to the first two outcome measures, where a move from “agree” to “strongly agree” corresponds to an increase of 9.7% (greenhouse effect) and 7.5% (fossil fuels) in the proportion of respondents

agreeing with climatologists. With this bivariate approach, there is no indication that a sign reversal should have been expected in the analysis.

Table 4.11: Distribution of faith-in-science scores by outcome measure

<i>Faith-in-science score</i>	<i>Greenhouse effect</i>		<i>Fossil fuels</i>		<i>Solar radiation</i>	
	<i>Agree IPCC</i>	<i>Disagree</i>	<i>Agree IPCC</i>	<i>Disagree</i>	<i>Agree IPCC</i>	<i>Disagree</i>
Strongly Disagree (N=11)	36.4% (4)	63.6% (7)	27.3% (3)	72.7% (8)	27.3% (3)	72.7% (8)
Disagree (N=72)	61.1% (44)	38.9% (44)	30.6% (22)	69.4% (50)	34.7% (25)	65.3% (47)
Agree (N=855)	66.2% (289)	33.8% (566)	54.4% (465)	45.6% (390)	39.1% (334)	60.9% (521)
Strongly Agree (N=415)	75.9% (315)	24.1% (100)	61.9% (257)	38.1% (158)	40.5% (168)	59.5% (247)

To investigate further, a series of bivariate logistic regressions were calculated (not shown). A bivariate regression suggests a positive, insignificant relationship exists between the faith-in-science index and solar radiation beliefs. It is not until science knowledge is added to the model that the direction of the relationship becomes negative. With this in mind, a cross-tabulation was performed between the three measures: the faith in science index, responses to the solar radiation question, and performance on the scientific knowledge quiz. The results are presented in Table 4.11. For the purposes of the table, respondents with an above average score on the science quiz (70% or above) were coded as possessing high levels of scientific knowledge while those below the threshold are placed in the low-knowledge category. The results offer a different view from those in the prior table. After controlling for high- and low-knowledge individuals, the negative relationship starts to emerge. The trend is most distinct among low-knowledge individuals, where there is a clear drop in agreement with climatologists among those ranking higher on the index.

For high-knowledge individuals, the relationship is a bit more mixed. Moves from “strongly disagree” to “disagree” to “agree” on the index correspond to an increase in agreement with climatologists – consistent with the expectations of the second hypothesis. However, the move from “agree” to “strongly agree” results in a drop in the level of agreement with climatologists. From the table, it appears the sign reversal is best understood as individuals with low-knowledge yet high levels of faith in science accepting the solar radiation counterargument in sufficient numbers to create the observed sign change.

Table 4.12: Faith-in-science by solar radiation response and level of knowledge

<i>Faith-in-science score</i>	<i>Agree IPCC, High Knowledge</i>	<i>Disagree IPCC, High Knowledge</i>	<i>High Know. N</i>	<i>Agree IPCC, Low Knowledge</i>	<i>Disagree IPCC, Low Knowledge</i>	<i>Low Know. N</i>
Strongly Disagree (N=11)	25.0% (2)	75.0% (6)	8	33.3% (1)	66.7% (2)	3
Disagree (N=72)	40.0% (12)	60.0% (18)	30	31.0% (13)	69.0% (29)	42
Agree (N=855)	52.2% (234)	47.8% (214)	448	24.6% (100)	75.4% (307)	407
Strongly Agree (N=415)	50.6% (135)	49.4% (132)	267	22.3% (33)	77.7% (115)	148

Notes: Percentages reflect the distribution of high knowledge and low knowledge responses by agreement with the IPCC and the faith in science index. The number in parenthesis indicates the sample size.

Ideology

Scientists are not alone, however, in offering causal arguments to the public. Political ideology as an alternative framework for understanding climate change found support in two of three analyses. This was especially true as to whether individuals understood the greenhouse effect, where liberals were more likely to recognize the outcomes of the scientific theory than both moderates and conservatives. For conservatives and others who failed to acknowledge the outcomes associated with the greenhouse effect theory, it is unclear whether that negative

correlation results from survey respondents not being familiar with the concept or whether it represents an outright rejection the theory. Some respondents could have approached the question as if it were asking whether certain human activities might induce increased temperatures, doubting whether greenhouse gases actually trap heat. Others might simply not have been familiar with the concept. Due to question wording, it is tempting to think the former interpretation is appropriate. The wording hints at a logical answer, as the term greenhouse implies a process of trapping heat. As such, it would seemingly be plausible for respondents to relate the outcome (rising temperatures) to the term greenhouse effect. Given this deductive process to answer the question, it possible answering “false” might indicate a rejection of the proposition that humankind can heat the Earth.

A similar question is raised about the fossil fuel questions. Did respondents interpret the question strictly as asking whether the burning of fossil fuels *might* cause global warming, or whether global warming is *certainly* occurring because of the burning of fossil fuels? Survey respondents with a limited amount of time might not have accurately interpreted the question. There are no supplementary questions, however, to help piece together an explanation why respondents answered as they did. However the questions were interpreted, ideological differences did emerge, suggesting the political framework individuals are socialized toward as youths influence interpretations of policy debates later in life as well.

One possible explanation for why conservatives reject arguments from the IPCC about climate change is the potential consequences of acknowledging its occurrence. That is, admitting to the problem opens up the possibility of eventual environmental regulation. If both political parties agree that anthropogenic climate change is a possibility, enough public support might develop to push for regulations. Government regulations, of course, are seen as undesirable to

conservatives. Thus, denying climate change may be a strategic decision. In a supplementary analysis, a measure of regulatory attitudes was developed, assessing how the survey respondents feel about tax, regulations, and healthcare regulations. Substituting this anti-regulatory index into the models as a replacement for ideology produced similar regression results. This anti-regulation index also correlates highly with ideology, suggesting the motivation for denying climate change might be out of a desire to avoid regulation.

Ideology & Solar Radiation

The lack of a significant relationship between ideology and solar radiation beliefs warrants further discussion. The first analysis was relatively uncontroversial among climatologists, at least compared to the other two outcome measures. Again, the first question was simply asking about the outcome associated with a scientific concept. Still, despite what seems like a relatively apolitical question, an ideological dimension was observed. The strength of the relationship between ideology and beliefs, however, diminishes as the outcome measure becomes more controversial. The average marginal effect of ideology in the first model was -0.04, decreasing slightly 0.005 points when considering the proposition on fossil fuels. This suggests the relationship between ideology and acceptance of arguments from climatologists is consistent. As noted earlier, the relationship is insignificant in the context of solar radiation, with the marginal effect declining to -0.01.

To explore the relationship further, a cross-tabulation is presented as Table 4.12. The table suggests there are considerable fluctuations in the rate at which ideologues identify the arguments of climatologists. The least likely to accept the arguments are moderates and moderate conservatives. Conversely, moderate liberals are more likely to accept the proposition. When it comes to strong liberals and strong conservatives, both groups are likely to express similar

opinions. This seemingly random distribution helps explain why there was no relationship between ideology and solar radiation beliefs.

Table 4.13: Cross-tabulation of whether respondents reject solar radiation by ideology

<i>Ideology</i>	<i>Fail to reject</i>	<i>Reject</i>	<i>Total</i>
Liberal (-5)	53.1%	46.9%	51
-4	59.0%	41.0%	25
-3	45.2%	54.8%	56
-2	46.2%	53.8%	86
-1	53.8%	46.2%	82
0	64.9%	35.1%	325
1	58.7%	41.3%	110
2	55.7%	44.3%	145
3	62.1%	37.9%	146
4	62.3%	37.7%	58
Conservative (5)	56.3%	43.7%	48

Notes: Percentages reflect weighted distributions.

This lack of a systematic pattern may occur because of the nature of the question. Again, the cause of rising temperatures is arguably the most contested claim in the policy debate. Individuals are embracing the counterargument perhaps because of their predispositions and own personal preferences. Others, however, may be rejecting the proposition because it is genuinely a confusing topic. The solar radiation argument has scientific roots, and the causal mechanism appears valid. Climatologists working with the IPCC argue they can reject this alternative hypothesis as an explanation for recent warming over the last few decades, but this does not prevent the counterargument from re-occurring, or a minority of climatologists insisting temperature change is largely a function of solar radiation (see Shaviv 2006).

Ideology & Interaction Effects

Whether from the ideological lens or other mechanisms, subgroups accept the arguments of climatologists at different rates. Of note is the within-group gap observed when the interactive effects are considered. It is notable that ideological differences emerge even when considering a

seemingly apolitical concept such as the greenhouse effect. Even basic scientific concepts can invoke ideological differences. Across all outcome measures, there is a gap in the beliefs between the “low knowledge” and “high knowledge” populations within each ideological groups. As noted earlier, however, that gap is significantly larger for liberals who “benefit” the most from accumulating knowledge. Conservatives, on the other hand, are less influenced by the foundational scientific knowledge that they have accumulated. In fact, in two out of three cases strong conservatives with elevated levels of knowledge were more likely to disagree with the proposition than their low-knowledge counterparts. This is consistent with the political polarization literature, which suggests partisans will seek out positions or beliefs that are inconsistent with their political counterparts (Nicholson 2012). It is also consistent with the idea of motivated reasoning, which was described in Chapter 2. Conservatives simply have no reason to accept the arguments from climatologists, as acknowledging their positions create an opportunity for future environmental regulations.

Support for the interaction hypothesis is found on multiple fronts, including the significance of the measures (linear log-odds coefficients), the probabilistic component (calculated by the Delta method in previous figures), and the overall improvement in the model fit once the interaction term is included. One finding in the interaction models is that low-knowledge conservatives tend to think differently about the outcome measures compared to moderates and liberals. However, this interpretation should be viewed cautiously due to few respondents populating the low end of the knowledge scale. At quiz scores of 0% and 10%, there are only a small number of respondents. It is not until quiz scores in the 30%-40% range that the frequencies of respondents increases. This is the area where there was little to no differences in the predicted probability of accepting the arguments of climatologists. Simplified cross-tabulations like below

suggest low-knowledge (score of 0 to 6 on the science quiz) conservatives are not more likely to identify the arguments asserted by climatologists, contrary to what the regression coefficients suggest. Attention is drawn to this relationship only to caution readers that the limited observations on the low end of the knowledge scale may be an anomaly.

Table 4.14: Distribution of faith in science scores by outcome measure

	<i>Greenhouse effect</i>		<i>Fossil fuels</i>		<i>Solar radiation</i>	
	<i>Agree IPCC</i>	<i>Disagree</i>	<i>Agree IPCC</i>	<i>Disagree</i>	<i>Agree IPCC</i>	<i>Disagree</i>
Low-knowledge conservative (N=27)	48.1% (13)	51.9% (14)	25.9% (7)	74.1% (20)	22.2% (6)	77.8% (21)
Low-knowledge moderate (N=161)	64.0% (103)	36.0% (58)	54.0% (87)	46.0% (74)	27.3% (44)	72.7% (117)
Low-knowledge liberal (N=15)	60.0% (9)	33.8% (6)	33.8% (6)	60.0% (9)	39.1% (4)	60.9% (11)

Overall, the interactive effects suggest values and predispositions play a strong role in guiding the beliefs of ideologues. However, the fact that a positive, strong relationship occurred between scientific knowledge and climate change beliefs despite the role of values suggests knowledge is also a significant driver. In all three outcome measures, a sufficient number of high-knowledge moderates agreed with high-knowledge liberals and conservatives maintain this positive relationship.

These findings are consistent with the idea that science is partly an information tool utilized to strengthen one's own ideological argument. For liberals in this context, science is a tool used to justify rallying around an issue that aligns with prior predispositions about the necessity of environmental protection. Knowing nothing else, they are less likely than moderates to accept the causal arguments of climatologists, but once they have a basic foundational understanding of science, they rally behind those causal stories in greater numbers. When science coincides with

values, the information provides a strong reason to believe. When information is at odds with predispositions, it is more tempting to call information into question or find a reason to disagree.

Summary

The analyses presented here supports the proposition that individuals possessing a foundational understanding of science are more likely to accept the causal arguments offered by climatologists. That is, they are more likely to understand and interpret the policy debate in a manner consistent with what the majority of scientists would advise. The strength of the relationship is best exemplified by the solar radiation analysis, where there was a notable increase in the probability of respondents agreeing with climatologists as they mastered the questions on the science knowledge quiz. There was a substantively meaningful increase in the probability of agreement with climatologists as one moved from the medium position on the quiz to full knowledge. A similar move did not produce as powerful of a change in prediction rates in the first two analyses, which is perhaps in part due to survey respondents generally answering the questions in a manner consistent with climatologists.

While there is support for the science comprehension thesis, there is also support for the other hypotheses. In the fossil fuel and the greenhouse effect analyses, individuals with favorable views of science were more likely to accept the propositions of scientists. Again, the substantive effect of an increase on the faith-in-science index corresponds to change from average to full knowledge on the science knowledge scale. This supports the second hypothesis. There was no support for the second hypothesis, however, when looking at solar radiation. In fact, individuals with elevated levels of faith in science were significantly less likely to accept the arguments of climatologists on the cause of global warming. Supplementary analyses suggest this change in sign

is likely the result of predominantly low-knowledge individuals disagreeing with climatologists at greater rates. A more detailed explanation for this relationship is offered in Appendix B.

The first and second analyses failed to support the third hypothesis. However, support for the proposition that those skeptical of science will disagree with climatologists was found in the context of solar radiation. This relationship only emerged from the most controversial question, where a change in the skeptical-of-science index roughly corresponded with a similar change in the faith-in-science index.

Support was also found for the value-centered thesis in two of the three analyses. With respect to the greenhouse effect and fossil fuel discussions, ideology could be considered the dominant predictor given the size of the average marginal effect. The relationship did not materialize, however, with respect to solar radiation – probably due to the contested nature of the question and the plausibility of the counterargument. Furthermore, supplementary analyses that operationalized ideology based on policy preferences rather than on the self-reported scale produced similar results, suggesting preferences for limited regulation are one reason why conservatives were on occasion more likely to disagree with the arguments of climatologists.

The fifth hypothesis tested for interactive effects, with results supporting the argument that the science comprehension thesis requires qualifications. On all three issues, high-knowledge liberals were more likely to accept the propositions from climatologists than were high-knowledge moderates, who in turn were more likely to accept the claims than high-knowledge conservatives. However, liberals were more likely than moderates to accept the proposition as well. This result can be taken two ways. While the observations support the science comprehension thesis for both moderates and liberals, the rapid rate of acceptance by liberals also supports the value-centered thesis. Recall the observed s-shaped pattern for the predicted probabilities of liberals. The evidence

that liberals rally around the scientific information on climate change while conservatives reject the same information is consistent with the value-centered approach. The positive relationship for high-knowledge moderates, however, cannot be dismissed as it offers clear support for the science comprehension thesis.

The socio-demographic measures correlated with beliefs only occasionally in the three analyses. There were no noteworthy relationships in the greenhouse effect analysis while the fossil fuel analysis revealed only a statistically significant relationship between gender and acceptance of the proposition. In both cases, the socio-demographic controls did little to improve the overall fit of the model. In these two areas that feature a high-level of certainty among climatologists, the dominant predictors were ideology and science knowledge. Conversely, the demographic controls were more noteworthy in the solar radiation analysis. In this area featuring reduced certainty among climatologists, there was more “noise” in that other relationships emerged – particularly with the partisan and education measures. In this situation, the measures did significantly improve the overall fit of the model.

These five hypotheses offered an initial test to the two-step process of understanding problem recognition. Appendix A offers a more detailed look at why high-knowledge individuals stood out in the analyses. The science comprehension thesis suggests high-knowledge individuals are more likely to engage in the debate as a means to vet information and make informed decisions, which is supported by additional analyses in the appendix. In addition, Appendix B examines the interrelationships between the three outcome measures discussed here. The fifth chapter goes beyond the first stage of the process by extending the analysis to climate change concern, examining the merits of the causal argument enunciated in Chapter 2.

CHAPTER 5: A TWO-STEP CONNECTION TO CLIMATE CHANGE CONCERN

The preceding chapter explored the first step of the proposed two-step relationship between scientific knowledge and climate change concern. In this next section, path analysis is utilized to further evaluate the first five hypotheses, as well as consider two additional hypotheses related to the two-step process. The argument has been that possessing higher levels of scientific knowledge provides the skill set and capacity to make sense of the causal arguments offered as part of the climate change debate. High-knowledge individuals demonstrate an increased likelihood of engaging in behavioral activities that lead to the acquisition of information about climate change (see Appendix A). This activity can be either passive (talk with acquaintances) or active (seek out information from books and websites). With this information, individuals can then make informed decisions that may or may not fully align with the causal arguments from climatologists working with the IPCC. The analyses presented in Chapter 4 support this conceptualization (see also Appendix A).

The next step looks at whether scientific knowledge and climate change knowledge correlate, either directly or indirectly, with climate change concern. Understanding climate change in a manner similar to climatologists (i.e., climate change knowledge) is expected to be associated with elevated levels of concern (Hypothesis 6). Since scientific knowledge correlates with the acceptance of causal arguments from climatologists, an indirect relationship between scientific knowledge and concern is expected. That is, basic scientific knowledge correlates with higher levels of concern through the prior effect of scientific knowledge on climate change knowledge. As indirect relationship would support Hypothesis 7, which suggests knowledgeable individuals are, in fact, part of a larger group demonstrating higher levels of concern about climate change. The role of basic scientific knowledge in this conceptualization suggests that the relationship

between science knowledge and concern is best understood as an indirect effect (see Figure 5.1). Scientific knowledge helps individuals understand arguments from climatologists. If the individuals reach this stage, then they are then more likely to be concerned about the phenomenon.

However, basic science knowledge is not a necessary component to understanding climate change or demonstrating elevated levels of concern. Messages from ideological leaders also reinforce predispositions and provides a heuristic for ideologues to navigate the climate change debate. As such, belief systems are likely to have effects on both how climate change is understood but also on whether climate change constitutes a problem for society. Ideology and science knowledge, as well as the faith-in-science and skeptical-of-science indices, all correlate with climate change knowledge to varying degrees. However, it is expected that normative views correlate with concern as well, given that their belief systems and values lead them to conclusions regardless of whether they are aware of the available scientific information.

Path analysis provides a method to assess the causal relationship specified in this two-step approach (Kline 2005). The technique compares structural relationships between multiple exogenous and endogenous measures by calculating and comparing the observed covariance for the relationships specified by the researcher. Fit statistics can then be utilized to assess which structural design best fits the data. The emphasis of this chapter is to assess the merits of the two-step process. The intent is not to compare competing alternative model specifications, but rather to assess the merits of the two-step process emphasized in Chapter 2.

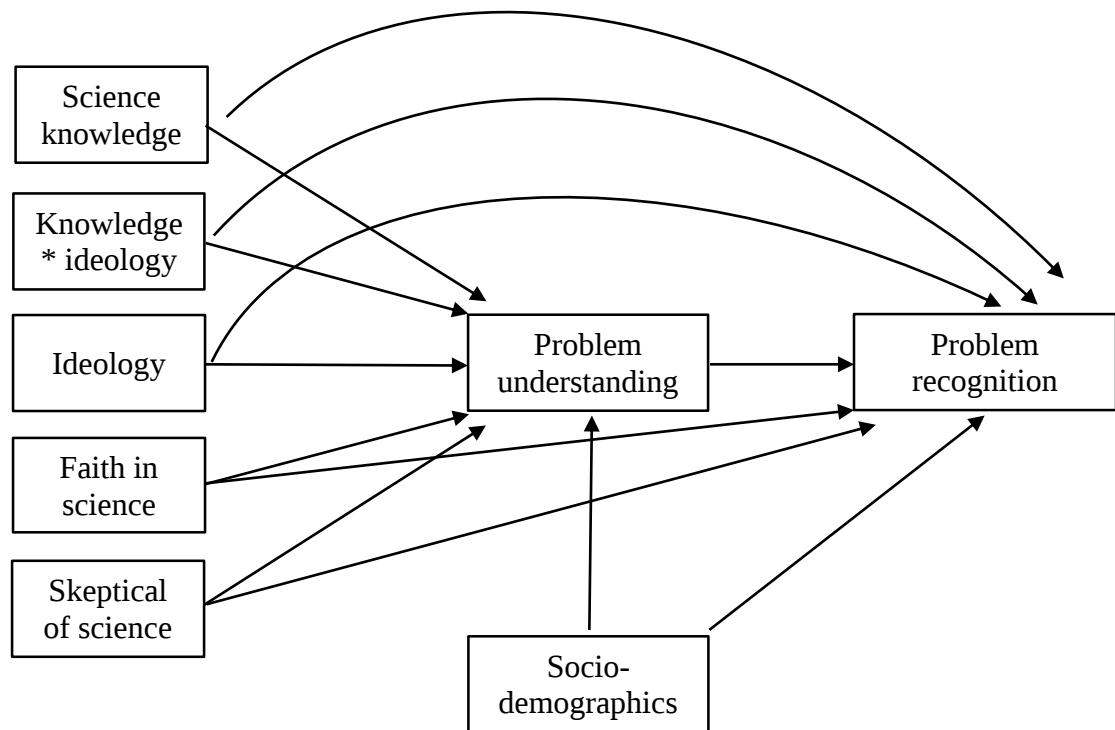
Figure 5.1 presents a fully developed path model consistent with the two-step process.¹⁸

The diagram captures the essence of the process enunciated earlier The diagram accounts for the

¹⁸ Note that Figure 5.1, as written, assumes that all measures except climate change beliefs and climate change concern are exogenous. Not including the socio-demographic controls, the model

heuristics and predispositions that individuals inherently rely upon when developing opinions. It also shows the expected indirect relationship between science knowledge and problem recognition. Thus, elements of both the science comprehension thesis and value-centered thesis are embedded within Figure 5.1.

Figure 5.1: Tested two-stage model



The analysis in this chapter proceeds as follows. The first stage of the model is briefly retested with path analysis. The independent variables from Model 3 of Chapter 4, which included the socio-demographic controls and the interaction between science knowledge and ideology, is

features 28 parameters: 10 covariances, 7 variances and 11 direct relationships. Because the model is recursive and all relationships are drawn, the model is considered just-identified. The model fits the data perfectly, which is not necessarily desirable for two reasons. First, the model may be fitting sampling error from the survey, which could lead to imprecise estimates. Second, there is an inability to compare alternative model specifications (Kline 2005). The “just-identified” model is utilized in this analysis, however, simply for hypotheses testing.

utilized due to the improved fit offered by the measures (see Chapter 4 discussion). This initial section notes whether there are any changes in support for the first five hypotheses when analyzing the covariance between the measures. This analysis functions as a further test of Hypotheses 1 through 5.

The second analysis expands on the model and tests the entirety of Figure 5.1, testing Hypotheses 6 and 7. Because of the prior analyses, it is assumed at this point that the interactive effect is a desirable aspect in modeling climate change beliefs and scientific knowledge. It is also assumed that the socio-demographic controls account for variations within the outcome measures not captured by the orientations identified for this analysis. Therefore, the second analysis includes the interaction and socio-demographic controls utilized in Chapter 4. In this setup, concern about climate change is used to operationalize problem recognition. Since the reliability analysis suggested the three outcome measures featured in Chapter 4 capture distinct views about climate change, problem understanding is operationalized with how respondents answered questions about fossil fuels and solar radiation. The greenhouse gas measure is omitted in this discussion in order to streamline the analysis and focus on these two more contested views about climate change.¹⁹

In the forthcoming analyses, the methodological techniques will utilize maximum likelihood estimation. The tables will present the direct, indirect, and total effects of each variable on the endogenous measure(s). Furthermore, all analyses utilize a weighting mechanism that weights the third wave of the *Science News Survey* back to the United States adult population. Utilizing this weighting mechanism will help control for any bias that might result from the loss

¹⁹ Recall from Appendix B that most respondents did correctly answer the greenhouse effect question. There is also a high degree of certainty among scientists that greenhouse gases do warm the planet. On the other hand, the fossil fuels and solar radiation question are more divisive and offer a stronger test of the science comprehension thesis.

of survey respondents between the first and third wave of the survey. The models are “just identified” in order to test the hypotheses, though this means there are limited opportunities to discuss goodness-of-fit metrics.

Re-Analysis of First Stage

The first analysis reconsiders the first step of the two-step process using path analysis techniques. Again, this analysis is offered to note differences within the analysis when considering the covariance between the included measures. Table 5.1 replicates the Chapter 4 analysis. The table presents standardized coefficients, with the z-statistic presented in parenthesis. Coefficients in bold indicate there was a change in either the sign or significance of the measures compared to the logistic regressions presented in Chapter 4.

As before, support for both the science comprehension and value-centered theses is observed in the analysis across all three questions. Those possessing higher levels of scientific knowledge were more likely to identify the position of scientists, but that relationship requires qualification: high-knowledge conservatives are less likely than high-knowledge liberals and moderates to accept the propositions. The increase in the size of the standardized coefficient for science knowledge in Model 3 (solar radiation) underscores the importance of knowledge in guiding beliefs on the most contested of the three issues.

One difference is the lack of a relationship between ideology and greenhouse effect beliefs (see Model 1). In this case, the interpretation is that low-knowledge conservatives do not possess unique beliefs about the greenhouse effect compared to low-knowledge liberals and moderates. The interaction effect, however, remains significant and in the expected direction.

Table 5.1: Total effects for the first stage of the two-step model

	<i>Greenhouse effect (Model 1)</i>	<i>Fossil fuels (Model 2)</i>	<i>Solar radiation (Model 3)</i>
Scientific knowledge	0.19 (4.15)	0.15 (3.42)	0.25 (5.76)
Faith-in-science	0.09 (2.18)	0.10 (2.42)	-0.07 (-1.48)
Skeptical-of-science	0.01 (0.22)	0.08 (1.62)	-0.09 (-1.90)
Ideology	0.20 (1.43)	0.26 (2.38)	0.28 (2.76)
Ideology * science knowledge	-0.44 (-3.49)	-0.48 (-4.58)	-0.39 (-3.83)
Republican	0.01 (0.22)	-0.03 (-0.63)	0.10 (1.98)
Democrat	0.03 (0.25)	0.08 (1.70)	0.04 (0.70)
Age	-0.02 (-0.40)	0.05 (1.06)	-0.01 (-0.24)
Female	-0.00 (-0.10)	-0.13 (-2.92)	-0.10 (-0.31)
4-yr degree	0.05 (1.21)	0.05 (1.20)	0.07 (1.57)
Advanced degree	0.05 (1.37)	-0.01 (-0.13)	0.11 (2.45)
Constant	0.46 (1.12)	-0.17 (-0.42)	0.77 (1.91)
Sample Size	758	758	758
Log-likelihood	-12290	-12346	-12343
R ²	0.12	0.13	0.12

Notes: The first number represents the standardized coefficient. The number in parentheses indicates the z-score from the significance test. A weight provided by Knowledge Networks was utilized in order to make inferences from the results back to the U.S. adult population. Bolded coefficients indicate there was either a change in the sign or significance of the measures compared to the logistic regressions presented in Chapter 4.

The relationship between normative views and climate change understanding remains for both the greenhouse effect and fossil fuel analyses. However, differences emerge in the context of solar radiation. There is no statistically significant relationship between normative views and solar radiation beliefs. The direction of the relationships, however, remains the same. Those more

skeptical of science as well as those more likely to perceive benefits from scientific advancement are less likely to agree with climatologists.

With respect to the socio-demographic controls, there are some changes in the sign of the measures, which is expected given the low-significance for many of the measures in Chapter 4. The most noticeable measure to change signs was gender, which moved from a positive to a negative relationship when considering propositions about the greenhouse effect and solar radiation. The negative, statistically significant relationship between gender and fossil fuel beliefs remained the same, however. The persistent negative sign is inconsistent with literature that suggests females are more knowledgeable about climate change (McCright 2010). There were two other sign reversals: Republicans switched from negative to positive in Model 1 (greenhouse effect) and those with advanced degrees switched from a positive to a negative relationship in Model 2 (fossil fuels). Neither relationship, however, is statistically significant here or in Chapter 4.

Two-Step Model

The next section shifts the analysis toward expanding the model with a multi-staged approach. Table 5.2 below assesses the relationships hypothesized in Figure 5.1 in two separate analyses – one using fossil fuels as the bridge between the exogenous measures and climate change concern, the other using solar radiation. In both models, the direct, indirect, and total effects of the measures on climate change concern are presented. The table suggests some common themes.

Table 5.2: Direct, indirect, and total effects on climate change concern

	<i>With fossil fuel response</i>			<i>With solar radiation response</i>		
	<i>Direct effect</i>	<i>Indirect effect</i>	<i>Total effect</i>	<i>Direct effect</i>	<i>Indirect effect</i>	<i>Total effect</i>
Scientific knowledge	-0.00 (-0.10)	0.02 (2.84)	0.02 (0.69)	0.01 (0.23)	0.01 (1.96)	0.02 (0.69)
Agree on fossil fuels	0.60 (5.77)	-	0.60 (5.77)	-	-	-
Agree on solar rad.	-	-	-	0.22 (2.13)	-	0.22 (2.13)
Faith-in-science	0.26 (2.78)	0.05 (2.18)	0.31 (3.31)	0.32 (3.36)	-0.01 (-1.19)	0.31 (3.31)
Skeptical-of-science	0.06 (0.74)	0.04 (1.55)	0.10 (1.18)	0.11 (1.37)	-0.02 (-1.51)	0.10 (1.18)
Ideology	0.06 (0.71)	0.03 (2.08)	0.08 (0.98)	0.08 (0.84)	0.01 (1.76)	0.08 (0.98)
Ideology *	-0.02 (-2.09)	-0.01 (-3.44)	-0.03 (-2.66)	-0.03 (-2.43)	-0.00 (-1.91)	-0.03 (-2.66)
Sci. Know.	-0.34 (-2.95)	-0.02 (-0.68)	-0.36 (-3.02)	-0.39 (-3.23)	0.03 (1.45)	-0.36 (-3.02)
Republican	0.39 (0.12)	0.05 (1.58)	0.44 (3.40)	0.43 (3.36)	0.01 (0.62)	0.44 (3.40)
Democrat	0.00 (1.11)	0.00 (0.94)	0.00 (1.26)	0.00 (1.29)	-0.00 (-0.22)	0.00 (1.26)
Age	0.08 (0.87)	-0.07 (-2.63)	0.01 (0.10)	0.01 (0.11)	-0.00 (-0.15)	0.01 (0.10)
Female	0.27 (2.86)	0.03 (1.13)	0.30 (3.09)	0.28 (2.85)	0.02 (1.31)	0.30 (3.09)
4-yr degree	0.30 (2.56)	-0.01 (-0.14)	0.29 (2.29)	0.25 (2.02)	-0.04 (1.63)	0.29 (2.29)
Fossil fuels	N=753	Log-pseudo likelihood	-13311	R ²	0.29 (concern)	
Solar radiation	N=753	Log-pseudo likelihood	-13333	R ²	0.24 (concern)	

Notes: The first number represents the standardized coefficient. The number in parentheses indicates z-score. A weight provided by Knowledge Networks was utilized in order to make inferences from the results back to the U.S. adult population.

First, how one understands the problem correlates with greater levels of concern. Respondents who agree that burning fossil fuels causes global warming were more likely to demonstrate elevated levels of concern (standardized coefficient of 0.60). Similarly, if one agrees with climatologists working with the IPCC about solar radiation, then they are also more likely to

demonstrate higher levels of concern (standardized coefficient of 0.22). Note the difference in the size of the coefficients. While both measures are statistically significant, it appears the fossil fuel proposition maintains a stronger relationship with climate change concern. Examining at the R^2 values for each analysis suggests that utilizing the fossil fuel proposition explains 5% more of the variance. Despite these differences, both relationships provide support for Hypothesis 6. Understanding climate change in a context similar to climatologists correlates with higher levels of concern. Note, however, that this is not consistent with the science comprehension thesis as the thesis only states knowledge allows citizens to make informed decisions about whether climate change poses a threat. It appears that obtaining knowledge about climate change is sufficient to make individuals attuned to the potential threat of climate change.

Because of the interaction, the science knowledge measure is interpreted as moderates with high levels of knowledge. For both models, the total effect of science knowledge for this population is minimal and insignificant. There are, however, distinct indirect effects. Scientific knowledge has a positive, significant indirect effect on climate change concern. The relationship is strongest in the fossil fuels model, where concern is predicted to increase by 0.02 standard deviations for a one standard deviation change of scientific knowledge. This relationship is statistically significant and substantively similar compared to the other indirect effects. The standardized coefficient is reduced by half in the solar radiation model, but it is still significant at the 95% confidence threshold. Both results suggest science knowledge has an effect on concern, but this relationship occurs through the prior effect of science knowledge on how the public understands climate change. This is taken as support for Hypothesis 7, which suggested knowledge is a key characteristic of those demonstrating more concern about climate change. Between Hypothesis 6 and Hypothesis 7, there is support for the two-step process enunciated in Chapter 2.

Basic scientific knowledge leads individuals to understand climate change in a manner similar to climatologists. Individuals who reach this stage are, in turn, more concerned about climate change.

Other orientations are found to correlate with concern. The interaction term between scientific knowledge and ideology speaks to high-knowledge ideologues. A direct, negative relationship is observed between the interaction term and climate change concern. High-knowledge conservatives are less likely to perceive climate change as a threat compared to their high-knowledge liberal and moderate counterparts. This direct effect suggests that regardless of knowledge, individuals will utilize their predispositions and values in establishing levels of concern. Some of this relationship, however, occurs through the prior relationship between the ideology/science knowledge interaction term and how respondents understand climate change. Because conservatives do not accept propositions about the dangers of burning fossil fuels (or accept the solar radiation counterargument), they are less likely to be concerned about climate change. The opposite pattern is observed for high-knowledge liberals.

The political ideology measure speaks to ideologues with low-levels of knowledge. The total effect of ideology in both models suggests no statistically significant direct relationship with concern in either model. The significant indirect effect in the fossil fuel analysis suggests there is a measurable number of low-knowledge conservatives who accept the arguments from climatologists about climate change and demonstrate slightly higher levels of concern compared to low-knowledge liberals and moderates, all else equal. This relationship is not observed when views about solar radiation is used in the model.

The faith-in-science index also maintains a positive, direct relationship with concern. Even after controlling for knowledge and ideological values, individuals perceiving benefits from scientific advancement were more likely to assert greater levels of concern about climate change.

There was a significant, sizeable total effect of 0.31 in both models. An indirect effect also emerges. The results suggest this relationship emerges because having faith in science correlates with acceptance of arguments about fossil fuels, although a similar pattern does not occur in the context of solar radiation. Lastly, there is also a significant direct effect, which supports the argument that normative views lead individuals to make decisions about a problem regardless of what they might know about climate change. This is consistent with the value-centered thesis and the expectation that individuals utilize heuristics.

Those skeptical of science, however, are not significantly more or less likely to perceive climate change as a threat. Neither the direct, the indirect nor the total effect is significant. The direction of the relationship is surprising, however. After accounting for climate change knowledge, basic science knowledge, ideology, and all the other factors, the leftover variance to be explained by the index suggests a positive relationship.

The model also considers the socio-demographic controls that test for additional relationships not identified by the four measures of orientations used in the analysis. There are two sets of direct effects worth noting. First, partisanship maintains a strong, direct relationship with climate change concern. Compared to Independents, Republicans are less likely to be concerned about the alleged problem while Democrats are more likely to express greater levels of concern. The size of the standardized coefficients for these partisan dichotomous variables is notable, suggesting they are, comparatively, powerful predictors of climate change concern.

The second set of relationships worth noting is between concern and the additional measures of educational achievement. Obtaining a college education, whether a four-year or advanced degree, is an alternative path that leads respondents to demonstrate elevated levels of concern. What is noteworthy in this case is that the two measures outperform science knowledge,

in that they are both positive and have a sizeable effect on concern. This observation is taken up in the next chapter, as it appears science knowledge may not always be the best predictor of all types of climate change beliefs.

Since the models presented here are just-identified, there are a limited number of fit statistics to discuss. One metric, however, that increased notably between the models is the portion of the variance explained. As noted earlier, the R^2 statistic was 5% higher when considering fossil fuels as the causal driver of the two-step model rather than views about solar radiation. As noted throughout the dissertation, there is considerably more noise, more counterarguments, and more uncertainty about the solar radiation argument. While individuals might not have a complete understanding of the cause of climate change, it appears that understanding basic technical arguments (as with the fossil fuel proposition) is sufficient to guide individuals to demonstrate greater levels of concern about climate change.

Summary

The intent of this chapter was to assess the proposed two-step model. The model proposes a causal process that envisions basic scientific knowledge helping individuals to understand climate change. If climate change is understood in the same manner as climatologists working with the IPCC, then the public was expected to demonstrate elevated levels of concern. This causal process materialized in the analysis.

First, there was support for Hypothesis 6. Specific types of climate change knowledge correlated with increased concern about climate change. As individuals come to understand climate change in a manner similar to climatologists (acknowledging that burning fossil fuels is a cause of global warming, and rejecting the solar radiation counterargument), they become more likely to express higher levels of concern over the phenomenon. Again, this relationship is not

specified by the science comprehension thesis. The thesis, at least as expressed here, only goes as far as saying information and knowledge allow the public to make informed decisions about whether a problem exists and whether remedial policies are required. It does appear, however, that individuals who understand climate change in a manner similar to climatologists also share their elevated level of concern.

Second, the model also revealed support for the Hypothesis 7, which suggested individuals who are concerned about climate change are knowledgeable about science. From Hypothesis 6, these individuals with elevated levels of concern are knowledgeable about climate change. However, Chapter 4 established that such individuals are also knowledgeable about basic scientific concepts. The indirect effect between scientific knowledge and climate change concern in the analysis above suggests basic, foundational knowledge does have an effect on concern, but that influence works through helping these high-knowledge individuals come to understand the technical components of climate change. Table 5.3 restates the hypothesis.

Table 5.3: Summary of support for hypotheses

<i>Hypothesis</i>	<i>Support?</i>
Hypothesis 6: Individuals who understand climate change in a manner consistent with climatologists are more likely to demonstrate higher levels of concern.	Yes
Hypothesis 7: Individuals concerned about climate change are knowledgeable about basic scientific principles.	Yes

As before, qualifications are in order. The use of an interaction term suggests the relationships identified above also hold for moderates with high-levels of knowledge. The interaction term suggests a familiar interpretation at this point, where high-knowledge conservatives demonstrate lower levels of concern than high-knowledge liberals. There were no significant differences among low-knowledge ideologues, however, in this analysis. The evidence that there were direct relationships between high-knowledge ideologues and concern suggests that

values and predispositions guide the public's level of concern regardless of climate change knowledge. This is consistent with the value-centered thesis.²⁰

Also consistent with the value-centered thesis are the direct relationships between the exogenous measures and climate change concern. In both models, five of the eleven exogenous measures were significantly correlated with climate change concern.

Individuals also appear to use heuristics provided by their orientation toward science. Individuals with more faith in science are also more likely to assert higher levels of concern. Holding skeptical views about scientists, however, does not correlate with higher levels of concern. Just as with ideological values, this use of science-oriented heuristics is consistent with the value-centered thesis.

For supplementary analysis, Appendix C is offered below as part of an attempt to identify a multi-stage model that offers a more nuanced and elaborated understanding of the science comprehension thesis. Afterward, the discussion shifts toward reviewing the results discussed throughout the dissertation, identifying next steps, and considering the conditions under which the polarization within public opinion over climate change might be reduced or mitigated.

²⁰ Future analyses might also model these relationships through a multi-group analysis. This technique would partition the ideologues into groups, allowing for a comparison of the knowledge coefficients for different groupings.

CHAPTER 6: DISCUSSION

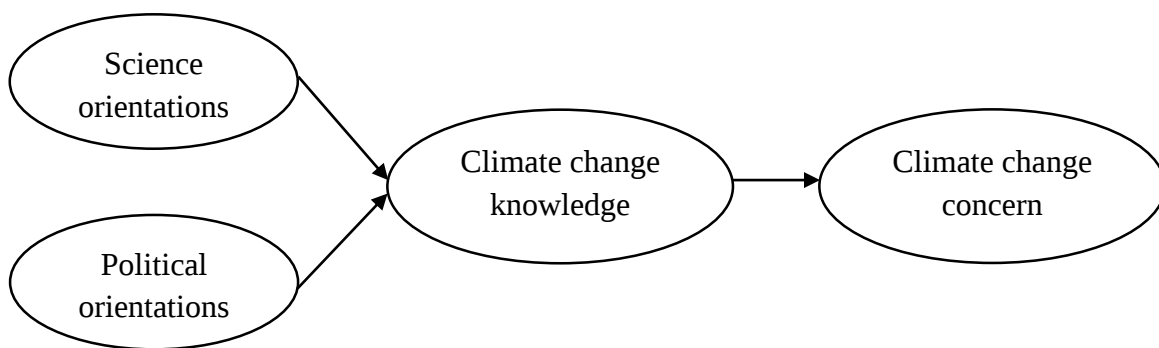
In this chapter, the discussion will reiterate the science comprehension and value-centered theses and review the support for each thesis when assessed through to the proposed two-step model. The discussion then turns toward speculating on the conditions under which the polarization in public opinion may be mitigated, as well as the policy implications for science advocates who emphasize science education policies. It concludes with an outline of additional research that branches off from this discussion.

This dissertation set out as an attempt to sort through competing claims from environmental scholars about why the public is polarized in their opinions about climate change, despite the fact that climatologists working with the IPCC are certain that temperatures are rising, the climate is changing, and the burning of fossil fuels is the leading cause of these changes. It acknowledged from the start that values lead individuals to hold certain predispositions. These predispositions lead individuals to accept or reject specific causal arguments from climatologist if the issue in question somehow resonates for or against those predispositions.

One of the differences in the argument presented earlier is that orientations toward science are said to provide another type of predisposition. Science provides a systematic approach to help individuals understand the world. If one is committed to the scientific approach, or at least thinks highly of the method, then high-knowledge individuals should stand out in empirical assessments. The science comprehension thesis proposes that exposure to science trains individuals to think systematically about the world. Once individuals begin thinking systematically about events such as climate change, they become more willing to accept the arguments from climatologists because (1) they believe in the validity of the process and (2) they have the capacity to understand technical, complex arguments coming from the IPCC and other scientists.

The precise relationship between scientific knowledge, a measure of one's orientation toward science, and climate change beliefs is unclear given prior research. The lack of a clear, precise relationship was argued to be the result of improper model specification. When considering knowledge, it is essential to recognize the multiple types of knowledge individuals may possess. That is, there is a two-step process at work. Two types of knowledge are conceptualized in this two-step model – foundational scientific knowledge and domain-specific knowledge. The former type of knowledge is relatively uncontroversial and covers only core scientific concepts such as DNA, molecular structures, and basic geology. Domain-specific knowledge is more specialized and, in the case of climate change, a small minority of scientists as well as ideological leaders contests the science. The science comprehension thesis would suggest that foundational scientific knowledge allows individuals to make sense of the contested causal arguments about climate change. That is, these individuals will have an appreciation for the scientific method and have the skills to sort through the public debate in order to identify the causal arguments from climatologists. At that point, they can then decide whether the information merits any type of concern. This two-step process is reproduced below in Figure 6.1, which is a replication of the model presented in Figure 2.2.

Figure 6.1: A two-step process for climate change beliefs



This two-step process offers a framework of public opinion that can assess both the science comprehension thesis and the value-centered thesis. The latter thesis emphasizes values as guiding interpretations of policy debates. Individuals are motivated to preserve their values, which leads them to rely on biases and predispositions when interpreting information. New information is interpreted in a manner consistent with those predispositions or otherwise outright rejected. These two theses are not mutually exclusive, however; individuals friendly to science may very well be motivated to align beliefs behind those of scientists, whether those beliefs are right or wrong. With this review of the theses in mind, the support for the previously identified hypotheses is now discussed.

Review of Empirical Results

Hypothesis 1 expected individuals with accumulated levels of scientific knowledge to think differently about climate change compared to their low-knowledge counterparts. This relationship is expected because knowledge of basic science reflects one type of orientation that can be utilized by individuals to guide interpretations of policy debates. Support for the first hypothesis emerged on several fronts. First, throughout Chapter 4 there was a positive, significant relationship between high-knowledge individuals and specific climate change beliefs. In terms of predictive capabilities, the models for the greenhouse effect and fossil fuel question produced prediction rates well above 50% for most levels of knowledge. Whether one scored average on the quiz or mastered the quiz, the predicted probability that one would accept the causal arguments of climatologists was notable. This indicates the possibility of a low threshold, in that individuals do not need to master the science quiz in order to accept the first two propositions offered by climatologists.

On the other hand, it was more difficult for the specified model to predict beliefs relying on responses to the solar radiation question, at least based on scientific knowledge. High-

knowledge individuals did not retain high probabilities of agreement with climatologists when compared to the prior two analyses that considered fossil fuels and the greenhouse effect. This might seem detrimental to the science comprehension thesis until the change from median knowledge to full knowledge is considered. There was a seventeen-point increase in the probability of agreement with climatologists based on a move from average to full knowledge. This improvement in predictive capabilities is almost double the improvement observed in the other two analyses. The threshold is higher in the solar radiation analysis in that there were more notable differences between average and high-knowledge individuals, compared to the first two issues. On one of the most politically contested aspects of the climate change debate, high-knowledge individuals were still more likely to stand out in terms of how they understand the problem.

As would be expected, individuals with higher levels of science knowledge were also more likely to accept all three positions. In Table B.6, over 40% of the individuals who scored 90-100% on the science quiz accepted all three positions. No other knowledge group accepted the proposition at rates greater than 31%. These relationships hold in Table 5.1, where path analysis was utilized to re-assess the findings of Chapter 4. The conclusion is that there is a positive, significant effect between high-knowledge individuals and climate change beliefs.

Hypothesis 2 assessed one dimension of the normative views individuals hold toward scientists, specifically the faith-in-science index. General feelings about science were argued to be just as important of a predictor of climate change beliefs as scientific knowledge. Hypothesis 2 is not part of the science comprehension thesis. Rather, it is considered part of the value-centered thesis, where predispositions and biases are utilized as heuristics to guide beliefs on a given issue. The faith-in-science index represents whether individuals perceive benefits from science and see society as better off because of technological advancements. Positive feelings about science were

expected to correlate with climate change beliefs. In the first two analyses of Chapter 4, which focused on the greenhouse effect and fossil fuel propositions, there was a positive, significant relationship between the faith-in-science index and climate change beliefs. A move from the “agree” to “strongly agree” position on the index was roughly equivalent in influence to a move on the science knowledge index from 70% to 100%.

The exception to the expectation of Hypothesis 2 occurred in the solar radiation analysis. A negative, significant relationship emerged. Individuals perceiving more benefits from science were less likely to reject the solar radiation counterargument. Supplementary analyses in Appendix B suggest this sign reversal likely occurred because low-knowledge individuals were less likely to reject the counterargument as they demonstrated higher scores on the faith-in-science scale. In bivariate analyses, it is only after controlling for scientific knowledge that the relationship between solar radiation beliefs and the faith-in-science index turns negative. This sign reversal remained in the path analysis provided in Table 5.1, which accounted for the error correlation between the independent variables. However, it did not achieve traditional levels of statistical significance. In two of the three cases, then, there was support for Hypothesis 2.²¹

Hypothesis 3, that those skeptical of science are more likely to reject the arguments of climatologists, found little support in the analyses. A significant relationship did not materialize in analyses that focused on fossil fuel usage or the greenhouse effect, although the direction of the relationship was in the expected direction. However, the relationship did materialize in the solar

²¹ The relationship may be an artifact of the analysis. Note that the constant term in the solar radiation analysis (Table 4.7) is significantly reduced compared to the other models. This suggests model specification and interrelationships between the independent variables, then, might also be responsible for the sign switch.

radiation analysis. Those more skeptical of scientists were less likely to reject the solar radiation counterargument. This relationship, however, was outside the 95% confidence interval when utilizing path analysis in Table 5.1. The evidence for skeptical science views significantly correlating with climate change beliefs, then, is weak at best, although alternative question wording or perhaps re-conceptualizing the questions utilized in constructing the skepticism index might produce different results.²² Conceptualizing normative views as a heuristic utilized by the public to make sense of climate change debates finds mixed support, although the relationships that do emerge are consistent with the value-centered thesis.

Hypothesis 4 focused explicitly on political ideology as an additional method of testing the value-centered theses. There is a well-developed literature pointing to ideological and partisan differences in the context of climate change, and those findings materialize in the Chapter 4 analysis. Conservatives were more likely to reject the positions of climatologists while liberals were more likely to embrace the arguments. Supplementary analysis (not shown) employed a measure of regulatory opinions as opposed to self-identified ideology in order to offer a more precise understanding of why this relationship occurred. Results were similar, suggesting the ideological divide occurs because conservatives express more aversion for government regulations while liberals are more likely to conceptualize government as a problem solver. A significant relationship between ideology and climate beliefs emerged across the first two analyses, but not in the solar radiation analysis. Additional analyses suggested the relationship did not materialize because of fluctuations within responses by ideological groups. Moderate liberals (at the “-3” and

²² Some surveys, for instance, specifically ask about the level of trust in what environmental scientists say. Drawing this distinction might offer a better explanation of negative attitudes toward science.

“-4” positions) were more likely to reject the counterargument as were (to a lesser extent) strong liberals (at the “-5” position) and strong conservatives (at the “5” position). It was the moderate conservatives (at the “3” and “4” position) and moderates (at the “0” position) who were less likely to identify with the position of climatologists. This fluctuation in the responses across the ideological scale did not lead to a detectable pattern in the survey responses, however.

The discussed relationships between climate change beliefs and both ideology and science knowledge deserve qualification, however, due to the interactive effects specified in Hypothesis 5. Throughout the analysis, there was a common theme when considering interactive effects. High-knowledge conservatives think differently about climate change compared to high-knowledge liberals and moderates. On all dependent variables in Chapter 4, high-knowledge conservatives were significantly less likely to accept the three propositions. In two of the three cases, as conservatives grew more knowledgeable, their predicted probability of agreement with climatologists actually decreased. The exception was solar radiation, where high-knowledge conservatives were more likely to reject the proposition than low-knowledge conservatives; however, they were still less likely to agree than high-knowledge liberals and moderates.²³ However, recall the average marginal effect was insignificant for strong conservatives (at the “5” position), but significant for more moderate conservatives. While it is clear knowledge has an

²³ One reason for this difference could be that the three questions represent different stages of the policy debate. The precise cause of climate change is a more complex topic, one where there is more uncertainty as to the primary driver of observed weather changes. However, as noted in Appendix B, the observed difference in responses of conservatives to the solar radiation question may be due to survey question wording. A notable number of conservatives only agreed with climatologists on the solar radiation proposition, whereas moderates and liberals who only agreed with climatologists once tended to agree just on the greenhouse effect question. If these conservatives were confused by the question wording and meant to disagree with climatologists, then the regression results for the interaction term would be similar across all three issues.

effect on beliefs, the effect is moderated by ideological predispositions as expected in the Hypothesis 5.

Furthermore, high-knowledge liberals were more likely to rally around the information when compared to moderates. The s-shaped nature of the predicted probabilities for liberals as they accumulated knowledge suggests that they are quick to rally around the information offered by scientists. This is because their predispositions favor environmental protection. These relationships materialized in Table 5.1 as well. The relationship between high-knowledge liberals and climate change beliefs can be interpreted as support for both the science comprehension and value-centered theses. On one hand, high-knowledge liberals think differently about climate change compared to low-knowledge liberals, as the science comprehension thesis would suggest. However, the s-shaped change in the predicted probability of liberals when compared to moderates suggests knowledge is interacting with values. This is consistent with the expectations of the value-centered thesis as well. Proponents of both theses can claim support.

Hypotheses 6 and 7 shifted focus toward the two-step process. Those who agreed with climatologists in respect to the solar radiation and fossil fuel propositions were more likely to demonstrate elevated levels of concern for climate change (Hypothesis 6). Those individuals demonstrating a high-level of climate change knowledge were also highly knowledge about science in general (see Chapter 4 and Appendix B). The path analysis revealed a significant indirect effect, where scientifically knowledgeable individuals were more likely to demonstrate elevated levels of concern. This relationship, however, occurs through the prior effect of scientific knowledge on climate change specific knowledge. This is taken as support for Hypothesis 7.

The Limits of Knowledge

The analysis provides support for both the science comprehension and value-centered theses. Scholarship (e.g., Kahan et al. 2012) has dismissed the role of knowledge in guiding beliefs about climate change. This conclusion is incorrect if climate change beliefs are modeled using the two-step process introduced here. The two-step model is consistent with the expectations of the science comprehension thesis. Basic scientific knowledge allows individuals to make sense of the causal arguments presented by scientists and other policy advocates. At that point, the science comprehension thesis has no expectation as to whether individuals demonstrate greater levels of concern for an alleged problem. The fact that there was a positive, significant relationship between climate change knowledge and concern simply suggests these individuals are reaching conclusions that climate change is a potential threat.

However, there are limits. There is no direct relationship between scientific knowledge and climate change concern. It does affect, however, climate change concern indirectly by guiding individuals in terms of how they come to understand climate change. As conceptualized here, scientific knowledge is limited to helping the public understand the problem. Even then, that relationship is conditional on ideological values. There is a window that provides an opportunity for scientific knowledge to correlate with climate change beliefs, but that window is small. There is the potential for basic scientific knowledge to correlate with other beliefs, such as problem recognition and maybe even policy preferences, but that relationship is best understood as indirect and minimal.

With this said, two caveats are in order. First, recall that question wording can exacerbate the degree of polarization in public opinion over climate change. Questions in the *Science News Survey* referred to the problem as global warming rather than climate change. Prior work has noted

that conservatives are more likely to reject the idea of global warming, but they are more agreeable when the problem is referred to as climate change (Schuldt et al. 2011). As such, the ideological gap noted throughout this analysis may be the result of question wording. Questions asking about climate change might produce different results.

Second, the survey was carried out online via Knowledge Networks. There are noticeable differences between probability-based online surveys and random-digit dialing data collection methods (Chang and Krosnick 2009). These differences could explain why these results vary compared to studies by Hamilton (2012). Although probability-based online surveys are argued to offer more representative samples, there could still be underlying biases within the survey population.

Additional Observations

Through the analyses presented in Chapter 4 and 5, there were several observations that did not speak to the hypotheses, but are worth reiterating. The construct validity of the science knowledge index may have been compromised by the true or false nature of the questions, with some respondents easily guessing answers to some of the questions. The opportunity for respondents to indicate “Don’t Know” on the survey may also have created a degree of noise in the measure. In Appendix C, participating in college science courses is a powerful predictor (comparatively) of both climate change beliefs and climate change concern. The notable effect of taking a college-level science course further underscores support for the science comprehension thesis. It also suggests a solution for public opinion scholars who are limited in the number of questions they can ask on a survey. If researchers do not have an opportunity to ask a battery of science knowledge questions, inquiring about whether science courses were completed in college might provide a useful measure of science knowledge for empirical analyses.

Including socio-demographic controls in Chapter 5 suggested partisanship, rather than ideology, might offer more explanatory power in empirical analyses when analyzing climate change concern. The powerful, direct effects between both the Democrat and Republican dichotomous measures and concern suggest devotion to the party message, rather than ideological values, might be a more appropriate understanding of problem recognition. An alternative viewpoint might conceptualize individuals as viewing political debates as a “team sport.” Individuals will support their preferred team, with more weight given to supporting the team than ideological values.

In several cases in Chapter 4, there was an observation that the models had room to improve their predictive capabilities of climate change beliefs. Other concepts that could add additional explanatory power include trust in scientists and risk perceptions. The analysis did not account for whether high-knowledge individuals trust the IPCC or the scientists researching climate change. There is an opportunity to specify additional models that introduce trust as an independent variable. The *Science News Survey* included several questions about the level of trust held for sources of climate change information. This included trust in the IPCC, NASA, various media outlets, and friends/family members. These measures of trust were excluded from the analysis given the subtle nuances within the measures. For instance, high-knowledge individuals do not trust the IPCC, but they do trust NASA and FOX News. They do trust information from interest groups like the Sierra Club and distrust information from energy companies. These relationships seem a bit counterintuitive (i.e., NASA scientists work with the IPCC) and require supplementary analyses that go beyond the scope of the two-step argument presented here. They were consequently left out of the analysis and reserved for future studies.

There also was no opportunity to compare political ideology with the cultural values, which were, again, the metric utilized by Kahan et al. (2012) and other proponents of the cultural cognition thesis. Ideally, the analysis here would compare science knowledge directly with cultural values in order to better respond to this work. At the same time, the cultural cognition theory emphasizes risk perceptions. Unfortunately, risk perceptions are not included in this study either. Their inclusion might improve the overall fit of the model, given other work in the literature (Leiserowitz 2006; Leiserowitz 2005; Lorenzoni et al. 2005).

Connection to Literature

The two-step process developed here informs the literature on three fronts. First, compared to prior studies it offers a more nuanced and accurate assessment of the science comprehension thesis. As noted earlier, Sturgis and Allum (2008) observed that the bulk of empirical analyses have considered generalized science attitudes as the outcome variable. The analysis offered here, with the focus on the acceptance of causal arguments about climate change, offers a more nuanced and complete assessment of the thesis.

This analysis is somewhat similar to Lawrence Hamilton's work, which utilizes interactive effects between a general measure of educational achievement and partisanship to understand beliefs about changes. In one paper, Hamilton (2011) finds evidence of interactive effects when looking at threat perceptions while in a second article (2012) he considers specific beliefs about climate change (similar to the questions in Chapter 4). In this latter analysis, Hamilton finds the interactive effect is largely insignificant. The strongest relationship observed is with respect to whether respondents believe in climate change. A multinomial regression revealed more educated Republicans were more likely to say global warming is ongoing and natural (compared to ongoing and anthropogenic). They were also more likely to say climate change is not occurring. Questions

about (1) changes in the Arctic Ocean, (2) the concentration of CO₂ in the atmosphere, or (3) the greenhouse effect produced no significant relationships between the interaction and expressed beliefs by the respondents. In most cases, partisanship and a measure of education (a four-point categorical variable) were insignificant.

The closest overlap between this dissertation and Hamilton's work is with respect to the greenhouse effect. The survey question in the *Science News Survey* was true/false in nature, asking whether global warming is the outcome associated with the greenhouse effect. Hamilton asked a multiple-choice question: "Scientists use the term 'greenhouse effect' to describe" with the answer options consisting of the following:

- "The heat-trapping properties of certain gases, such as carbon dioxide or CO₂;
- A hole in the Earth's ozone layer, which allows more sunlight to get through;
- The warming effect of pavement and cities; and
- Don't know/no answer."

In Hamilton's multinomial regression, educated Independents were more likely to select an incorrect answer, but the interaction variable was largely insignificant. Compared to the analysis offered in Chapter 4, the results differ in that low-educated populations in the middle of the political spectrum were less likely to identify with the position of climatologists. Furthermore, Chapter 4 suggested a strong, significant interaction effect between science knowledge and ideology.

In supplementary analyses not shown here, the greenhouse effect analysis was replicated using the variables utilized by Hamilton. The intent was to identify whether the differences in results were due to question wording in the dependent variable or the choice of variables for the interaction term. Utilizing a categorical measure of education and partisanship as the interaction

term (as well as using controls similar to Hamilton), Hamilton's (2012) work was replicated using the *Science News Survey*. In short, the differences between Hamilton's analysis and the findings here are largely due to how education achievement is measured. These differences are noted in Table 6.1. Science knowledge appears to be a superior and more nuanced measurement for predicting belief when compared to other, simpler education measures.

Table 6.1: Differences between Hamilton and Kalmbach

	<i>Hamilton (2012)</i>	<i>Kalmbach (2013)</i>
Interaction: Science knowledge * ideology	-	Significant
Interaction: Education * partisanship	Not significant	Not significant
Interaction: Science knowledge * partisanship	-	Significant

The second contribution of this dissertation is the use of the generalized science attitudes as normative views that may also shape climate change beliefs. While there was little support that those skeptical of science reject arguments from climatologists, there was typically a strong, positive correlation between beliefs and the faith-in-science index (although see the solar radiation analysis discussion above). This relationship also materialized when looking at climate change concern. In fact, in terms of standardized coefficients, having favorable views of science was a powerful predictor of climate change concern. This finding contributes to the science literacy literature by utilizing a traditional dependent variable and moving it to the right-hand side of the equation. It also reinforces the role of predispositions and heuristics in shaping beliefs about climate change.

The third and main contribution of the dissertation is the conceptualization of knowledge as a two-step process. This is noteworthy given the recent work of Kahan et al. (2012) that has increasingly emphasized cultural values as the dominant explanatory force behind climate change beliefs. The emphasis on values suggests there is only a small opportunity for objective

information to guide beliefs. Indeed, the analyses presented here did support conclusions that predispositions and values are a primary predictor of climate change beliefs. However, the analyses also suggest it is inappropriate to contend there is no role for a basic, foundational understanding of science to help individuals navigate the climate change debate. Such individuals who master the science knowledge quiz are more likely to understand the technical arguments about climate change, which is essential for making informed decisions about whether climate change poses a threat. Given the discussions in the Chapters 4 and 5, possessing a familiarity with science is highly correlated with understanding and agreeing with the arguments from climatologists.

In short, the science comprehension thesis should not be as quickly dismissed as others have suggested. Are scientifically knowledgeable individuals more concerned about climate change? No. Are individuals who understand the causal arguments from climatologists more likely to share the views of climatologists? Yes, and the people who understand these technical arguments from climatologists also tend to be scientifically knowledgeable. That relationship deserves emphasis as scholars search for additional biases and predisposition.

Robustness

The use of weights throughout the analysis does substantively alter the strength of the coefficients on occasions. Thus, conclusions that there are differences between the survey population and the random adult population is appropriate. However, the influence of the weights is in the direction against the hypotheses. That is, the strength of the relationship for key measures such as science knowledge and ideology is increased, more often than not, in analyses that do not utilize the weights from Knowledge Networks.

These relationships discussed above also emerge in other issues outside climate change. Analyses not included here found similar relationships in the context of evolution and vaccination

safety. Understanding foundational aspects of science led individuals to accept contested propositions about whether humans evolved from lesser species while high-knowledge individuals are also more likely to identify with arguments from the Centers for Disease Control and Prevention about vaccination safety. Although there is no equivalent question on the survey to assess problem recognition in the context of these alternative issues, the first-stage of the analysis appears robust and is applicable to non-environmental issues.

Temporal Component

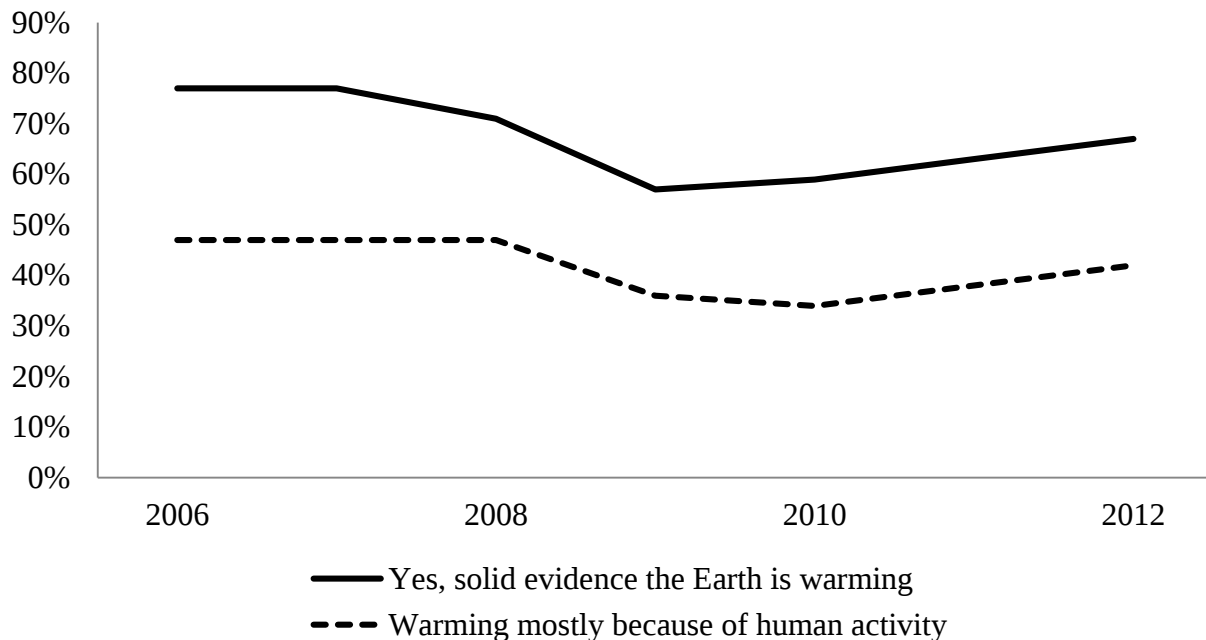
One theme in the climate change literature is the instability of public opinion. For instance, the Pew Research Center regularly tracks public sentiments related to climate change. From 2006 to 2012, they note a shift within public opinion.²⁴ These survey findings are replicated below in Figure 6.2. Beliefs about the strength of evidence supporting global warming dropped 20-points while there was an approximate 10-point drop in beliefs that warming can be attributed to anthropogenic causes. In both cases, the numbers have rebounded in recent years, although they have not reached the level of support prior to the 2009 marked decline.

The drop in 2009 coincides with two events. First, the “Great Recession” was peaking in terms of its influence on the economy. At the time of the *Science News Survey* (March 2008), the United States economy had not yet been declared to be in a state of recession. That label was not applied until December 2008, which was after the Pew Research Center’s October 2008 survey as well. By the 2009 cycle of the survey, numerous countries had declared their economies to be in a state of recession. Meanwhile, public discourse centered on the necessity of various stimulus packages to boost the economy, as well as how to regulate (if at all) industries which were labeled

²⁴ Additional work by Marquart-Pyatt et al. (2011) suggests this movement in public opinion was observed for only a limited number of survey items.

“too big to fail.” During this time of economic trial, there is said to have been a drop in public support for environmental issues.

Figure 6.2: Replication of climate change beliefs from the Pew Research Center



A second event coinciding with the drop in public opinion was the passage of the American Clean Energy & Security Act in the U.S. House of Representatives. The legislation would have implemented a cap-and-trade program on carbon dioxide. The public debate over the legislation featured the expected partisan divide, with Republicans and Democrats split on the legislation. Once Republicans regained control of the House in the 2010 elections, new legislation – Stop the War on Coal Act – was proposed to counter President Obama’s attempt to regulate greenhouse gases through new rules from the Environmental Protection Agency. It is perhaps this polarized political setting, rather than economic conditions, that are driving the fluctuations observed in Figure 6.2. A time-series analysis suggests partisan rhetoric, as well as media attention, correlate with changes to the public’s perceived threat of climate change (Brulle et al. 2012). Changes in macroeconomic indicators did not appear to correlate with the observed movement in the figure.

Regardless of what is driving these fluctuations, do the fluctuations themselves have implications for the science comprehension thesis? That is, are the results observed in Chapters 4 and 5 conditional on exogenous political events? The question, perhaps, is which segment of the population is moving its opinion as a response to events within the political system. A supplementary analysis was performed utilizing survey data from a summer 2009 Pew Research Center study that featured questions emphasizing science knowledge and questions about climate change. This analysis focused on whether individuals perceived a scientific consensus existing on climate change. In this analysis, those with higher levels of science knowledge were more likely to acknowledge the existence of a consensus. The analysis demonstrated support for the science comprehension thesis even when utilizing an alternative dataset, with different science knowledge questions, and in a timeframe featuring declining beliefs in climate change. A more robust analysis would require a longitudinal study of individuals in order to track changes in public opinion as various factors became relevant. The key question, in terms of the science comprehension thesis, is which respondents change their beliefs given external events.

Policy Implications

In terms of policies, the AAAS spends considerable time and resources focusing on how well the public understands science. Special issues of *Science* are devoted to better understanding how to teach and communicate science. Policies to enhance educational opportunities – particularly when it comes to teaching climate change – are not uncontroversial. Although these analyses suggest science education programs potentially decrease polarization within public opinion, there has been a backlash to teaching climate change in some communities (Reardon 2011). Observers have noted similarities between teaching climate change and evolution, and some teachers simply elect to skip the discussion altogether.

Based on the analyses presented earlier, the “good news” for advocates is that they do not necessarily need to teach climate change in the classroom. It appears a focus on basic scientific concepts, as well as participation in college science courses, would be sufficient to create movement in public opinion. In fact, efforts to increase the public’s level of scientific knowledge would increase the public’s understanding and interpretation of the climate change debate through multiple paths. A more knowledgeable public would increase the rate at which causal arguments from the scientific community are accepted. The greatest change in beliefs is likely to occur among low-knowledge liberals. Compared to moderates and conservatives, liberals were more likely to rally around the information and accept the arguments of climatologists. Providing the necessary foundational knowledge to understand debates would potentially drive more liberals to rally around the information offered by climatologists. The effect would not be as large for moderates, but there would still be gains. Conservatives, on the other hand, do not appear to align beliefs with scientists, even if they accumulate more foundational knowledge (although see the solar radiation argument above). In fact, educational programs, if not implemented carefully, might spark further resistance among some conservatives, as they are likely to rally against the threatening information.

Of course, any policy prescriptions designed to help the population understand complex policy debates and make sense of causal arguments must acknowledge the influence of normative views. Being overly optimistic about science and technology might have unexpected consequences, as it can lead to respondents to both accept and reject different causal arguments offered by scientists. As long as the story is technical in nature (greenhouse effect), it appears favorable normative views facilitate acceptance of the causal story. However, with more complex arguments about the cause of climate change, normative views might have the opposite effect. If

students are socialized to think more positively about science, the solar radiation analysis suggests a backfire effect might occur (see technology defender hypothesis in Appendix B). Still, it does not appear this backlash observed in the solar radiation context drives individuals away from being concerned about climate change as indicated in Chapter 5.

More importantly, though, is the recognition that values cannot easily be altered. A change from average to full knowledge on a science quiz score is a change that can be manufactured through education efforts. It is more difficult to change the ideological positions of individuals. Both ideology and partisanship are seen as stable (Jennings 1996; Jennings and Markus 1984; Abramson and Ostrom 1991). From this standpoint, there are few policy options, aside from those at the margins, which may significantly alter climate change beliefs for these partisans. Except for in the context of solar radiation, ideology was a more dominant predictor of beliefs than science knowledge in Chapter 4. Meanwhile, when considering concern in Chapter 5, partisanship was the identified as the dominant predictor, although knowledge measures did not lag considerably. Alleviating the polarization within public opinion may require some sort of an agreement between ideological leaders, such as the 2007 television commercial featuring then-Speaker Pelosi and former Speaker Gingrich discussing the need to address climate change.

Generational Replacement

Still, the generational gap noted earlier suggests some of the polarization within public opinion can be ameliorated through generational replacement. This gap can be understood as the byproduct of lower college attendance rates for the older generation. Could generational replacement possibly reduce the degree of polarization in public opinion? Table 6.3 looks at the outcome measures of Chapter 4 by age cohort. The table suggests elderly segments of the population are less likely to have taken science college courses, which appears to correlate with

lower performance on the science quiz. Note, however, that while the 26-35 age group is the most likely to have taken a science college course (52.6%), that increased exposure does not appear to translate into a significantly improved quiz score when compared to other groups.

With respect to climate change beliefs, divergent patterns emerge, especially for the greenhouse effect. Those 66 and older are anywhere from ten to 20 points less likely to identify the outcome associated with the greenhouse effect (depending on the comparison group). That gap disappears when looking at fossil fuels. Younger generations were only two to six points higher in terms of their agreement with the fossil fuel proposition. The gap reopens, however, when considering solar radiation, although it is not as large when compared to responses about the greenhouse effect. Those 26-35 years old are thirteen points higher in their level of agreement with the proposition compared to those 66 and older. The gap is less noticeable between other groups, however – ranging from a four to eight point difference.

Table 6.2: Age by select science measures

<i>Age</i>	<i>College science</i>	<i>Average quiz score</i>	<i>Agree greenhouse effect</i>	<i>Agree fossil fuels</i>	<i>Reject solar radiation</i>	<i>N</i>
18-25	40.9%	6.8	74.9%	54.3%	35.6%	149
26-35	52.6%	7.0	66.8%	58.4%	44.5%	280
36-45	41.8%	6.9	66.9%	53.4%	38.7%	299
46-55	37.6%	6.8	74.4%	54.2%	39.3%	267
56-65	27.3%	6.5	62.8%	51.1%	35.9%	201
66+	15.1%	5.5	56.7%	52.1%	31.1%	203

Despite some noticeable differences, the prospects of alleviating polarization via generational replacement appear limited. At most, generational replacement would likely improve scores on the science knowledge quiz. However, a high quiz score does not guarantee uniform views on climate change. There is considerable variation among the non-retired population despite having similar quiz scores. For instance, the 18-25 year old cohort scores similarly on the quiz compared to the 26-35 cohort, yet there is a nine-point difference with respect to how these two

cohorts approach the solar radiation proposition. Participating in college science courses might help explain this gap between the 26-35 year olds, but only with respect to solar radiation. It cannot explain, for instance, differences in beliefs about the greenhouse effect. In short, it is difficult to see a clear process under which generational replacement would reduce polarization within the public. What change in beliefs would occur appear minor.

Next Steps

The preceding discussion and analyses specified and found a set of conditions under which scientifically knowledgeable individuals think differently about climate change compared to their low-knowledge counterparts. According to the science comprehension thesis, high-knowledge individuals should accept the causal arguments from climatologists and, as expected, this relationship materialized. However, this relationship is conditional on political values and does not extend (directly) to threat perceptions. This conceptualization of the science comprehension thesis can be expanded through additional research. Some targeted opportunities for additional research are noted below.

Besides comparing alternative path models (see Appendix C summary), there is an opportunity to include policy preferences in the discussion. The shorter, more parsimonious two-step model discussed here could easily be expanded to a three-step process, where policy questions hinge on how the problem is understood and whether a threat is perceived if the problem goes unchecked. Preliminary analyses have suggested support for this third step. The *Science News Survey* was limited in terms of the number of environmental policy questions presented to respondents. There is only such one policy question, about fuel economy standards for automobiles. There are additional opportunities, however, to pursue similar analyses as those here

through other surveys by Dr. Jon Miller that include not only the science questions discussed here but also questions about policy preferences.

Within the *Science News Survey*, there are also opportunities to apply the science comprehension thesis to other issues. The survey asks about evolution and religious beliefs, which would provide an excellent comparison to the discussion here on climate change. Preliminary analyses suggest the first stage of the model can be reproduced, with the substantive effect of science knowledge similar to the effects found in Chapter 4. Similar analyses can also be carried out in the context of vaccination safety via a different survey. Like evolution and climate change, competing causal arguments emerge about the safety of vaccinations. There is a possibility to run a similar two-step model in this situation: science knowledge leading to vaccination knowledge, which leads in turn to decisions to get an influenza vaccination.

Regarding partisan differences, there is a suggestion in the literature that Republicans are anti-science. This argument is at odds with the emphasis here on value differences. As emphasized throughout the text, it is not that conservatives are anti-science; rather they are likely to rally around their core values when those values are threatened by unwelcome information. When exploring the survey data, there were areas where both liberals and conservatives shared similar attitudes about science. For instance, both liberals and conservatives scored high on the faith-in-science index. Elsewhere, analyses were performed of legislators and their voting habits on science issues. The results were similar to the patterns and views discussed in this dissertation. When values are not in conflict with science, there is bipartisan support for science issues. When values are in conflict, some partisan group will rally against the scientific information. Additional research that merges individual survey data with legislative behavior at the state or federal level

would be beneficial, given continued scholarship that insists Republicans are anti-science, which is argued here not to be the case.

Lastly, the framing of science and the battle to interpret information is relevant to this discussion. Strategic framing of science occurs throughout the policy process. Policy entrepreneurs call scientific information into question as part of an attempt to focus the debate on their preferred alternative solutions. Potential strategies include (1) outright denial of the causal argument suggested by the information, (2) acceptance of the causal story but insistence the information is not complete enough to produce informed policies, and (3) acceptance of causal stories and thoroughness of information, yet assert reluctance to pursue ambitious policy solutions.

Based on these strategies, a survey experiment would allow for an assessment of how scientifically knowledgeable individuals respond to perceptions of scientific and political conflict on select issues. Such a survey experiment could include multiple issues that have varying degrees of presence in public debates. That is, not all issues have clear, partisan boundaries. Of interest is the role of both ideological and science-based orientations in processing the presented information. The expectation is that frames that emphasize conflict and disagreement reduce both trust in scientists and support for relevant policies. However, orientations toward science such as scientific knowledge and faith in the scientific process are expected to lessen the influence of the partisan frames and perhaps even produce a backlash effect. This effect would occur if those with pro-science orientations ended up supporting and trusting scientists even more when conflict erupts. Also of interest is whether individuals rely on ideological beliefs when the issues are far removed from public discourse, as there would be less commentary from ideological leaders to guide views. Such an experiment would offer insights toward further mapping out the “vulnerable points” at which advocates can sway opinion, and thus accelerate or delay policy change.

The research outlined above provides a way to assess the degree to which scientifically knowledgeable individuals differ from the rest of the population. The framing experiment is particularly worthwhile, given the degree to which scientists are involved in offering information to decision-makers and the willingness of partisans to call into question scientists' assertions. As science advocates continue to push for a more scientifically aware public, it is essential that society understands what a high-knowledge public "looks like" – both in terms of what a scientifically aware public believes and how they behave.

APPENDICES

Appendix A: Participation in the Climate Change Debate

With some evidence for the science comprehension thesis in the analysis, an unanswered question is how knowledge promotes congruence between public opinion and science. Specifically, the thesis suggests that knowledgeable individuals have the capacity to engage in the climate change debate. This follow-up to the prior analyses considers whether individuals with higher levels of knowledge engage in climate change discussions and seek out information more frequently than their low-knowledge counterparts. These two activities represent different levels of engagement in the policy debate. The latter activity is more passive. Conversations can occur while in the car, over dinner, or while simply hanging out over the weekend. Individuals who engage in these activities are effectively paying attention to the issue, but it is more passive in nature as the activity is contingent on the presence and willingness of others to engage in these conversations. The second activity represents a more active form of attention as individuals have to devote considerable time and cognitive effort to seek out and consume additional information about climate change.

The third wave of the *Science News Survey* included a battery of activities that represent types of participation, with respondents reporting how many times they engaged in various information acquisition activities over the last year. Specifically, the question asked the following question: “Thinking about the global climate change issue, how many times have you done each of the following activities during the last 12 months. If you have not done an activity, please enter zero and go to the next item.” Respondents were then presented with a series of activities, which speak to the level of attention respondents devoted to the climate change discussions. These activities have been grouped into a “passive” and “active” form of attention.

The measure of passive attention includes the following activities, which were listed after the above noted question:

- Talked to my friends or co-workers about this issue; and
- Talked to other members of my family about this issue.

Responses to the two questions were simply added together to create a combined score. The average reported number of conversations in a given year was approximately 11, with a median occurrence of four (N=926). Approximately one-third of the survey respondents indicated that they did not talk about climate change with friends, co-workers or family members at all over the course of the last year.

The measure of active attention includes the following three activities listed after the above noted question, with respondents again allowed to indicate their level of engagement:

- Read a newspaper or magazine article about this issue;
- Looked for information about climate change on the Internet; and
- Read a book about climate change.

Responses to the three questions were added together. The average reported number of times information was actively consumed was approximately nine, with a median occurrence of three (N=925). Approximately 34% of the population indicated no activity on this front.

A negative binomial regression was selected to model the relationship between knowledge and activity due to the nature of the dependent variable as it represents a count process where individuals have a propensity to engage in these select activities once they reach an unspecified threshold. That is, respondents who engage in an activity once or twice possess increased likelihoods that they will continue to engage in such activities. This conceptualization is inappropriate for ordinary least squares regression, which assumes a linear relationship and no

threshold effects. Instead, a negative binomial regression is utilized because of the non-linear nature of the dependent variable. Furthermore, a negative binomial is favored over a Poisson model because the conditional mean and variance fluctuate based on performance on the science knowledge quiz. The analysis utilizes equations one and three from Chapter 4. There was no evidence of an interactive effect, so the following table presents a core model followed by a secondary model that includes socio-demographic controls. The anticipated directions of the relationships are diagrammed in Figure A.1.

Figure A.1: Proposed relationships between selected orientations and attention to climate change (passive/active)

Science orientations

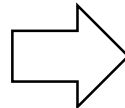
- Science Knowledge (+)
- Faith in science (+)
- Skeptical of science (-)

Political orientations

- Political ideology (+)

Socio-demographic controls

- Age (-)
- Gender (+)
- Democrat (+)
- Republican (-)
- Four-year degree (+)
- Advanced degree (+)



Active attention (additive index)

- 1) Read newspaper/magazine
- 2) Research on Internet
- 3) Read book

Passive attention (additive index)

- 4) Talked with friends/co-worker
- 5) Talked with family

Results from the negative binomial regressions are presented in Table A.1. Focusing first on the willingness of respondents to talk about climate change, Model 1 suggests those with elevated levels of scientific knowledge are more likely to talk about climate change with their friends and family members. However, the level of significance is outside the 95% confidence level. Still, 94 out of 100 times the relationship is expected to match that identified here. When it comes to looking up information (Model 3), those who possess elevated levels of scientific

knowledge are indeed more likely to read newspapers and books, as well as carry out research on the internet. This relationship is significant at traditional levels of significance. These relationships do not change in the expanded models (Model 2 and 4). The substantive effect of science knowledge on attention will be discussed more below, but at this stage, the relationships are consistent with what proponents of the science comprehension thesis would suggest.

Table A.1: Determinants of climate change debate participation

	<i>Discuss climate change</i>		<i>Seek information</i>	
	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>
Scientific knowledge	0.11 (1.87)	0.11 (2.08)	0.19 (5.11)	0.189 (4.75)
Faith-in-science	0.28 (1.88)	0.35 (2.60)	0.35 (2.01)	0.35 (2.27)
Skeptical-of-science	-0.34 (-2.04)	-0.29 (-2.00)	-0.11 (-0.81)	-0.11 (-0.83)
Ideology	-0.00 (-0.09)	-0.05 (-1.38)	-0.01 (-0.36)	-0.04 (-1.17)
Republican	-	0.40 (1.49)	-	0.09 (0.37)
Democrat	-	0.07 (0.40)	-	-0.09 (-0.47)
Age	-	0.01 (1.70)	-	0.01 (2.47)
Female	-	-0.48 (-2.72)	-	-0.10 (-0.54)
Education (4 year)	-	-0.01 (-0.04)	-	0.09 (0.36)
Education (advance)	-	0.46 (2.00)	-	0.40 (1.80)
Constant	1.46 (1.49)	0.81 (0.92)	-0.03 (0.04)	-0.53 (-0.67)
Log-likelihood	-2289	-2275	-2188	-2181
N=	743	743	742	742
Pseudo R ²	0.012	0.018	0.017	0.020

Notes: The first number represents the coefficient derived from a logistic regression. The number in parenthesis indicates the z-score from the significance test. In all models, a weight provided by Knowledge Networks was utilized in order to make inferences from the results back to the U.S. adult population.

Unlike in previous analyses that examined climate change beliefs, ideology retains little influence on the level of attention respondents devote to climate change throughout the models. Liberals and conservatives do not differ in their tendencies to talk about climate change or seek out information. This interpretation remains after including the socio-demographic controls.

Normative views of science reveal inconsistent relationships. Individuals who perceive more benefits from science are more likely to talk about science and look up information. The relationship is significant at the 95% confidence level in all models except Model 1. However, those more skeptical of scientific endeavors are less likely to talk about climate change, but they are not significantly less likely to carry out research on the issue by looking up information.

A Wald test suggests the socio-demographic controls increase the explanatory power of the model ($p < 0.01$). This explanatory power comes from accounting for females, who were less likely to talk about climate change with their acquaintances. Furthermore, individuals with advanced degrees were also more likely to talk about climate change – suggesting science knowledge is not the only education metric capable of predicting climate change behavior. These two measures are the primary drivers of Model 2's improved explanatory power. A similar Wald test, however, suggests the socio-demographic controls add no explanatory power when it comes to seeking out information about climate change (Model 4). This is expected, given the poor performance of the controls in predicting behavior.

Substantive Effects

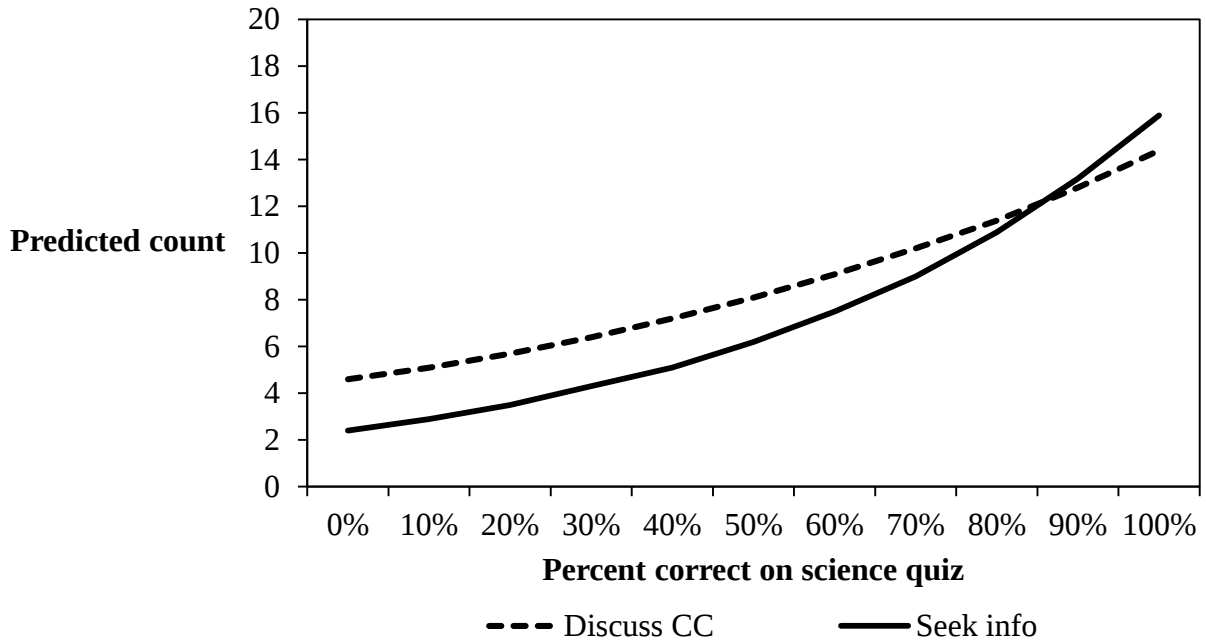
Given the additional explanatory power offered by the socio-demographic controls in Model 2, the expanded models (2 and 4) will be used to look at the substantive effects of the four core hypotheses. Figure A.1 displays the predicted level of activity for survey respondents based on the coefficients derived from Models 2 and 4 of Table A.1. Looking specifically at

conversations with friends, family, and co-workers suggests that individuals with no basic foundational understanding of science talk about climate change approximately five times each year. As knowledge accumulates, the number of times respondents engage in conversations increases steadily. For respondents with a median score on the science quiz (70% correct), the predicted number of conversations is just over ten times per year. This increases to fourteen discussions per year for those mastering the science quiz. In this context, those with scientific knowledge demonstrate an increased willingness to engage in climate change conversations.

A similar pattern emerges when looking at the tendencies of individuals to seek out information on climate change, which are also charted in Figure A.1. Those who fail the quiz are likely to look up information on climate change approximately twice a year. At the median science quiz score of 70%, an individual is likely to look up climate change information roughly nine times per year. At full knowledge, individuals are likely to pursue additional information almost sixteen times per year. That is, those possessing higher levels of scientific knowledge are more likely to engage in both discussions about climate change and in seeking additional information, although the relationship between knowledge and information gathering is stronger.

Table A.2 focuses on normative science views, utilizing the three main profiles noted earlier. The weak pro-science profile again provides the baseline for the discussion. These individuals agree with propositions about the benefits of scientists and disagree with positions that express skepticism about science. A move from weak to strong pro-science views corresponds to four additional climate change discussions each year and approximately four more information acquisition activities. An increase in skepticism, however, corresponds to a three-point decline in climate change conversations, but only a one-point decrease in the pursuit of additional information.

Figure A.2: Expected level of engagement in information acquisition activities



Notes: Predicted counts calculated with coefficients from models two and four in Table A.1. All other variables held at their respective means.

Table A.2: Expected involvement in climate change debate by normative views

	<i>Strong pro-science: Faith science (s. agree), skeptical science (disagree)</i>	<i>Weak pro-science: Faith science (agree), skeptical science (disagree)</i>	<i>Conflicted: Faith science (agree) skeptical science (agree)</i>
Discuss climate change	14.6	10.3	7.7
Seek information	12.1	8.5	7.6

Notes: Probabilities calculated with coefficients from Models 2 and 4 of Table A.1. All other variables held at respective means, unless noted in column heading.

To see whether attention corresponds to specific climate change beliefs, mean scores for the attention metrics are presented in Table A.3, which are then cross-tabulated with answers to the climate change questions featured in Chapter 4. The difference of means was then calculated to see if those agreeing with climatologists were more likely to pay attention to climate change. The results suggest individuals agreeing with climatologists are indeed more likely to engage in

these identified behaviors. However, the difference is only significant in two of the six situations. Individuals agreeing with climatologists on the greenhouse effect and solar radiation were more likely to seek out additional information. There were no significant relationships when considering an individual's propensity to talk about climate change.

Table A.3: Expected involvement in climate change debate by normative views

	<i>Greenhouse effect</i>		<i>Fossil fuels</i>		<i>Solar radiation</i>	
	Agree	Disagree	Agree	Disagree	Agree	Disagree
Discuss climate change	11.7	8.5	11.3	9.9	12.8#	9.4#
Seek information	10.2*	7.1*	10.2	7.9	12.1*	7.3*

Notes: Values reflect mean level of activity for each index. Calculations reflect weighting mechanism provided by Knowledge Networks. An * indicates the means are significantly different at the 95% confidence level, while a # indicates significance at the 90% threshold.

This secondary analysis provides a preliminary explanation for the results uncovered when exploring climate change beliefs. It appears possessing a higher level of scientific knowledge provides a foundation for the public to talk about climate change and seek out additional information. That is, they have the capacity to vet the claims of both climatologists and partisan commentators. This is especially true in the context of seeking out additional information via web searches, reading books, or other information acquisition activities, where the relationship is stronger and the results suggest greater confidence in the results. This does not always translate, however, into the acceptance of causal arguments. The proposition that foundational knowledge increases the capacity to consume information, which then allows individuals to make informed decisions about what to believe finds the most support in the context of solar radiation. The fact that the relationship materializes for this most contested and controversial take on climate change reinforces support for the science comprehension thesis.

Discussion

This supplementary analysis informs why some of the relationships noted earlier in Chapter 4 materialized. The models suggest scientific knowledge maintains a positive overall relationship

with behavior. Knowledgeable individuals are more likely to talk about climate change with friends and family. Knowledge also appears to provide the skills and intellectual capacity for respondents to seek out additional climate change information. The results suggest scientific knowledge provides an essential foundation that guides the citizenry to engage in policy debates by providing the capabilities to assess the information and causal arguments from climatologists. This relationship is especially true in the context of solar radiation, where seeking out additional information is associated with rejecting the solar radiation counterarguments. This is consistent with the science comprehension thesis, which speculates knowledge helps provide the intellectual capacity to engage in discussions with friends and family members.

It is not clear who is actually initiating the conversations reported by respondents. Is it the respondent or the family that initiates the discussions? It might be the case that those who are less knowledgeable of science turn to family members (or friends) they deem more knowledgeable on these matters for advice. As such, it is not that knowledge drives individuals to talk about climate change and analyze ideas, but rather knowledge makes individuals “beacons” that attract less-knowledgeable acquaintances.

Those possessing ideological predispositions did not appear more or less likely to engage in specific behavior. This can be expected given the attention climate change has received at times on the systemic agenda. The fact that climate change has gathered the attention of political leaders and policy entrepreneurs on both sides of the political spectrum increases the likelihood that both conservatives and liberals will engage in the selected behavior. As such, the results suggest that just because an issue does not align with core beliefs or a base set of values, respondents are still willing to engage in discussions and seek out information. That is, they do not ignore the issue just

because it does not resonate with them. It is important for the ideologues to keep pace with their counterparts to maintain a level of competence in the policy discussions.

The difficulty in further assessing the ideological relationships within the data is that the content of the discussions is unknown. For instance, it is not known what specific information is being gathered when conservatives research climate change information. A follow-up question might consider what information such individuals are relying on or trust when they engage in this activity. Are they turning to an official report from the IPCC (IPCC), or are they turning to conservative blogs that offer an alternative message? In the former instance, it is possible they are assessing the claims of political leaders that climate change is anthropogenic, but in the latter case, they might be looking for a reason to remain skeptical. If they do turn to the IPCC, then it would further support the science comprehension thesis. Respondents are using their scientific knowledge as a foundation to understand the complex arguments coming from climatologists.

This appendix was offered to help further understand why high-knowledge individuals appear more likely to accept the ideas coming from climatologists. The science comprehension thesis suggests individuals have the capacity to engage in the debate by engaging in information acquisition activities and discussing the information with others. Support for this component of the thesis was found in Appendix A. With this understanding, the discussion turns to the second appendix to look at the interrelationship between the three belief measures utilized throughout Chapter 4.

Appendix B: Interrelationship between Beliefs

The three outcome measures discussed in Chapter 4 represent various stages of the climate change debate and are interrelated. To support the position that humans are the cause of escalating temperatures seemingly requires someone to understand the greenhouse effect and acknowledge that the burning of fossil fuels warms the Earth. In this supplementary analysis, the relationship between these three outcome measures is further explored in an attempt to identify whether any systematic differences exist within the interrelationship between responses to these three questions.

A correlation matrix is presented in Table B.1. The matrix suggests a moderate correlation between beliefs about the greenhouse effect and fossil fuels, but a weaker correlation between solar radiation beliefs and the other two measures. For an additional look at the relationship between the measures, a reliability analysis was also performed. Table B.2 presents the Cronbach's alpha for the interrelationships between the three outcome measures. The results suggest the survey respondents consider each question in a unique way. Responses to one component of the climate change debate do not appear to correlate with agreement elsewhere. As with the correlation matrix, the greatest similarity is between the greenhouse effect and fossil fuel questions. The coefficient (0.59), however, suggests they do not align along a single dimension. The coefficient is reduced noticeably when considering the relationship between solar radiation and the other two measures. Combined, the Cronbach's alpha is only 0.54 between the three measures. This "unreliability" is expected given that each question represents different components of the policy debate and invokes different reactions from survey respondents.

Table B.1: Correlation matrix				Table B.2: Reliability coefficients			
	<i>Green. effect</i>	<i>Fossil fuels</i>	<i>Solar rad.</i>		<i>Green. effect</i>	<i>Fossil fuels</i>	<i>Solar rad.</i>
Greenhouse effect	1.0000			Greenhouse effect	-	.5860	.3512
Fossil fuels	0.4153	1.000		Fossil fuels	-	-	.3649
Solar radiation	0.2544	0.2557	1.000	All three		.5425	
Notes: Coefficients represent Pearson's r calculations between the indicated measures.				Notes: Coefficients represent Cronbach's alpha calculations between the indicated measures.			

Given the degree of controversy and scientific certainty found within each component of the climate change debate, it is likely systematic patterns exist within the additive index. To explore this further, Table B.3 presents an additive index of the three questions. The distribution indicates 25% of the sample agrees with all three measures. The majority of respondents agree with at least two of the environmental questions. Only 16% of the sample rejected all three propositions. Collectively, this additive index (referred to as climate change knowledge) represents the degree to which respondents agree with climatologists.

Table B.3: Distribution of additive index of climate change knowledge		
	<i>N</i>	<i>%</i>
None correct	222	16.2%
One correct	386	28.3%
Two correct	414	30.3%
Three correct	343	25.1%
	1364	
Note: Distribution weighted to U.S. adult population		

Given the argued progression between the three questions, it is expected that ideological players might “drop out” along the path to full agreement with the IPCC. That is, with more certainty about the first two propositions and less certainty as to the third, it might be expected that individuals in the “2” category agree in respect to questions about fossil fuels and the greenhouse

effect, but fail to reject the solar radiation counterargument as the IPCC suggests. Table B.4 charts how ideologues perform across the climate change knowledge scale. Three different ideological patterns emerge when looking at the table. Liberals are more likely to agree with all three propositions compared to conservatives, with 43% of all strong liberals agreeing with climatologists working with the IPCC. Conservatives were more likely to disagree with all three questions as over 20% of moderate and strong conservatives (value of “3” or greater on the ideology scale) received a score of zero on the knowledge index. Moderates are more uniform in their distribution across the index compared to liberals and conservatives.

Table B.4: Climate change knowledge by ideology

<i>Ideology</i>	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>Total</i>
Liberal (-5)	27.5%	7.3%	22.2%	43.0%	48
-4	12.0%	7.3%	39.7%	41.0%	25
-3	0.0%	20.5%	34.0%	45.4%	56
-2	3.6%	25.6%	27.9%	43.0%	86
-1	4.8%	24.6%	36.6%	34.0%	80
0	14.6%	25.7%	35.6%	24.2%	317
1	6.1%	35.0%	36.3%	22.6%	110
2	16.8%	27.0%	28.0%	28.3%	145
3	23.8%	30.3%	30.7%	15.2%	146
4	23.4%	42.6%	20.5%	13.4%	58
Conservative (5)	21.6%	40.1%	25.2%	13.1%	48

Note: Distribution weighted to U.S. adult population

Focusing on which specific questions respondents answered incorrectly reveals a common theme across ideology, however. As shown above, conservatives are more likely to agree with only one claim (Category 1). Conservatives (defined by those with a score of “3” or higher on the ideology scale) agreed with just the greenhouse effect question at a rate of 40%; 19% agreed with only the fossil fuels proposition; and 40% rejected only the solar radiation argument. Of the few liberals agreeing with only one claim, the large majority, 87.5%, agreed with the question about the greenhouse effect. Of the moderates agreeing with only one of the arguments, the greenhouse

effect was again the question most commonly answered in a manner consistent with the IPCC, at 56.7%. Shifting focus to those who agreed with two questions, liberals (defined as those with scores of “-3” or lower on the ideology scale) most often disagreed with climatologists about solar radiation (89.5%). Conservatives in the second category (agreeing with two climate change claims) also largely disagreed with climatologists on this issue (63.2%). Moderates were also more likely to disagree with the IPCC on solar radiation (73.7%). Individuals who answered only two questions consistently with climatologists, then, largely disagreed with the IPCC on whether solar radiation explains rising temperatures. These distributions are found in Table B.5.

Table B.5: Patterns in disagreement with climatologists

<i>Ideology</i>	<i>Agree with IPCC once, Only Agreeing with:</i>			<i>Agree with IPCC twice, Only disagreeing with:</i>		
	<i>Green. effect</i>	<i>Fossil fuels</i>	<i>Solar rad.</i>	<i>Green. effect</i>	<i>Fossil fuels</i>	<i>Solar rad.</i>
Conservatives	40.0% (35)	18.8% (17)	41.2% (36)	13.1% (9)	24.0% (16)	62.9% (43)
Moderates	56.6% (114)	25.0% (50)	18.3% (37)	5.1% (13)	21.0% (52)	73.9% (182)
Liberals	85.2% (14)	14.8% (2)	0.0% (0)	8.6% (3)	12.5% (5)	78.9% (31)

Note: Distribution weighted to U.S. adult population

Lastly, the relationship between science knowledge and climate change knowledge is presented in Table B.6. Those with higher quiz scores are more likely to agree with all three climate change questions. The jump is particularly noticeable for those who achieve quiz scores of 90% and 100%. Of those with above-average performance on the science quiz, more than two-fifths agreed to all three of the climate change arguments. Less than one-third of the respondents with medium levels of knowledge (70%) were likely to agree with all three propositions. This distribution meet the expectations of the science comprehension thesis, as those with higher quiz scores were noticeably more likely to express beliefs consistent with mainstream climatologists.

Table B.6: Climate change knowledge by science quiz score performance

<i>Science quiz score</i>	<i>Climate change knowledge score</i>				<i>Total</i>
	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	
0%	47.5%	52.5%	0.0%	0.0%	15
10%	64.5%	21.6%	0.0%	13.9%	22
20%	44.9%	40.4%	11.0%	3.7%	65
30%	25.6%	45.8%	23.7%	4.9%	97
40%	15.3%	40.1%	32.7%	11.9%	125
50%	18.9%	28.2%	33.7%	19.2%	167
60%	10.5%	35.0%	39.0%	15.5%	151
70%	15.2%	23.1%	30.5%	31.3%	154
80%	13.1%	18.3%	42.4%	26.1%	193
90%	4.9%	20.2%	28.4%	46.4%	170
100%	11.0%	23.0%	24.6%	41.5%	204
Mean science quiz score	51.6%*	58.5%*	67.7%*	78.2%*	

Note: Distribution weighted to U.S. adult population. An * indicates whether the mean quiz scores are significantly different at the 95% confidence level from other quiz scores.

Technology Defender Hypothesis

The combined climate change knowledge index provides another opportunity to explore the relationship between the faith-in-science index and solar radiation beliefs. Recall there was a sign reversal in Table 4.7. Individuals may understand the greenhouse effect and agree that burning fossil fuels damages the environment, but still view those technological advancements – such as the combustion engine and the development of “power-hungry” consumer products – that emit more greenhouse gases into the atmosphere as beneficial to society. Some scholars have noted technological advancement comes at a price (Brown and Sovacool 2011). One potential response to this trade-off is to embrace natural forces as an alternative causal explanation for global warming rather than accept the environmental costs of technological advancement. If this interpretation holds, this finding raises the possibility of a “backfire” effect. If respondents think *too* highly of science and technological advancements, they might become blind to the negative consequences associated with these developments. Thus, positive orientations toward science may actually

exacerbate the polarization within public opinion. This is one alternative explanation to the change in sign associated with the faith-in-science index. This possibility, referred to as the *technology defender hypothesis*, is explored further below.

In supplementary analyses, a dichotomous measure was constructed to assess who belongs in this profile of individuals, those who accept propositions about the greenhouse effect and fossil fuels yet fail to reject the solar radiation argument. Survey respondents were assigned a score of “1” if they agreed with all the propositions except solar radiation, 0 for all others. A regression analysis is presented in Table B.7. Model 1 suggests that liberals and those with higher degrees of faith in technology comprise this group. These ideological results are consistent with prior analyses, as conservatives were less likely to agree with two of the three arguments. As such, this grouping contained more liberals and moderates than the rest of the survey population. Just as importantly, those demonstrating elevated levels of faith in science were more likely to dominate this category of individuals. Model 2, with demographic controls, offers slightly different results. The coefficients suggest the Republican dichotomous measure does a better job explaining variation than ideology. In fact, Republicans are less likely to fall into Category 2 compared to others (which is still consistent with Table B.4). Females also fall into this group more frequently than males. However, an additional difference of means analysis suggests men and women who fit this technology defender profile perform equally well on the science knowledge quiz.

The coefficients from Model 2 were utilized to calculate the substantive effects of a change in the normative science profiles. As before, Model 2 is utilized because the socio-demographic controls increases the explanatory power of the model. Substantively, a move from the earlier noted “weak pro-science” profile to the “strong pro-science” profile produced a change of 7.2% in

the probability respondents fall within this profile of individuals. This change is similar in magnitude to other analyses performed earlier.

Table B.7: Determinates of individuals who believe in climate change but reject the solar radiation argument

	<i>Model 1</i>	<i>Model 2</i>
Scientific knowledge	-0.00 (-0.03)	0.02 (0.46)
Faith-in-science	0.47 (3.02)	0.41 (2.64)
Skeptical-of-science	0.21 (1.34)	0.15 (0.94)
Ideology	-0.07 (-2.02)	-0.04 (-0.85)
Republican	-	-0.73 (-3.02)
Democrat	-	-0.13 (-0.61)
Age	-	0.00 (0.45)
Female	-	-0.38 (-2.01)
4-yr degree	-	-0.39 (-1.60)
Advanced degree	-	-0.45 (-1.45)
Constant	-3.22 (-4.21)	-2.61 (-3.03)
Model 2: N=1082	Log-likelihood -563.3	Wald Chi ² 15.2
Model 2: N=1082	Log-likelihood -549.3	Wald Chi ² 35.3

Notes: The first number represents the coefficient derived from a logistic regression. The number in parenthesis indicates the z-score from the significance test. In all models, a weight provided by Knowledge Networks was utilized in order to make inferences from the results back to the U.S. adult population.

Summary

The analyses here support an interpretation of conservatives as growing increasingly resistant to arguments from the IPCC as the issues become more technical and specific about the relationship between humans and the environment. They are less likely to agree with the fossil fuel

and solar radiation propositions. The claims they do agree with tend to be of low controversy, such as the basic facts about the outcomes associated with the greenhouse effect. Meanwhile, liberals are more likely to agree with all three propositions, although they also dominate Category 2.

It is puzzling as to why 41% of conservatives rejected propositions about the greenhouse effect and fossil fuels, yet aligned their views with the IPCC in respect to climate change. It is possible that they found the question wording confusing, and that their true intent was to deny anthropogenic climate change. Supplementary analysis, not shown here, recoded conservatives who only agreed only with climatologists on solar radiation as, in fact, disagreeing with climatologists. Recalculations of Model 3 from Table 4.7 produced an interactive effect similar to the first two issues. That is, strong conservatives were increasingly less likely to agree with climatologists as they accumulated knowledge. This is, again, consistent with arguments that ideologues adopt positions opposite their political opponents.

Still, there are some commonalities regardless of ideology. Of those who only agree with one proposition, all ideological groups appear most likely to agree with the greenhouse effect argument. Of those who agree with two propositions, they are likely to agree that the greenhouse effect is associated with warming and that humans can influence the climate by burning fossil fuels. Regardless of ideology, respondents in Category 2 are not likely to accept the IPCC's narrative on solar radiation.

There was also support for the technology defender hypothesis. Those who accept arguments from climatologists but still reject the solar radiation counterargument have elevated levels of faith in science. This effect is likely understated, as individuals – notably conservatives – might be defending their way of life when they deny the other propositions as well. Most importantly, perhaps, is that some of these individuals who reject the arguments of climatologists

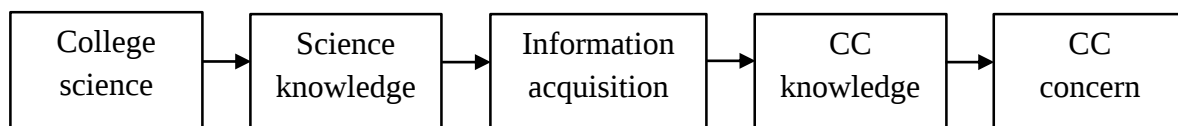
– particular on solar radiation – do have positive feelings about scientists and their work. This creates a potential “backfire” effect, where efforts to generate goodwill for scientists may make it difficult for those same scientists to convince a meaningful segment of the population there is a problem.

Appendix C: Toward a More Complete Model

The prior path models were just-identified, meaning that all potential relationships among the variables were tested. Outside the R^2 statistic, there was little ability to talk about the goodness-of-fit for the models. The style of analysis was chosen, however, in order to test the two-step process enunciated in the theory. Typically, it is beneficial to compare and contrast models and look at the fit statistics to identify a superior conceptualization of the relationships. A more elaborate, multi-staged model of public opinion is discussed below as a way to offer an expanded test of the science comprehension thesis.

This conceptualization relies on the basic arguments discussed throughout the dissertation. At a basic level, Figure C.1 provides a more elaborate diagram of the science comprehension thesis. This process starts with the socialization process, where individuals are exposed to science in their educational careers (Step 1). That process is the source of one's foundational understanding of science (Step 2). Science knowledge provides the skills to engage in information acquisition activities (Step 3), which in turn lead individuals to understand and evaluate the claims of scientists (Step 4). From that point, individuals can make informed decisions about whether they need to be concerned about climate change (Step 5).

Figure C.1: Basics of the science comprehension thesis



Again, scientific knowledge is simply one factor that helps guide public opinion. Figure C.2 populates the relationships found within Figure C.1 with additional measures. Going from left to right, the model starts with two exogenous variables – age and gender. These two independent variables are not contingent on any other factor. Once individuals are born, they begin the

socialization process. Unfortunately, the only question in the *Science News Survey* that might account for this socialization processes is participation in college science courses. There are no measures of political socialization that assess how parents and communities socialized their youth. Once they go through this socialization process, individuals have developed a belief system. These belief systems feature a series of orientations toward specific viewpoints. The science knowledge quiz score represents an individual's familiarity with science and whether they accept basic, fundamental arguments from scientists. As noted in Chapter 2, individuals who score high on the science knowledge quiz are also familiar with the scientific method. There are other orientations as well, such as ideology and normative views of science. These additional orientations are included alongside scientific knowledge. Individuals use these orientations to gather information about climate change. These activities correspond to the information acquisition activities discussed in Appendix A. They use this information, in turn, to develop specific beliefs about the phenomenon. After developing these beliefs, they are in a position to determine whether climate change constitutes a threat.

This description constitutes a multi-stage conceptualization of public opinion. While there are elements of the parsimonious two-step model discussed earlier, the model presented in Figure C.2 offers a more nuanced understanding of public opinion. The solid lines in Figure C.2 indicate relationships consistent with the empirical results throughout the first two empirical chapters, although some relationships come from unreported auxiliary research. The circular symbols around the endogenous measures indicate the errors for the respective measures, with the dotted lines indicating the anticipated correlation between the designated error terms. The results of running Figure C.2 through a path analysis are presented in Table C.1. The analysis will focus on the model's explanatory power of climate change knowledge and climate change concern.

Figure C.2: Multi-stage model

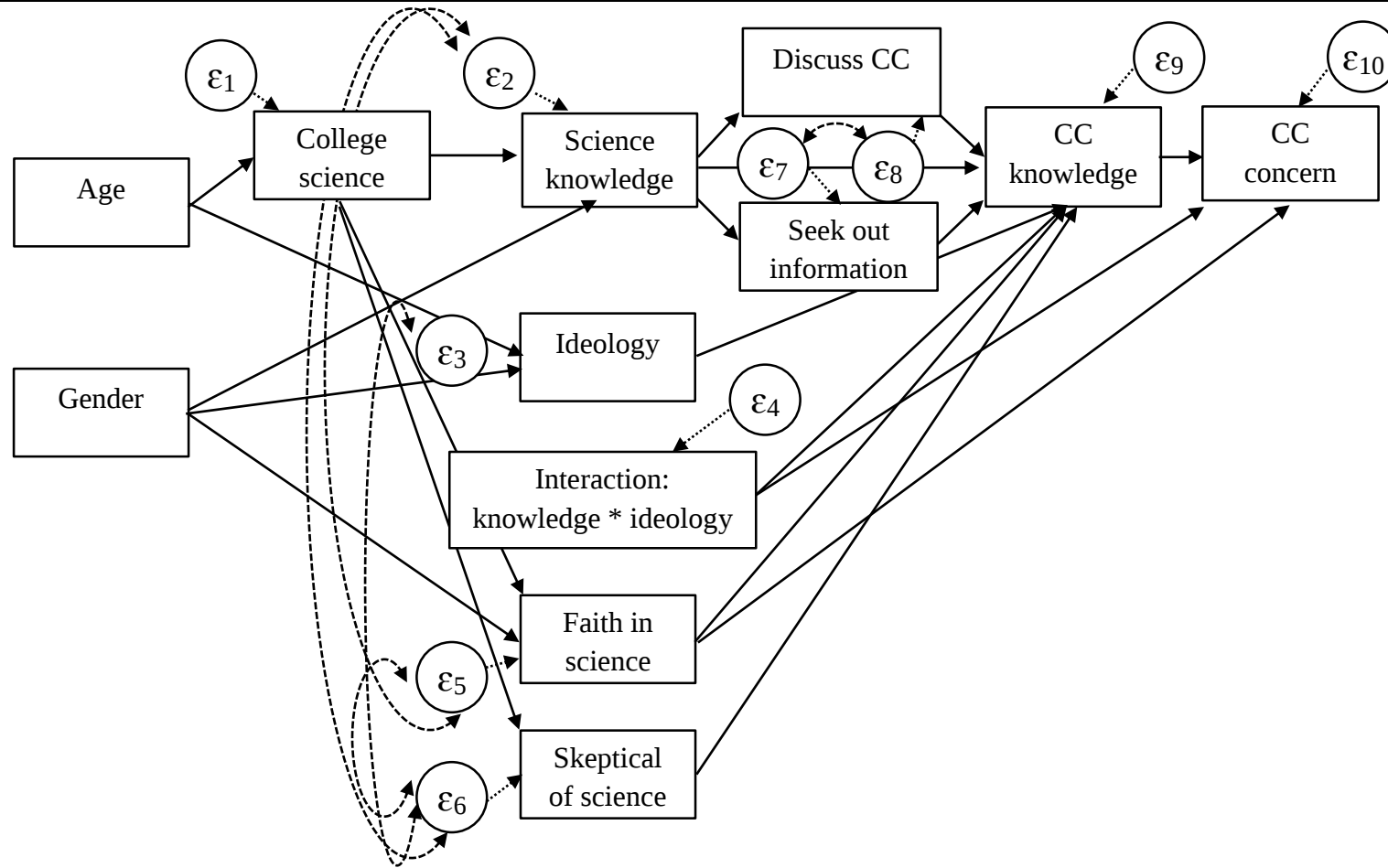


Table C.1: Direct, indirect and total effects of climate change knowledge and concern						
	<i>Climate change knowledge</i>			<i>Climate change concern</i>		
	<i>Direct effect</i>	<i>Indirect effect</i>	<i>Total effect</i>	<i>Direct effect</i>	<i>Indirect effect</i>	<i>Total effect</i>
Age	-	-0.00 (-0.71)	-0.00 (-0.71)	-	-0.00 (-0.10)	0.00 (-0.10)
Gender	-	-0.13 (-4.29)	-0.13 (-4.29)	-	-0.08 (-3.02)	-0.07 (-3.02)
College Science	-	0.25 (11.61)	0.25 (11.61)	-	0.12 (10.35)	0.12 (10.35)
Science Knowledge	0.12 (8.14)	0.00 (6.26)	0.13 (8.41)	-	0.05 (10.17)	0.05 (10.17)
Ideology	0.05 (1.02)	-	0.05 (1.02)	0.02 (0.39)	0.01 (1.02)	0.03 (0.65)
Interaction	-0.02 (-4.06)	-	-0.02 (-4.06)	-0.02 (-3.76)	-0.01 (-3.59)	-0.03 (-4.72)
Faith Science	0.08 (1.23)	-	0.08 (1.23)	0.14 (2.07)	0.02 (1.23)	0.16 (2.34)
Skeptical Science	-0.00 (-0.01)	-	-0.00 (-0.01)	-	-0.00 (-0.01)	0.00 (-0.01)
Talk CC	-0.00 (-0.14)	-	-0.00 (-0.14)	-	-0.00 (-0.14)	0.00 (0.30)
Seek Information	0.00 (1.00)	-	0.00 (1.00)	0.01 (3.77)	0.00 (1.00)	0.01 (3.87)
Climate Ch. Knowledge	-	-	-	0.30 (7.68)	-	0.30 (7.68)
Model Details: N = 737 Log-likelihood = -20249 R ² : 0.27(c.c. know.) R ² : 0.31 (concern)						
Notes: The first number represents the standardized coefficient. The number in parentheses indicates the z-score from the significance test. All covariances between the error terms drawn in Figure C.2 are significant (p<0.01). Results are not weighted. ²⁵						

Analysis

Table C.1 displays the results from the path analysis, which reveal the direct, indirect, and total effects for the two key endogenous measures for this discussion – climate change knowledge and climate change concern. There are several notable observations in the model. First, consistent

²⁵ The analysis is not weighted, in order to offer a discussion of the models' goodness-of-fit measures. Stata utilizes robust standard errors when applying the weight to the data, which invalidates the goodness-of-fit statistics. Weighting the analysis to the third wave of the survey increases the size of the coefficients, but the significance remains the same. Thus, this analysis may understate the substantive strength of the relationships.

with the science comprehension thesis, there is continued support for the Hypothesis 1 and 7. Moderates with higher levels of science knowledge are more likely to score higher on the climate change knowledge scale while an indirect, significant relationship between knowledge and concern. There is also support for Hypothesis 5. The interaction term suggests the science comprehension deserves qualifications, as high-know moderates, liberals, and conservatives all think differently about climate change, with similar interpretations to those made in Chapter 4 and 5. As in Chapter 5, the substantive effect of ideology is limited. Absent in this model compared to others in Chapter 5 are partisan measures, which appear to be a more dominant predictor of climate change concern compared to ideology.

There is still evidence of support for Hypothesis 2. Those scoring higher on the faith-in-science index were more likely to identify with the arguments of climatologists. However, this relationship is not significant when observing the total effect between the index and climate change knowledge. There is a direct, significant effect, however, between the index and concern. Compared to prior analyses, the strength of the direct effect is noticeably weaker – suggesting some of the variance between the faith-in-science index and concern is explained by other relationships specified in the model. As before, there continues to be no support for Hypothesis 3. Those skeptical of science have no statistically significant relationship with the key dependent variables in the analysis.

The direct effect between climate change knowledge and concern (Hypothesis 6) remains strong. In terms of total effects, understanding climate change in a manner similar to climatologists is substantively the most powerful predictor of climate change concern. Understanding climate change, as expected, comes from one's foundational understanding of science. Note, however, the total effect of participating in a science college course. The standardized coefficient is nearly

double that of scientific knowledge. In the context of climate change concern, the total effect of college science is double the total effect of science knowledge. In terms of the science comprehension thesis, this observation speaks to the effects of formally socializing students toward science. It appears in this analysis to be just as strong, if not stronger, of a predictor of beliefs than scientific knowledge.

Other components of the science comprehension thesis, as specified in Figure C.1, do not materialize. Those who seek out additional information, presumably to evaluate the arguments of scientists, are not more likely to accept the causal arguments from climatologists. Given observations in Appendix A, this lack of a relationship is not surprising. The measures of attention do not appear to mediate the relationship between science knowledge and climate change knowledge, likely because it is unknown which sources individuals are turning to for information.

In terms of the exogenous measures and their total effects, there is no detectable relationship between age and climate change beliefs. However, the gender gap does emerge in the model, with females less likely to accept the arguments from climatologists and demonstrate a lower level of concern compared to males. Again, this is inconsistent with literature that suggests females are more knowledgeable about climate change (McCright 2010).

Model Performance

The model itself performs fairly well when considering the portion of the variance in climate change beliefs it can explain. The R^2 statistic for climate change concern is 31%. Compared to 5.2, the R^2 statistic increases slightly for climate change concern.²⁶ The other

²⁶ With the survey weights applied to the model, there is a 10% improvement in the R^2 statistic for concern and a 20% improvement for climate change knowledge.

goodness-of-fit metrics, however, do not suggest the model explained a unique amount of variance. That is, the model is not significantly different from a saturated model that simply connected all the measures. The chi-squared assessment compares the difference between an over-identified and just-identified model (with all lines connected). Results from the test suggest that the model specification offered above is not significantly different than if all paths were drawn. That is, no theoretical insights were gained by the researcher's model. An alternative evaluation metric is the Root Mean Square Error of Approximation (RMSEA), which accounts for parsimony in calculating a goodness-of-fit statistic by controlling for sample size.²⁷ The RMSEA for the proposed model here is above 0.05, further indicating no unique insights were gained from the model. Other fit statistics suggest the model is not acceptable and are reported in the Table C.2.

Table C.2: Further diagnostics

<i>Goodness-of-fit metric</i>	<i>Result</i>
Likelihood ratio (model vs. saturated)	1791, reject unique difference
RMSEA	0.26, reject unique difference
Comparative Fit Index ²⁸	0.43, reject unique difference
Standardized Root Mean Squared Residual ²⁹	0.13, reasonable

Summary

While the model performs poorly, there are several observations that can be utilized to improve the model fit in future analyses. The model suggests mixed support for the science comprehension thesis. With respect to the Hypotheses 1 and 6, the anticipated relationship between science knowledge, climate change beliefs, and concern materialized. Those with elevated levels

²⁷ Formally, the metric is calculated by taking the difference between the chi-squared value and degrees of freedom, divided that by the degrees of freedom multiplied by sample size minus one.

²⁸ This statistic compares noncentrality parameters for a baseline and fuller model. If there is little difference, it can be seen as a good fit.

²⁹ Values less than 0.1 are considered favorable. The calculation looks at the mean absolute value of the covariance residuals.

of knowledge were capable of identifying the arguments from climatologists, which in turn led them to perceive climate change as a greater threat. To be clear, again, the science comprehension thesis does not suggest high-knowledge individuals should be more concerned: it simply specifies that individuals can better understanding the problem. Whether high-knowledge individuals perceive more of a threat from a changing climate depends on risk attitudes and other factors. It appears from the relationship above, however, that these individuals are more likely to perceive a threat.

For the science comprehension thesis, there is no support for the proposition that respondents who understand climate change are also engaging in specific activities such as talking about climate change and seeking out information. While Appendix A suggested it is the high-knowledge individuals engaging in these information acquisition activities, they are not necessarily reaching unique conclusions. Further insight might be gained if information about whom these respondents are consulting for additional information might improve the analysis.

The model could also be significantly improved, perhaps, by specifying a different order to the relationships. For instance, concern might lead individuals to consume information. Alternatively, concern might lead individuals to know something about climate change in the first place, regardless of one's level of basic science knowledge. Alternative models – perhaps a non-recursive model – could be specified and compared in order to parse out a superior framework.

The possibility of additional direct relationships could also be explored. There were additional relationships that could have been drawn in the model, but were not because they were outside the expected relationships of the hypotheses. Exploratory analyses might suggest additional relationships that were not considered here.

Lastly, including additional variables might also provide further insight. The strong effect observed for the partisan metrics in Chapter 5, as well as the strength of the college science measure, suggests it might be appropriate to consider mediating effects. The *Science News Survey* also has questions about trust in science organizations that theoretically could have a place in the model.

BIBLIOGRAPHY

BIBLIOGRAPHY

- Abramowitz, Alan I., and Kyle L. Saunders. 2008. "Is Polarization a Myth?" *The Journal of Politics* 70 (02):542-55.
- Abramson, Paul R., and Charles W. Ostrom, Jr. 1991. "Macropartisanship: An Empirical Reassessment." *The American Political Science Review* 85 (1):181-92.
- Achen, Christopher H. 1978. "Measuring Representation." *American Journal of Political Science* 22 (3):475-510.
- . 2002. "Parental Socialization and Rational Party Identification." *Political Behavior* 24 (2):151-70.
- Alberts, Bruce. 2011. "The New Egypt." *Science* 332 (6029):513.
- Allum, Nick, Patrick Sturgis, Dimitra Tabourazi, and Ian Brunton-Smith. 2008. "Science knowledge and attitudes across cultures: a meta-analysis." *Public Understanding of Science* 17:35-54.
- Almond, Gabriel A. 1960. *The American People and Foreign Policy*. New York: Praeger.
- American Association for the Advancement of Science (AAAS). 2010. "Climate change and the public: Overcoming skepticism after Climategate."
- Anderson, Norman H. 1981. *Foundations of Information Integration Theory*. San Diego: Academic Press.
- Ansolabehere, Stephen, James M. Snyder, Jr., and Charles Stewart, III. 2001. "Candidate Positioning in U.S. House Elections." *American Journal of Political Science* 45 (1):136-59.
- Ansolabehere, Stephen., and David. Konisky. 2009. "Public Attitudes Toward Construction of New Power Plants." *Public Opinion Quarterly* 73 (3):566-77.
- Barker, David, and Kathleen Knight. 2000. "Political Talk Radio and Public Opinion." *The Public Opinion Quarterly* 64 (2):149-70.
- Bauer, Martin, John Durant, and Geoffrey Evans. 1994. "European Public Perceptions of Science." *International Journal of Public Opinion Research* 6 (2):163-86.
- Beck, Paul Allen, and M. Kent Jennings. 1982. "Pathways to Participation." *The American Political Science Review* 76 (1):94-108.
- Bodmer, Walter F. 1985. "The public understanding of science." London: Royal Society.

- Borick, Christopher P., and Barry G. Rabe. 2010. "A Reason to Believe: Examining the Factors that Determine Individual Views on Global Warming*." *Social Science Quarterly* 91 (3):777-800.
- Brambor, Thomas, Williams R Clark, and Matt Golder. 2006. "Understanding Interaction Models: Improving Empirical Analyses." *Political Analysis* 14:63-85.
- Brody, Samuel D, and Sammy Zahran. 2007. "Commentary: Linking particulate matter and sulphur concentrations to air pollution annoyance: problems of measurement, scale and control." *International Journal of Epidemiology* 36 (4):820-3.
- Brody, Samuel D., B. Mitchell Peck, and Wesley E. Highfield. 2004. "Examining Localized Patterns of Air Quality Perception in Texas: A Spatial and Statistical Analysis." *Risk Analysis* 24 (6):1561-74.
- Brody, Samuel D., Sammy Zahran, Arnold Vedlitz, and Himanshu Grover. 2008. "Examining the Relationship Between Physical Vulnerability and Public Perceptions of Global Climate Change in the United States." *Environment and Behavior* 40 (1):72-95.
- Brown, Marilyn A., and Benjamin K. Sovacool. 2011. *Climate Change and Global Energy Security: Technology and Policy Options*. Cambridge, MA: The MIT Press.
- Brulle, Robert J., Jason Carmichael, and J. Craig Jenkins. 2012. "Shifting public opinion on climate change: an empirical assessment of factors influencing concern over climate change in the U.S., 2002-2010." *Climatic Change* 114 (2):169-88.
- Burstein, Paul. 2003. "The Impact of Public Opinion on Public Policy: A Review and an Agenda." *Political Research Quarterly* 56 (1):29-40.
- Carmines, Edward G., and James A. Stimson. 1986. "On the Structure and Sequence of Issue Evolution." *The American Political Science Review* 80 (3):901-20.
- Chang, Linchiat, and Jon A. Krosnick. 2009. "National Surveys Via Rdd Telephone Interviewing Versus the Internet: Comparing Sample Representativeness and Response Quality." *Public Opinion Quarterly* 73 (4):641-78.
- Chong, Dennis, and James N. Druckman. 2007. "Framing Theory." *Annual Review of Political Science* 10 (1):103-26.
- Converse, Philip E. 1964. "The Nature of Belief Systems in Mass Publics." In *Ideology and Discontent*, ed. D. E. Apter. Reprinted in *Critical Review* 19 (2006): 1-74.
- . 1972. "Change in the American Electorate." In *The Human Meaning of Social Change*, ed. A. Campbell and P. E. Converse. New York: Russell Sage.
- Cook, Summer B., Marvin Druger, and Lori L. Ploutz-Snyder. 2011. "Scientific literacy and attitudes towards American space exploration among college undergraduates." *Space Policy* 27 (1):48-52.

- Critchley, Christine R. 2008. "Public Opinion and Trust in Scientists: The Role of the Research Context, and the Perceived Motivation of Stem Cell Researchers." *Public Understanding of Science* 17 (3):309-27.
- Delli Carpini, Michael X., and Scott Keeter. 1996. *What Americans Know about Politics and Why It Matters* New Haven: Yale University Press.
- Doherty, David, and Jennifer Wolak. 2012. "When Do the Ends Justify the Means? Evaluating Procedural Fairness." *Political Behavior* 34 (2):301-23.
- Douglas, Mary. 1983. *How Institutions Think*. Syracuse, NY: Syracuse University Press.
- Douglas, Mary, and Aaron Wildavsky. 1983. *Risk and Culture: An Essay on the Selection of Technical and Environmental Dangers*. Berkeley, CA: University of California Press.
- Druckman, James N. 2001. "On the Limits of Framing Effects: Who Can Frame?" *The Journal of Politics* 63 (4):1041-66.
- Druckman, James N., and Toby Bolsen. 2011. "Framing, Motivated Reasoning, and Opinions About Emergent Technologies." *Journal of Communication* 61 (4):659-88.
- Dunlap, Riley E., and Araon M. McCright. 2008. "A Widening Gap: Republican and Democratic Views on Climate Change." *Environment: Science and Policy for Sustainable Development* 50 (5):26 - 35.
- Dunlap, Riley., Chenyang. Xiao, and Aaron McCright. 2001. "Politics and Environment in America: Partisan and Ideological Cleavages in Public Support for Environmentalism " *Environmental Politics* 10 (4):23-48.
- Durant, John, Geoffrey A. Evans, and Geoffrey P. Thomas. 1989. "The public understanding of science." *Nature* 340:11-4.
- Egan, Patrick J., and Megan Mullin. 2012. "Turning Personal Experience into Political Attitudes: The Effect of Local Weather on Americans' Peceptions about Global Warming." *Journal of Politics* 74 (3):796-809.
- EPA. 2012a. "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards; Final Rule."
- . 2012b. "National Emission Standards for Hazardous Air Pollutants From Coal-and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units ": Federal Registrar.
- Evans, Geoffrey, and John Durant. 1995. "The relationship between knowledge and attitudes in the public understanding of science in Britain." *Public Understanding of Science* 4 (1):57-74.

- Feldman, Lauren, Edward W. Maibach, Connie Roser-Renouf, and Anthony Leiserowitz. 2011. "Climate on Cable: The Nature and Impact of Global Warming Coverage on Fox News, CNN, and MSNBC." *The International Journal of Press/Politics*.
- Fenno, Richard F., Jr. 1977. "U.S. House Members in Their Constituencies: An Exploration." *The American Political Science Review* 71 (3):883-917.
- Fiorina, Morris P., Samuel A. Abrams, and Jeremy C. Pope. 2005. *Culture War? The Myth of a Polarized America*: Pearson Longman.
- Gamkhar, Shama, and J. Mitchell Pickerill. 2012. "The State of American Federalism 2011-2012: A Fend for Yourself and Activist Form of Bottom-Up Federalism." *Publius-the Journal of Federalism* 42 (3):357-86.
- Gauchat, Gordon. 2011. "The cultural authority of science: Public trust and acceptance of organized science." *Public Understanding of Science* 20 (6):751-70.
- Gelman, Andrew, and Gary King. 1993. "Why Are American Presidential Election Campaign Polls so Variable When Votes Are so Predictable?" *British Journal of Political Science* 23 (4):409-51.
- Giddens, Anthony. 1991. *Modernity and Self-Identity: Self and Society in the Late Modern Age*. Stanford, CA: Stanford University Press.
- Green, Donald., Bardley. Palmquist, and Eric. Schickler. 2002. *Partisan Hearts & Minds*. New Haven & London: Yale University Press.
- Griffin, John D. 2006. "Electoral Competition and Democratic Responsiveness: A Defense of the Marginality Hypothesis." *The Journal of Politics* 68 (4):911-21.
- Guber, Deborah Lynn. 2003. *The Grassroots of a Green Revolution: Polling American on the Environment*. Cambridge, Massachusettes: The MIT Press.
- Hamilton, Lawrence. 2011. "Education, politics and opinions about climate change evidence for interaction effects." *Climatic Change* 104 (2):231-42.
- Hamilton, Lawrence C. 2012. "Did the Arctic Ice Recover? Demographics of True and False Climate Facts." *Weather, Climate, and Society* 4 (4):236-49.
- Hamilton, Lawrence C., Chris R. Colocousis, and Cynthia M. Duncan. 2010. "Place Effects on Environmental Views." *Rural Sociology* 75 (2):326-47.
- Hamilton, Lawrence C., and Barry D. Keim. 2009. "Regional variation in perceptions about climate change." *International Journal of Climatology* 29 (15):2348-52.
- Hart, P. Sol, and Erik C. Nisbet. 2012. "Boomerang Effects in Science Communication: How Motivated Reasoning and Identity Cues Amplify Opinion Polarization About Climate Mitigation Policies." *Communication Research* 39 (6):701-23.

- Hayes, Bernadette C. 2001. "Gender, Scientific Knowledge, and Attitudes toward the Environment: A Cross-National Analysis." *Political Research Quarterly* 54 (3):657-71.
- Hayes, Bernadette C., and Vicki N. Tariq. 2000. "Gender differences in scientific knowledge and attitudes toward science: a comparative study of four Anglo-American nations." *Public Understanding of Science* 9 (4):433-47.
- Ho, Shirley, Dietram Scheufele, and Elizabeth Corley. 2010. "Making sense of policy choices: understanding the roles of value predispositions, mass media, and cognitive processing in public attitudes toward nanotechnology." *Journal of Nanoparticle Research* 12 (8):2703-15.
- Inhofe, James. 2012. *The Greatest Hoax: How the Global Warming Conspiracy Threatens Your Future*: WND Books.
- IPCC. 2007. "Climate Change 2007: Synthesis Report." ed. R. K. Pachauri and A. Reisinger: Intergovernmental Panel on Climate Change.
- Irwin, Alan, and Brian Wynne. 1996. *Misunderstanding science? The public reconstruction of science and technology*: Cambridge University Press.
- Jacquemin, Bénédicte, Jordi Sunyer, Bertil Forsberg, Thomas Götschi, Lucy Bayer-Oglesby, Ursula Ackermann-Liebrich, Roberto de Marco, Joachim Heinrich, Deborah Jarvis, Kjell Torén, and Nino Künzli. 2007. "Annoyance due to air pollution in Europe." *International Journal of Epidemiology* 36 (4):809-20.
- Jasanoff, Sheila. 1990. *The Fifth Branch: Science Advisers as Policymakers*. Cambridge, Massachusetts: Harvard University Press.
- Jennings, M. Kent. 1996. "Political Knowledge Over Time and Across Generations." *The Public Opinion Quarterly* 60 (2):228-52.
- Jennings, M. Kent, and Gregory B. Markus. 1984. "Partisan Orientations over the Long Haul: Results from the Three-Wave Political Socialization Panel Study." *The American Political Science Review* 78 (4):1000-18.
- Jerit, Jennifer, Barabas Jason, and Bolsen Toby. 2006. "Citizens, Knowledge, and the Information Environment." *American Journal of Political Science* 50 (2):266-82.
- Jones, Bryan D., and Frank R. Baumgartner. 2005. *The Politics of Attention: How Government Prioritizes Problems*: The University of Chicago Press.
- Jones, Michael D. 2011. "Leading the Way to Compromise? Cultural Theory and Climate Change Opinion." *Ps-Political Science & Politics* 44 (4):720-5.
- Jones, Robert Emmet, and Riley E. Dunlap. 1992. "The Social Bases of Environmental Concern: Have They Changed Over Time?1." *Rural Sociology* 57 (1):28-47.

- Kahan, Dan M., Hank Jenkins-Smith, and Donald Braman. 2011. "Cultural cognition of scientific consensus." *Journal of Risk Research* 14 (2):147-74.
- Kahan, Dan M., Ellen Peters, Maggie Wittlin, Paul Slovic, Lisa Larrimore Ouellette, Donald Braman, and Gregory Mandel. 2012a. "The polarizing impact of science literacy and numeracy on perceived climate change risks." *Nature Climate Change* advance online publication.
- Kahan, Dan M., Ellen. Peters, Donald. Braman, Paul. Slovic, Maggie. Wittlin, Lisa Larrimore. Ouellette, and Gregory. Mandel. 2012b. "The Tragedy of the Risk-Perception Commons: Culture Conflict, Rationality Conflict, and Climate Change." In *The 70th Annual Conference of the Midwest Political Science Association*. Chicago, Illinois.
- Kahneman, Daniel, and Amos Tversky. 1982. "Judgment under uncertainty: Heuristics and biases." In *Judgment under Uncertainty: Heuristics and Biases*. New York: Cambridge University Press.
- Kellstedt, Paul M., Sammy Zahran, and Arnold Vedlitz. 2008. "Personal Efficacy, the Information Environment, and Attitudes toward Global Warming and Climate Change in the United States." *Risk Analysis* 28 (1):113-26.
- Kline, Rex B. 2005. *Principles and Practice of Structural Equation Modeling*: The Guilford Press.
- . 2013. *Beyond Significance Testing: Statistics Reform in the Behavioral Sciences*. Second ed: American Psychological Association.
- Kohut, Andrew, Scott Keeter, Carroll Doherty, and Michael Dimock. 2009. "Scientific Achievements Less Prominent Than a Decade Ago: Public Praises Science; Scientists Fault Public, Media." Washington, D.C. : The Pew Research Center.
- Krosnick, Jon A., and Donald R. Kinder. 1990. "Altering the Foundations of Support for the President Through Priming." *The American Political Science Review* 84 (2):497-512.
- Kuklinski, James H., Daniel S. Metlay, and W. D. Kay. 1982. "Citizen Knowledge and Choices on the Complex Issue of Nuclear Energy." *American Journal of Political Science* 26 (4):615-42.
- Kunda, Z. 1990. "The Case for Motivated Reasoning." *Psychological Bulletin* 108 (3):480-98.
- Kunda, Ziva. 1987. "Motivated Inference: Self-Serving Generation and Evaluation of Causal Theories." *Journal of Personality and Social Psychology* 53 (4):636-.
- Lau, Richard R., and Caroline. Heldman. 2009. "Self-Interest, Symbolic Attitudes, and Support for Public Policy: A Multilevel Analysis." *Political Psychology* 30 (4):513-37.
- Lawler, Andrew. 2011. "A New Day for Egyptian Science? ." *Science* 333 (6040):278-84.

- Lax, Jeffrey R., and Justin H. Phillips. 2012. "The Democratic Deficit in the States." *American Journal of Political Science* 56 (1):148-66.
- Leiserowitz, Anthony. 2006. "Climate Change Risk Perception and Policy Preferences: The Role of Affect, Imagery, and Values." *Climatic Change* 77 (1-2):45-72.
- Leiserowitz, Anthony A. 2005. "American Risk Perceptions: Is Climate Change Dangerous?" *Risk Analysis* 25 (6):1433-42.
- Leiserowitz, Anthony A., Edward W. Maibach, Connie Roser-Renouf, Nicholas Smith, and Erica Dawson. 2013. "Climategate, Public Opinion, and the Loss of Trust." *American Behavioral Scientist* 57 (6):818-37.
- Lewenstein, Bruce V. 1992. "The meaning of 'public understanding of science' in the United States after World War II." *Public Understanding of Science* 1 (1):45-68.
- Liang, Jiaqi, and Daniel J. Fiorino. 2013. "The Implications of Policy Stability for Renewable Energy Innovation in the United States, 1974–2009." *Policy Studies Journal* 41 (1):97-118.
- Lindzen, Richard S. 2008. "Is the Global Warming Alarm Founded on Fact?" In *Global Warming: Looking Beyond Kyoto*, ed. E. Zedillo: Center for the Study of Globalization, Yale University.
- Locke, Simon. 2002. "The Public Understanding of Science—A Rhetorical Invention." *Science, Technology & Human Values* 27 (1):87-111.
- Lorenzoni, Irene, Nick F. Pidgeon, and Robert E. O'Connor. 2005. "Dangerous Climate Change: The Role for Risk Research." *Risk Analysis* 25 (6):1387-98.
- Luskin, Robert C., and John G. Bullock. 2011. "'Don't Know' Means 'Don't Know': DK Responses and the Public's Level of Political Knowledge." *Journal of Politics* 73 (2):547-57.
- MacCoun, Robert J., and Susannah Paletz. 2009. "Citizens' Perceptions of Ideological Bias in Research on Public Policy Controversies." *Political Psychology* 30 (1):43-65.
- Malka, Ariel, Jon A. Krosnick, and Gary Langer. 2009. "The Association of Knowledge with Concern About Global Warming: Trusted Information Sources Shape Public Thinking." *Risk Analysis* 29 (5):633-47.
- Marquart-Pyatt, Sandra T., Rachael L. Shwom, Thomas Dietz, Riley E. Dunlap, Stan A. Kaplowitz, Aaron M. McCright, and Sammy Zahran. 2011. "Understanding Public Opinion on Climate Change: A Call for Research." *Environment: Science and Policy for Sustainable Development* 53 (4):38-42.
- Matisoff, Daniel. 2008. "The Adoption of State Climate Change Policies and Renewable Portfolio Standards: Regional Diffusion or Internal Determinants." *The Review of Policy Research* 25 (6):527-46.

- Mayhew, David R. 2004. *Congress: The Electoral Connection*. Second ed: Yale University Press.
- McCaffrey, Mark, and Joshua Rosenau. 2012. "Science literacy still matters." *Nature Climate Change* 2 (9):636-.
- McCright, Aaron. 2010. "The effects of gender on climate change knowledge and concern in the American public." *Population and Environment* 32 (1):66-87.
- . 2011. "Political orientation moderates Americans' beliefs and concern about climate change." *Climatic Change* 104 (2):243-53.
- McCright, Aaron, M. , and Riley E. Dunlap. 2000. "Challenging Global Warming as a Social Problem: An Analysis of the Conservative Movement's Counter-Claims." *Social Problems* 47 (4):499-522.
- McCright, Aaron M., and Riley E. Dunlap. 2011. "The Politicalization of Climate Change and Polarization in the American Public's Views of Global Warming, 2001-2010." *Sociological Quarterly* 52 (2):155-94.
- Michaud, Kristy E. H., Juliet E. Carlisle, and Eric R.A.N. Smith. 2009. "The Relationship between Cultural Values and Political Ideology, and the Role of Political Knowledge." *Political Psychology* 30 (1):27-42.
- Mielby, Henrik, Peter Sandøe, and Jesper Lassen. 2012. "The role of scientific knowledge in shaping public attitudes to GM technologies." *Public Understanding of Science*.
- Miller, Jon D. 1983. *The American People and Science Policy*: Pergamon Press.
- . 1998. "The measurement of civic scientific literacy." *Public Understanding of Science* 7 (3):203-23.
- . 2001. "Public Understanding of Science at the Crossroads." *Public Understanding of Science* 10:115-20.
- Miller, Jon D. 2004. "Public understanding of, and attitudes toward, scientific research: what we know and what we need to know." *Public Understanding of Science* 13:273-94.
- Mondak, Jeffrey J. 2001. "Developing Valid Knowledge Scales." *American Journal of Political Science* 45 (1):224-38.
- Mucciaroni, Gary, and Paul J. Quirk. 2006. *Deliberative Choices: Debating Public Policy in Congress*. Chicago, IL: University of Chicago Press.
- Myers, T. A., E. W. Maibach, C. Roser-Renouf, K. Akerlof, and A. A. Leiserowitz. 2013. "The relationship between personal experience and belief in the reality of global warming." *Nature Climate Change* 3 (4):343-7.

- Nicholson, Stephen P. 2012. "Polarizing Cues." *American Journal of Political Science* 56 (1):52-66.
- Niemi, Richard G., and M. Kent Jennings. 1991. "Issues and Inheritance in the Formation of Party Identification." *American Journal of Political Science* 35 (4):970-88.
- Nir, Lilach. 2011. "Motivated Reasoning and Public Opinion Perception." *Public Opinion Quarterly* 75 (3):504-32.
- Nisbet, Matthew C., Dietram A. Scheufele, James Shanahan, Patricia Moy, Dominique Brossard, and Bruce V. Lewenstein. 2002. "Knowledge, Reservations, or Promise?: A Media Effects Model for Public Perceptions of Science and Technology." *Communication Research* 29 (5):584-608.
- Nyhan, Brendan, and Jason Reifler. 2010. "When Corrections Fail: The Persistence of Political Misperceptions." *Political Behavior* 32 (2):303-30.
- Oreskes, Naomi. 2004. "The Scientific Consensus on Climate Change " *Science* 306 (5702):1686.
- Page, Benjamin I., and Robert Y. Shapiro. 1983. "Effects of Public Opinion on Policy." *The American Political Science Review* 77 (1):175-90.
- Pidgeon, Nick, and Catherine Butler. 2009. "Risk analysis and climate change." *Environmental Politics* 18 (5):670-88.
- Pielke, Robert A. 2010. "The Climate Fix: What Scientists and Politicians Won't Tell You About Global Warming." Basic Books.
- Popkin, Samuel L., and Michael A. Dimock. 1999. "Political Knowledge and Citizen Competence." In *Citizen Competence and Democratic Institutions*, ed. S. L. Elkin and K. E. Soltan. University Park: Pennsylvania State University Press.
- Pralle, Sarah, and Jessica Boscarino. 2011. "Framing Trade-offs: The Politics of Nuclear Power and Wind Energy in the Age of Global Climate Change." *Review of Policy Research* 28 (4):323-46.
- Prewitt, Kenneth. 1983. "Scientific Illiteracy and Democratic Theory." *Daedalus* 112 (2):49-64.
- Price, Vincent, and John Zaller. 1993. "Who Gets the News? Alternative Measures of News Reception and Their Implications for Research." *The Public Opinion Quarterly* 57 (2):133-64.
- Putnam, Robert D. 2000. *Bowling Alone*: Simon & Schuster Paperbacks.
- Rabe, Barry G. 2010. "Racing to the Top, the Bottom, or the Middle of the Pack? The Evolving State Government Role in Environmental Protection." In *Environmental Policy: New Directions for the Twenty-First Century*, ed. N. J. Vig and M. E. Kraft. Washington, D.C.: CQ Press.

- Reardon, Sara. 2011. "Climate Change Sparks Battles in Classroom " *Science* 333 (6043):688-9.
- Ripberger, Joseph T., Geoboo Song, Matthew C. Nowlin, Michael D. Jones, and Hank C. Jenkins-Smith. 2012. "Reconsidering the Relationship Between Cultural Theory, Political Ideology, and Political Knowledge." *Social Science Quarterly* 93 (3):713-31.
- Roberts, Dave. 2012. *What 'left' and 'right' really mean on climate change* [cited Dec. 3 2012]. Available from <http://grist.org/climate-change/what-left-and-right-really-mean-on-climate-change-hint-nothing/>.
- Sabatier, Paul A., and Hank C. Jenkins-Smith, eds. 1993. *Policy Change and Learning: An Advocacy Coalition Approach*: Westview Press.
- Scharwz, Michiel, and Michael Thompson. 1990. *Divided We Stand: Redefining Politics, Technology, and Social Choice*. Philadelphia, PA: University of Pennsylvania Press.
- Schattschneider, E. E. 1960. *The Semisovereign People: A Realist's View of Democracy in America*. 1975 ed. Hindale, Illinois: The Dryden Press.
- Schneider, Stephen H. 2010. *Science as a Contact Sport: Inside the Battle to Save Earth's Climate*. Washington, D.C. : National Geographic.
- Schuldt, Jonathon P., Sara H. Konrath, and Norbert Schwarz. 2011. ""Global warming" or "climate change"?" *Public Opinion Quarterly* 75 (1):115-24.
- Searle, Kristina, and Kathryn Gow. 2010. "Do concerns about climate change lead to distress?" *International Journal of Climate Change Strategies and Management* 2 (4):362-79.
- Sears, David O. 1975. "Political Socialization." In *Handbook of Political Science*, ed. F. I. Greenstein and N. Polsby. Reading, MA: Addison-Wesley.
- Sears, David O., and Carolyn. Funk. 1990. "Self-Interest in Americans' Political Opinions." In *Beyond Self-Interest*, ed. J. Mansbridge.
- Shaviv, Nir. 2006. "On Climate Sensitivity and why it is probably small." In *ScienceBits*.
- Spence, Alexa, Wouter Poortinga, and Nick Pidgeon. 2012. "The Psychological Distance of Climate Change." *Risk Analysis* 32 (6):957-72.
- Stone, Deborah A. 2002. *Policy Paradox: The Art of Political Decision Making*. Revised ed. New York: W.W. Norton & Company.
- Stratmann, Thomas. 2000. "Congressional Voting over Legislative Careers: Shifting Positions and Changing Constraints." *The American Political Science Review* 94 (3):665-76.
- Sturgis, Patrick, and Nick Allum. 2004. "Science in Society: Re-Evaluating the Deficit Model of Public Attitudes." *Public Understanding of Science* 13:55-74.

- Sturgis, Patrick, Helen Cooper, and Chris Fife-Schaw. 2005. "Attitudes to biotechnology: estimating the opinions of a better-informed public." *New Genetics and Society* 24 (1):31-56.
- Sturgis, Patrick J., and Nick Allum. 2001. "Gender differences in scientific knowledge and attitudes toward science: Reply to Hayes and Tariq." *Public Understanding of Science* 10 (4):427-30.
- Swedlow, Brendon. 2012. "Cultural Coproduction of Four States of Knowledge." *Science, Technology & Human Values* 37 (3):151-79.
- Taber, Charles S., and Milton Lodge. 2006. "Motivated Skepticism in the Evaluation of Political Beliefs." *American Journal of Political Science* 50 (3):755-69.
- Thompson, Michael, Richard Ellis, and Aaron Wildavsky. 1990. *Cultural Theory*. Boulder, CO: Westview Press.
- Trefil, James. 2008. *Why Science?*: Teachers College Press & National Science Teachers Association.
- Wood, B. Dan, and Arnold Vedlitz. 2007. "Issue Definition, Information Processing, and the Politics of Global Warming." *American Journal of Political Science* 51 (3):552-68.
- Wright, Gerald C., Jr., Robert S. Erikson, and John P. McIver. 1987. "Public Opinion and Policy Liberalism in the American States." *American Journal of Political Science* 31 (4):980-1001.
- Wynne, Brian. 1991. "Knowledges in Context." *Science, Technology & Human Values* 16 (1):111-21.
- Yearley, Steven. 2000. "Making systematic sense of public discontents with expert knowledge: two analytical approaches and a case study." *Public Understanding of Science* 9 (2):105-22.
- Zaller, John, and Stanley Feldman. 1992. "A Simple Theory of the Survey Response: Answering Questions versus Revealing Preferences." *American Journal of Political Science* 36 (3):579-616.
- Zaller, John R. 1992. *The Nature of Origins of Mass Opinion*: Cambridge University Press.
- Ziman, John. 1991. "Public Understanding of Science." *Science, Technology & Human Values* 16 (1):99-105.
- Zumbrunnen, John, and Amy Gangl. 2008. "Conflict, Fusion, or Coexistence? The Complexity of Contemporary American Conservatism." *Political Behavior* 30 (2):199-221.