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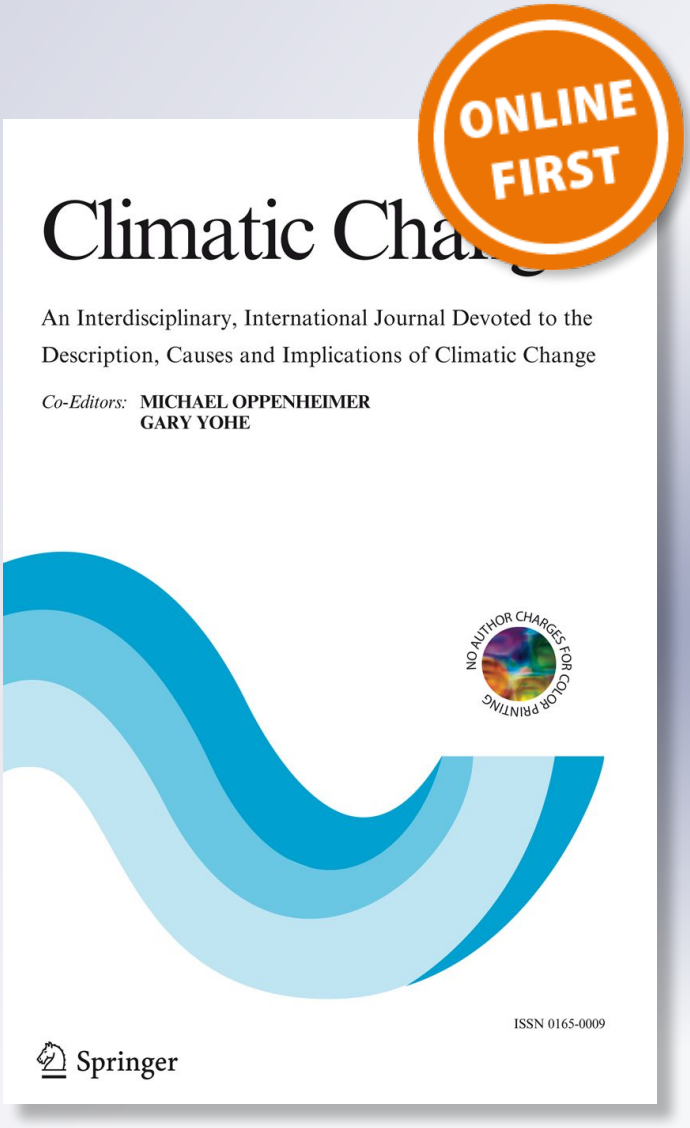

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The legitimacy of environmental scientists in the public sphere

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Abstract Previous research has examined public perceptions of climate change, including opinions about the severity of its effects, whether it is human caused, the degree of its exaggeration in the news media, and the level of scientific consensus on the issue. This research has shown that public beliefs about each of these aspects of climate change are politically charged. What remains understudied are the sources of environmental scientists' authority in the broader society and whether perceptions of environmental scientists themselves are polarized. Using data from the General Social Survey's Science and Technology Module, this study fills this gap in knowledge by examining public perceptions of environmental scientists across several dimensions. We develop and formally test a theoretical model of the legitimacy of environmental scientists in the public sphere, as measured by public support for their influence on climate policy. Consistent with other research on public beliefs about climate change, we find that perceptions of environmental scientists are polarized across multiple measures. Moreover, while previous theory and research have emphasized beliefs about scientific consensus on climate change, we find that perceptions of scientists' understanding of the issue and the integrity of their policy advice are each stronger predictors of scientists' legitimacy in the public sphere.

1 Introduction

Climate change poses a perplexing policy challenge for contemporary democracies. While many of its large-scale effects will not be felt for decades, the social efforts required to mitigate them must be implemented in the near-term (Intergovernmental Panel on Climate Change 2014; United Nations 2015). This means that the motivation for large-scale policy change

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cannot rely on people's direct experience with climate change but, instead, must be based on the predictions and recommendations of environmental scientists and other experts (McCright et al. 2014b).

Yet, previous research has identified a growing distance in the USA between public beliefs about climate change and scientists' consensus on the severity and causes of the problem (Hamilton 2011a, 2011b, 2014, 2015; Hamilton et al. 2012; Hamilton and Saito 2015; Kahan 2015; Kahan et al. 2012; van der Linden et al. 2015). These studies have suggested that political polarization is the primary mechanism behind this widening chasm. Since the early 1990s, those self-identifying as conservative and republican in the USA have grown more skeptical of climate change on numerous metrics relative to liberals and democrats, resulting in a growing divergence in public perceptions based on political orientation (Dunlap and McCright 2008; Dunlap et al. 2016; McCright and Dunlap 2011; McCright et al. 2014a).

However, this research has often stopped short of investigating *which* characteristics of scientists and their work have become politicized. Identifying these features is essential in order to evaluate which communication strategies are most likely to succeed in informing the public about climate change and its effects, as well as in recognizing the main challenges that scientists and policymakers must overcome in science communication around this issue. This study addresses these omissions by examining public perceptions of environmental scientists using a variety of novel, theoretically grounded metrics.

Public opinion research in the area of climate science has typically emphasized attitudes toward the scientific claims associated with climate change, such as a belief in global warming, the breadth of its environmental impact, whether it is anthropogenic, and whether it is exaggerated in the media. This research establishes that once scientific claims about climate change enter the public sphere, either through accounts in the news media or from elected officials, they become politically charged. It has also shown that an organized climate change denial movement in the USA has worked to undercut trust in climate science and the degree of scientific consensus on the issue (Dunlap et al. 2016; McCright and Dunlap 2011; Oreskes and Conway 2010). The denial movement's strategy of "casting doubt" on the scientific consensus on climate change has led scholars to identify the perceived level of agreement among scientists as the central characteristic that determines public acceptance of climate change along partisan lines (see Dunlap 2014, McCright and Dunlap 2011; McCright et al. 2014a). Indeed, recent research finds that the public's recognition of the scientific consensus on climate change is a "gateway belief" that leads to increased support for climate policy action (van der Linden et al. 2015).

However, this emphasis on scientific consensus overlooks other characteristics of climate scientists that are also potentially politicized, such as their perceived understanding of the problem and the disinterestedness of their research (i.e., whether their advice is self-serving). Ignoring these features can lead to misguided strategies for science communication. For instance, communication efforts that focus on convincing the public of the high level of agreement among climate scientists will not succeed if individuals assume that scientists have an incomplete or faulty grasp on climate science or if scientists are believed to promote their own selfish agendas instead of disinterested, objective science.

Building on previous research on public understanding of science (Bauer 2009; Gauchat 2012, 2015; Kahan 2015), this study explores the legitimacy of environmental scientists—measured by the extent to which the public agrees that scientists should shape government policy—as a function of environmental scientists' credibility—i.e., the public's attitudes toward the qualities of scientists that inspire trust in their claims about climate change.

The current study uses nationally representative survey data from 2006 and 2010 to advance the work of McCright et al. (2013). We extend this research in two fundamental ways. First, while McCright et al. focus on scientific *agreement* as the sole characteristic of environmental scientists that affects their legitimacy in the public sphere, we argue that multiple characteristics are relevant and rooted in public beliefs about scientists' *credibility*, as measured by perceptions of their (1) understanding of climate change, (2) the integrity of their policy advice, and (3) the level of agreement among scientists. Second, while past research has measured political orientation using a liberal-conservative ideology scale or party identification questions (usually with five- or seven-value scales), we employ confirmatory factor analysis from a number of political variables to construct a robust indicator of political disposition. This allows us to model a "latent" variable that overcomes the measurement error and estimation bias that accompany alternative specifications of this complex construct, providing more reliable estimates of the predicted effect of political disposition on public opinion of climate scientists. Our analytical model, depicted in Fig. 1, thus expands and elaborates upon the one described by McCright et al. (2013, p. 513).

2 The study

We investigate public perceptions of environmental scientists using data from the General Social Survey's Science and Technology Module. The survey was administered by the National Opinion Research Center at the University of Chicago. It is conducted via face-to-face interviews with a nationally representative sample of non-institutionalized adults in the USA. Our investigation combines data from the 2006 and 2010 waves of the survey. In supplemental analyses, we examined multi-group comparisons to test the possibility of substantively different estimates and model fit between the 2 years. We found no evidence that combining the survey years biased the results. In fact, the larger sample size improved the efficiency of the model estimation. We therefore pool cases from the two survey years for the analysis presented here, which is based on a sample of 1216 respondents. Table 1 shows the survey items and response options for the outcome and mediator variables in our model. Table 2 provides descriptive statistics for the variables used in the analysis. Additional details concerning our data and methods are provided in the Appendix.

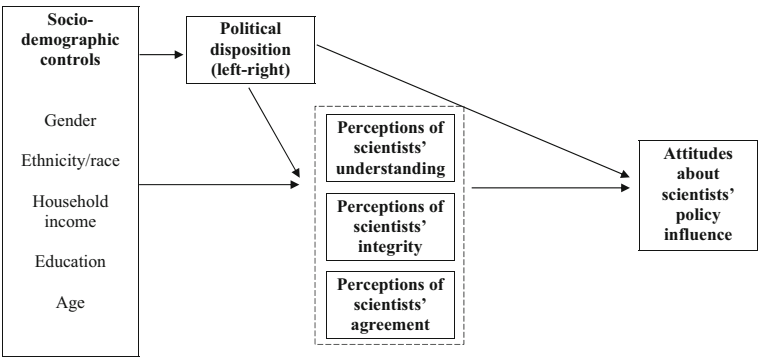

Fig. 1 Analytical model. Relationship of political disposition, sociodemographic variables, and support for environmental scientists' influence as policy advisors through mediators (perceived understanding, integrity, and agreement)

Table 1 Survey wording for outcome and mediator variables

	Survey items
Outcome variable	Global warming means a trend toward warmer temperatures throughout the world, with more extreme weather in many places and changes in food production that could affect our way of life. Some people believe that the burning of gasoline and other fossil fuels causes global warming. Others say that global warming has purely natural causes.
Attitudes about scientists' policy influence	How much influence should environmental scientists have in deciding what to do about global warming? Would you say a great deal of influence, a fair amount, a little influence, or none at all?
Mediator variables	
Perceptions of scientists' understanding	On a scale of 1 to 5, where 1 means "very well" and 5 means "not at all," how well do environmental scientists understand the causes of global warming?
Perceptions of scientists' integrity	When making policy recommendations about global warming, on a scale of 1 to 5, to what extent do you think environmental scientists would support what is best for the country as a whole versus what serves their own narrow interests?
Perceptions of scientists' agreement	On a scale of 1 to 5, where 1 means "near complete agreement" and 5 means "no agreement at all," to what extent do environmental scientists agree among themselves about the existence and causes of global warming?

Source: General Social Survey Science and Technology Module

We use structural equation modeling (SEM) to examine our core research questions. Specifically, we estimate the direct effects of political disposition on perceptions about the credibility of environmental scientists and the legitimacy of their policy advice. In addition, we examine the indirect effects of political dispositions on environmental scientists' legitimacy that are mediated by (operate through) perceptions about their credibility. These analyses were conducted using Mplus 7.14 software. SEM is ideal for this investigation, because it can simultaneously estimate direct and indirect effects while controlling for other sociodemographic factors in the model. Another advantage of SEM is that it can incorporate measurement models or confirmatory factor analysis (CFA) for complex constructs prone to measurement error and misspecification, such as political disposition (see Kahan 2015; Perrin et al. 2014). We included a CFA model for political disposition based on seven observed items indicating respondents' political views. Supplemental Table A1 contains the question wording and response options for the variables in our CFA, and supplemental Table A2 contains factor loadings for the CFA. In our analytical model (Fig. 1), all predictor variables and measures of perceptions of environmental scientists are observed and political disposition is a latent factor. The overall model has a good fit as shown by a variety of indices. The CFI is greater than 0.95, the TLI is greater than 0.90, and the RMSEA is less than 0.05.

Missing data were imputed using the Full Information Maximum Likelihood imputation procedure that is included with Mplus 7.14 software (Asparouhov and Muthén 2010). Because many of our items are categorical, we estimate our structural model using diagonally weighted least squares, which simulation research has shown are efficient for samples greater than 200 (Muthén et al. 1997). In supplementary analyses, numerous alternative specifications were examined to test the robustness of our model. For example, we replaced our latent measure of political disposition with a single 7-point measure of political ideology. Additionally, we estimated models that included measures of (a) general confidence in science and (b) scientific knowledge as mediator variables. Finally, we estimated a model that allowed direct effects of socio-demographic controls on the distal outcome. Results from each of these supplemental

Table 2 Descriptive statistics for variables of interest

	Mean/proportion	SD	Min.	Max.
Attitudes about scientists' policy influence			1	4
None at all	0.025	–		
A little	0.086	–		
A fair amount	0.397	–		
A great deal	0.492	–		
Perceptions of scientists' understanding			1	5
Not at all	0.049	–		
2	0.059	–		
3	0.218	–		
4	0.234	–		
Very well	0.439	–		
Perceptions of scientists' integrity			1	5
Serves own narrow interests	0.061	–		
2	0.068	–		
3	0.177	–		
4	0.274	–		
What is best for the country	0.420	–		
Perceptions of scientists' agreement			1	5
No agreement	0.075	–		
2	0.102	–		
3	0.379	–		
4	0.306	–		
Near complete agreement	0.138	–		
Sociodemographic characteristics				
Female	0.559	–	0	1
African American (non-Latino)	0.122	–	0	1
White (non-Latino)	0.750	–	0	1
Other race (non-Latino)	0.049	–	0	1
Latino	0.079	–	0	1
Income (natural log of household income category midpoints)	10.540	1.080	6.215	12.058
Education (years)	13.775	2.887	0	20
Age (years divided by 10)	4.666	1.687	1.80	8.90

Source: General Social Survey Science and Technology Module; $n = 1216$

analyses are available on request from the authors. However, a χ^2 difference test indicated that none of the alternative specifications provided a better fit for the data than what is presented here.

3 Results and discussion

Table 3 summarizes the main findings of the multivariate analysis. It reports the standardized direct, indirect, and total effects from the SEM predicting perceptions of environmental scientists' understanding of global warming, perceptions of the integrity of their policy advice, perceptions of their agreement about global warming, and attitudes about their influence on climate policy decisions. The total effect column represents the sum of the direct and indirect effects in the estimated SEM. Supplemental Table A3 contains coefficient estimates and tests of significance for the full model.

Results indicate that each of these dimensions of scientists' credibility directly affects their legitimacy as policy advisers. Specifically, individuals with more favorable impressions of

Table 3 Standardized direct, indirect, and total effects from SEM predicting attitudes about environmental scientists' policy influence

	Attitudes about scientists' policy influence		
	Direct	Indirect	Total
Credibility of scientists (mediators)			
Perceptions of scientists' understanding[a]	0.218***	–	0.218***
Perceptions of scientists' integrity[a]	0.278***	–	0.278***
Perceptions of scientists' agreement[a]	0.150***	–	0.150***
Political disposition[a]	−0.113**	−0.192***	−0.304***
Sociodemographic characteristics			
Female[b]	–	0.190***	0.190***
African American (non-Latino)[b]	–	−0.020	−0.020
Other race (non-Latino)[b]	–	0.122	0.122
Latino[b]	–	0.110	0. 110
Income[a]	–	<0.001	<0.001
Education[a]	–	0.063**	0.063**
Age[a]	–	−0.061**	−0.061***
r^2	–	–	0.326

Source: General Social Survey Science and Technology Module; $n = 1216$. Reference groups are men and non-Latino whites

***$p < .001$; **$p < .01$

[a] XY-standardized

[b] Y-standardized

scientists' integrity (0.278; $p < .001$), understanding (0.218; $p < .001$), and agreement (0.150; $p < .001$) believe that scientists should be more influential in policy decisions about global warming. Notably, these patterns are statistically significant net of controls for gender, race, education, income, and age. The model's r^2 statistic (0.326) indicates that the independent variables together account for approximately 33% of the variance in attitudes about scientists' policy influence. Additional Wald tests indicate that the effect of scientists' perceived integrity is significantly greater than the effect of perceived scientific agreement on their legitimacy ($\chi^2 = 8.023$, $p < .01$), which previous studies have identified as a key predictor of public attitudes about climate policy (McCright et al. 2013).

Table 3 also shows that political disposition has both direct and indirect effects on attitudes about environmental scientists' legitimacy as policy advisers. Individuals with conservative political dispositions think that environmental scientists should have less influence on climate policy when compared to their liberal counterparts (−0.304; $p < .001$). This total effect operates both directly (−0.113, $p < .01$) and indirectly (−0.192, $p < .001$). The indirect effect suggests that differences in liberals' and conservatives' attitudes about scientist policy advisers result partly from differences in liberals' and conservatives' perceptions of scientists' credibility. We examined Wald tests of the differences between the three pathways: (1) political disposition ➔ perceived understanding ➔ policy influence, (2) political disposition ➔ perceived integrity ➔ policy influence, and (3) political disposition ➔ perceived agreement ➔ policy influence. The pathways operating through perceived integrity ($\chi^2 = 9.869$, $p < .01$) and perceived understanding ($\chi^2 = 4.341$, $p < .05$) are each larger than the effect operating through perceived agreement. That is, polarized attitudes toward environmental scientists' understanding and integrity are each more important to their advisory legitimacy than perceptions of their agreement. Importantly, however, the direct effect of political disposition on scientists'

legitimacy indicates that conservatives assign less policy influence to scientists' *regardless* of scientists' perceived credibility. This suggests that part of conservatives' skepticism toward environmental scientists moves beyond perceptions about their qualities as sources of expert information and toward deeper doubts about their authority in public life.

This investigation builds upon the McCright et al. (2013) study in several ways. First, we analyze data from another national survey conducted in different years. Second, we focus on an alternative distal outcome (attitudes about scientists' influence on climate policy) and mediator variables (perceptions of scientists' understanding, integrity, and agreement on climate change). In doing so, our results shed new light on the role of scientists' perceived credibility in establishing their legitimacy in the policy-making arena. Third, we use a more refined measure of political disposition in order to reduce measurement error and improve the estimated effect of our focal independent variable.

Consistent with a mounting body of research, our results offer further evidence that public opinions on this issue are highly polarized, so that the legitimacy and credibility of environmental scientists to make claims have become politically charged. Our study extends existing knowledge by demonstrating that attitudes *about scientists themselves* are also divided along political lines, not just their claims or media accounts of climate change. Moreover, while previous research illustrates that scientists' perceived credibility is a crucial source of their legitimacy in the policy realm (O'Brien 2013), our findings reveal that political dispositions directly affect beliefs about scientists' role in climate policy decisions after accounting for perceptions of their credibility.

4 Conclusion

Overall, this study advances existing research on public perceptions of climate change in several directions. First, unlike earlier studies, we demonstrate that attitudes about environmental scientists as policy advisers are highly politicized. Second, our results show that perceptions of scientists' understanding of climate change and the integrity of their advice are critical to explaining support for their influence on climate policy decisions. Equally important, the indirect effects of ideological orientation are stronger when operating through the "understanding" and "integrity" pathways compared to the "consensus" pathway. This adds to our knowledge of public perceptions of climate change, which has emphasized the role of perceived scientific consensus in driving polarization, by showing that other characteristics of environmental scientists have even greater weight on public opinion.

Given that polarization extends beyond claims about climate change to perceptions of the scientists themselves, science communication strategies must contend with the public image of scientists in addition to their claims about climate science. Science participation and outreach efforts may offer opportunities for rebuilding credibility in the communities that are most critical of scientists and provide potential strategies for reducing polarized beliefs around climate science (Wynne 2006, 2007). Given the politicized nature of mediating agents, these efforts may require direct engagement by *scientists themselves* rather than relying on surrogates in the news media or among elected officials.

Scientific organizations such as the American Geophysical Union, the National Academy of Sciences, and the American Academies of Arts and Sciences can play an essential role in this process by offering resources that facilitate communication between skeptical publics and climate scientists. Universities and science museums, in coordination with these organizations,

can contribute public spaces from which outreach programs can diffuse to various communities. Government organizations with a strong internet presence, such as NASA or the National Oceanic and Atmospheric Administration, also provide opportunities for public engagement through social media. Concentrating efforts on conservative organizations and social networks, where negative views about scientists are more likely to circulate, may have the greatest potential for moving public perceptions of climate change and enhancing support for ameliorative policy. The growing body of research on political polarization, social networks, and media consumption can enhance outreach programs by familiarizing scientists with networks and beliefs that have become ideologically sorted, thus improving targeted communication to skeptical communities. Finally, the findings in this paper provide relevant insights to enhance the effectiveness of scientific messaging in public discourse. For example, proponents of climate policy action often point out that most scientists agree about the causes of climate change. However, our results indicate that this message is unlikely to resonate across partisan boundaries because scientific consensus is not the primary indicator of environmental scientists' credibility in the general public. New messaging that focuses on scientists' understanding of climate change and on the integrity of their policy advice is required.

Based on the findings in this study, future research might examine the effects of science participation efforts and issue framing on the types of outcomes analyzed here, along with new metrics for measuring public perceptions of scientists' credibility and legitimacy in the context of a policy debate. This could further illuminate whether, as suggested by this project, changing beliefs in a highly polarized environment depends less on the presentation of scientific evidence and consensus than on improving the public image of experts.

Appendix

Outcome variable. Respondents were given a brief statement that described the debate surrounding global warming: *Global warming means a trend toward warmer temperatures throughout the world, with more extreme weather in many places and changes in food production that could affect our way of life. Some people believe that the burning of gasoline and other fossil fuels causes global warming. Others say that global warming has purely natural causes.* To measure scientists' legitimacy as policy advisors, respondents were asked to rate on a four-point scale how much influence environmental scientists should have in deciding what to do about global warming. In our analysis, higher scores are coded to mean more influence.

Mediator variables. Respondents were also asked to respond to the following three questions on five-point scales: (1) *How well do environmental scientists understand the causes of global warming?* (2) *When making policy recommendations about global warming, to what extent do you think environmental scientists would support what is best for the country as a whole* versus *what serves their own narrow interests?* (3) *To what extent do environmental scientists agree among themselves about the existence and causes of global warming?* Responses are coded so that higher values correspond to greater perceived understanding, more support of the nation's best interests, and greater agreement among scientists.

Analytical technique. SEMs are ideal for this analysis, because they can simultaneously estimate a CFA, accommodate mediating factors, and allow for omnibus tests of alternative models simultaneously included in the system of equations (Hoyle 2012). In addition, unlike simple regression models, mediator variables are allowed to covary in the SEM format,

reducing overall error in the model. All models were computed using Mplus 7.14 statistical software. Because our endogenous variables are categorical, we estimate our SEM using diagonally weighted least squares. Fit statistics, including the RMSEA, CFI, and TLI, indicate an excellent fit between the model and the data. Complete estimates for the SEM are contained in Supplemental Table A3.

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