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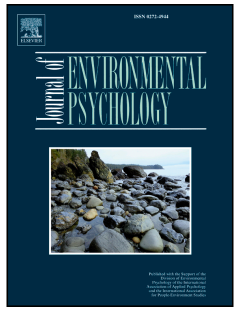

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The Gateway Belief Model: A Large-Scale Replication

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Abstract: The Gateway Belief Model describes a process of attitudinal change where a shift in people's perception of the scientific consensus on an issue leads to subsequent changes in their attitudes which in turn predict changes in support for public action. In the current study, we present the first large-scale confirmatory replication of the GBM. Specifically, we conducted a consensus message experiment on a national quota sample of the US population (N = 6,301). Results support the mediational hypotheses of the GBM: an experimentally induced change in perceived scientific consensus causes subsequent changes in cognitive (belief) and affective (worry) judgments about climate change, which in turn are associated with changes in support for public action. The scientific consensus message also had a direct effect on support for public action. We further found an interaction with both political ideology and prior attitudes such that conservatives and climate change disbelievers were more likely to update their beliefs toward the consensus. We discuss the model's theoretical and practical implications, including potential explanations for why conveying scientific consensus can help reduce politically motivated reasoning.

Keywords; Gateway belief model; scientific consensus; climate change; motivated cognition.

1. Introduction

Although a consensus has emerged in the scientific community on a range of scientific "facts", including human evolution, the safety of childhood vaccines, and human-caused climate change, the public remains sharply divided on many of these topics (Pew, 2015a). This large discrepancy between the state of agreement in the scientific community and the general public has been referred to as the "consensus gap" (Cook et al., 2018)

Among all of these important societal issues, human-caused climate change is arguably the most urgent, particularly because large-scale societal solutions will require significant changes in individual and collective human behavior and decision-making (Gifford, 2011; van der Linden, Maibach, & Leiserowitz, 2015). Yet, many climate change mitigation solutions are constrained when publics remain divided on basic scientific facts, such as whether or not humans are causing global warming. For example, despite the fact that about 97% of climate scientists have concluded that human-caused climate change is happening (Cook et al., 2016), only about half of Americans believe that climate change is *mostly* caused by human activity (Leiserowitz et al., 2017).

The Gateway Belief Model (GBM) introduced by van der Linden, Leiserowitz, Feinberg, & Maibach (2015) views the public's (mis)perception of the degree of scientific consensus as an influential "gateway" cognition. A growing line of research has emerged evaluating the model's theoretical mechanisms and the National Academy of Sciences (2017) has called for more research on the topic (p. 62). To further advance the literature, we conducted the largest confirmatory replication and extension of the Gateway Belief Model (GBM) to date using a nationally balanced quota sample of the US population (N = 6,301). Before proceeding to the method and analysis, we outline and expand on the history of the model's development below, followed by an assessment of the empirical evidence to date, presentation of method and results, and a discussion of current issues.

2. The Gateway Belief Model

"Should the public come to believe that the scientific issues are settled, their views about global warming will change accordingly. Therefore, you need to continue to make the lack of scientific certainty a primary issue in the debate" – Frank Luntz (2002), political strategist

The GBM captures what political strategists have intuitively understood for decades: the degree to which people perceive science as certain is an important heuristic that informs their personal views. At its core, the Gateway Belief Model (GBM) is a descriptive model in the sense that it describes a *process* of judgment and attitude change (van der Linden et al., 2015). In particular, the model outlines a two-stage sequential mediational process (Figure 1). The first stage involves a "de-biasing" process where highlighting the degree of normative agreement ("scientific consensus") on an issue, such as climate change, influences the public's perception of that consensus. This change in perceived scientific consensus then predicts cascading changes in other key beliefs about the issue, such as the belief that climate change is happening, human-caused, and a worrisome risk that requires societal action.

Notably, a *change* in perceived scientific consensus acts as a "gateway" in the sense that it predicts smaller subsequent changes in personal (private) beliefs and attitudes about climate change (van der Linden et al., 2015). In turn, changes in these central beliefs predict support for public action. In short, the influence of perceived scientific consensus on support for public action emerges *indirectly*, as the causal effect is mostly mediated by changes in key personal beliefs. This is largely a theoretically motivated hypothesis because highlighting scientific consensus is a *non-persuasive* communication: it only conveys the consensus that most climate scientists have concluded that are humans are causing global warming but does not directly speak to solutions or policy-support. Accordingly, information about scientific consensus should mainly have detectable first-order effects on those beliefs that directly relate to the consensus, with relatively weaker second-order effects on constructs that diverge further from the communication (e.g., worry, support for action). Nonetheless, the predictions that flow from the GBM suggest that consensus in one domain (climate science) can serve as a “gateway” (foot-in-the-door) to achieving consensus in other domains (public opinion).

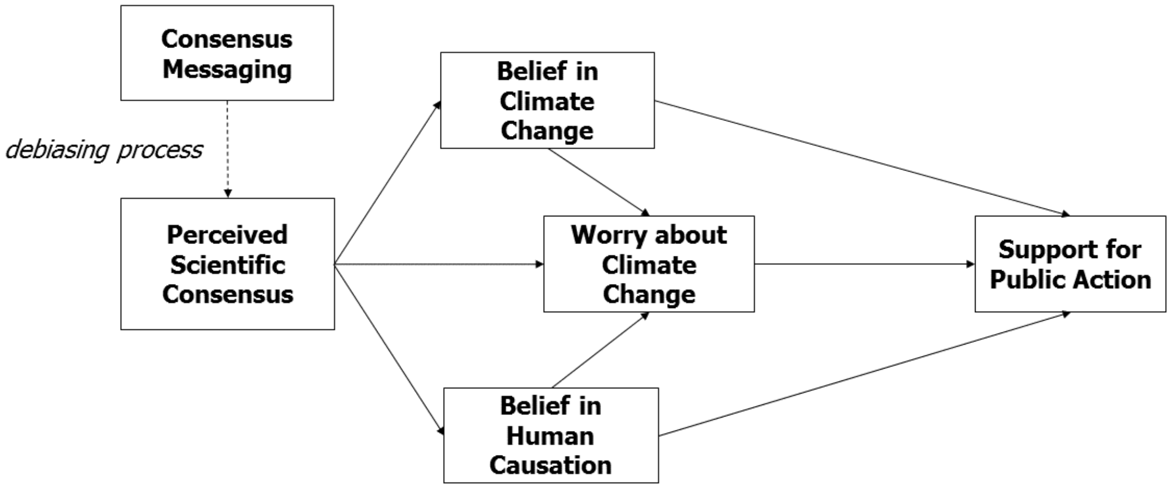

Figure 1. Gateway Belief Model (GBM).

The theoretical structure of the GBM was derived from important earlier correlational work, which independently found that perceptions of scientific agreement are strongly associated to science acceptance and support for climate policy (Ding et al., 2011; Lewandowsky, Gignac, & Vaughan, 2012; McCright, Dunlap, & Xiao, 2013). The GBM combined and validated these relationships experimentally on a national US sample (van der Linden et al., 2015).

At its most generic level, the GBM offers a dual-processing account of judgment formation (Chaiken & Trope, 1999; Evans, 2008; Marx et al., 2007) in the sense that the model combines both cognitive (belief-based) and affective (worry) determinants of public attitudes toward societal issues. To the extent that the left-hand side of the model represents input in the form of a consensus cue, the GBM is consistent with the literature on heuristic information processing (Chaiken, 1980). Because “consensus implies correctness”, people tend to heuristically process consensus cues in the absence of a strong motivation to cognitively elaborate on a message (Darke et al., 1998; Mutz, 1998). For example, when the scientific consensus message is contested (motivating elaboration), its persuasiveness is reduced (Bolsen & Druckman, 2015; van der Linden, Leiserowitz, Rosenthal, & Maibach, 2017). However, it should be noted that no explicit distinction is made between conscious and non-conscious processing because heuristics can be deployed in *both* a reflective and intuitive manner (Todorov, Chaiken, & Henderson, 2002; Gigerenzer & Gaissmaier, 2011).

In fact, reliance on heuristics can sometimes lead to (more) accurate judgments (Gigerenzer & Gaissmaier, 2011). For example, in the face of uncertainty, people often look to experts for guidance (Cialdini, Martin, & Goldstein, 2015) and for good reason: through the law of large numbers (Darke et al., 1998), the consensus-heuristic reduces the cost of individual learning. Research shows that people prefer to rely on the combined judgment of multiple experts (Mannes, Soll, & Larrick, 2014)—a process which improves judgment accuracy by selectively tapping the “wisdom of the crowd” (Budescu & Chen, 2014).

Moreover, although expert consensus is a scientific “fact”, it also has the distinct advantage of being social in nature, as group consensus is typically conveyed as a descriptive norm, i.e. it describes the average level of normative agreement [e.g. 97%] within a referent group (van der Linden et al., 2015) and as such, exerts informational influence (Deutsch & Gerard, 1955; Cialdini et al., 1991). Given the central role that consensus decision-making has played in the evolution of human cooperation (Conradt & Roper, 2005), people are keenly attuned to cues about group consensus. Unfortunately, people frequently misperceive social norms (Tankard & Paluck, 2016). For example, many individuals overestimate the pervasiveness of undesirable health behaviors, such as binge drinking (Prentice & Miller, 1993). Although misperceiving the norm on unhealthy behaviors can be deleterious for the individual, collective misperceptions about the scientific evidence on existential risks such as climate change arguably pose an even greater societal challenge. Importantly, because people have a basic motivation to hold accurate perceptions about the world (Kunda, 1990), biased perceptions of the norm can be corrected, which in turn often leads to subsequent changes in behavior because people want to align their behavior with the norm (Prentice & Miller, 1993; Spear & Haines, 1996; Schultz et al., 2007). Moreover, it is often easier to change people's perception of the norm than it is to change private beliefs, which are more closely linked to deep-rooted ideologies (Tankard & Paluck, 2016). The GBM is premised on the same mechanism: closing the gap between the perceived and actual scientific norm on an issue. This can be done by shifting the central tendency (average) of the perceived norm to a new location (e.g. 97%) and by reducing its perceived variability (conveying high consensus).

3. The State of Empirical Evidence

A growing number of empirical studies have either directly or indirectly investigated the core theoretical mechanisms of the GBM across different domains and cultures using a variety of measures. For example, many studies have found consistent support for the basic finding that providing people with normative cues about the scientific consensus on climate change can reliably shift people's perception and understanding of that consensus (e.g. see Bolsen & Druckman, 2017; Brewer & McKnight, 2017; Cook et al., 2017; Cook & Lewandowsky, 2016; Deryugina & Shurchkov, 2016; Harris et al., 2018; Kerr & Wilson, 2018; Lewandowsky et al., 2013; Myers et al., 2015; van der Linden et al., 2015). Crucially, these findings are not limited to climate change, but also extend to the scientific consensus on vaccines (van der Linden, Clarke, & Maibach, 2015), GMOs (Dixon, 2016; Kerr & Wilson, 2018), the Brexit vote (Harris et al., 2018), nuclear power (Kobayashi, 2018a), and non-politically charged issues (Chinn, Lane, & Hart, 2018; Johnson, 2017).

With respect to the effects on people's private attitudes, evidence in support of the GBM is accumulating. For example, Tom (2017) notes that people inherently value conformity with scientific authority and that the perception of expert consensus could therefore have important effects on an individual's private attitudes. The author confirms this empirically by noting that when it comes to global warming and evolution, perception of a scientific consensus substantially increases the odds of personal acceptance (Tom, 2017; see also Dunwoody & Kohl, 2017). This finding is further bolstered by a recent meta-analysis in which Hornsey et al. (2016) identify perceived scientific consensus as one of the strongest correlates of belief in climate change, stronger than e.g. ideology or cultural worldviews. Conceptual replications of the gateway hypothesis have also offered evidence in support for the model. For example, in their national consensus message experiment on climate change, Bolsen and Druckman (2017) test and confirm the GBM's key mediational hypotheses. Similarly, in the context of climate change and GMOs, Kerr and Wilson (2018) find that consensus messages significantly increased personal agreement and that this increase was in turn mediated by changes in perceptions of a scientific consensus, as predicted by the GBM.

Brewer and McKnight (2017) also evaluate the GBM's mediational predictions in the context of global warming. The authors find that their result "reinforces the argument that consensus messaging can be an effective tool at fostering belief in global warming" (p. 177). Similarly, in a Japanese sample, Kobayashi (2018a) concludes; "*overall, the present research gives empirical support for the idea—the assumption underlying the gateway belief model—that perceived scientific consensus plays a unique role in scientific belief change*" (p. 81).

Yet, support for the GBM has not been unanimous. For example, Kahan (2015) questioned the practical importance of van der Linden et al.'s (2015) mediational hypotheses for the final outcome variable in the model: public support for action. Further, Deryugina and Shurchkov (2016) and Dixon, Hmielowski, and Ma (2017) both find that scientific consensus messages did not directly impact support for climate policy. However, it is important to note that the key hypothesis of the GBM is that any direct effects on the key outcomes variables are expected to be mediated by changes in perceived scientific consensus. Because studies do not always include both type of variables, they cannot reliably adjudicate on this matter. Moreover, detecting a significant indirect effect in the absence of a *total* effect is both common and theoretically justified in psychological research (Hayes, 2009; Rucker et al., 2011; Shrout & Bolger, 2002). Nonetheless, we recognize the applied value of direct effects and a significant main effect on each outcome variable would further strengthen the importance of any subsequent mediation.

A final issue in the GBM revolves around the role of political ideology. Because polarization on climate change has sharply increased over the last decades (Dunlap & McCright, 2016), the extent to which people use scientific consensus as a heuristic cue for informing their own judgments may depend on their ideology and trust in referent groups, such as scientists. Given the concern that climate change campaigns could disengage [conservative] audiences, it is of both theoretical and practical importance to establish whether a backfire effect occurs. For example, the cultural cognition thesis predicts that exposure to the scientific consensus would lead to belief polarization (Kahan, Jenkins-Smith, & Braman, 2010). Yet, in their original studies, van der Linden et al. (2014, 2015) found evidence for an interaction between exposure to the scientific consensus and party affiliation such that Republicans (positively) adjusted their perception of the scientific consensus more than Democrats. This finding is consistent with work by Lewandowsky et al. (2013) and Cook et al. (2017) who both found that highlighting scientific consensus neutralized the effect of free-market ideology on belief in climate change. Similarly, Brewer and McKnight (2017) find greater consensus-effects among those with low environmental interest.

Other studies did not find a significant interaction, but concluded that the scientific consensus message elicited relatively uniform effects across the political spectrum (Bolsen & Druckman, 2017; Deryugina & Shurchkov, 2016; Myers et al., 2015). Regardless of whether the scientific consensus appeals equally well or more to certain groups, what's of particular note is that, with some exceptions (e.g. Cook & Lewandowsky, 2016), these studies jointly provide little to no support for a so-called "polarizing", "backfire", or "boomerang" effect. Indeed, Dixon et al. (2017) state; "It is notable that a backfiring effect among conservatives was not observed" (p. 7). Similarly, Brewer and McKnight (2017) conclude; "*viewers did not engage in motivated reasoning in response to consensus messaging*" (p. 177).

4. Present Study

The main objective of the present study is to provide a confirmatory replication of the Gateway Belief Model (GBM) by van der Linden et al. (2015). We advance the literature in two important aspects. First, the experimental and control groups in the original study were unbalanced, which affects power and interaction effects. In addition, prior studies have only offered partial conceptual replications of the mediational hypotheses posited by the GBM, often using convenience samples. To our knowledge, no study has directly replicated the full GBM (as theorized) using the same variables on a high-powered national sample of U.S. adults (N = 6,301). Second, we extend the original research by evaluating the robustness of the interaction with Party ID across a range of additional and arguably more direct measures, including political ideology and prior attitudes toward climate change. Because our sample is much larger and balanced across experimental groups on political ideology, the current study provides a more robust test of the causal structure of the GBM.

5. Method

5.1 Sample and Procedure

We obtained a large national quota sample (*N* = 6,301) of the US population from Qualtrics LLC, who maintain a panel of over 60 million people in the United States (Qualtrics, Provo, UT). National quotas were included for gender, age, region, education, ethnicity, and political ideology. In addition to approximating U.S. census demographics overall, both the experimental (*n* = 3,150) and control (*n* = 3,151) groups were also each balanced on the same socio-demographic characteristics (please see Supplement for details).

The experiment was conducted online with the Qualtrics survey software using a mixed factorial design, combining *within* (post-pre) as well as *between* (treatment vs. control) subject measures. This design is statistically powerful because it controls for both within and between subject sources of variation (Charness, Gneezy, & Kuhn, 2012). Following van der Linden et al. (2015), respondents were first presented with three randomized blocks of bogus questions about popular media topics (of equal length) to hide the true purpose of the study and to reduce potential demand effects. One block featured questions on new state-level regulations around drunk driving, the other asked people about the Apple watch, and the last block contained the key questions about global warming. Respondents were then (falsely) told that the researchers maintain a large database of media statements and that they would randomly be shown one of these statements (the descriptive norm was always the same, namely that; "*97% of climate scientists have concluded that human-caused global warming is happening*")[1]. Consistent with van der Linden et al. (2015), the control group completed a short neutral word sorting task. After exposure, participants were asked a few unrelated questions about the new Star Wars movie as an additional distraction. We asked the same

[1] We used text instead of the original pie chart as van der Linden et al. (2014) found no difference in format.

questions both at the start (pre-test) and at the end of the survey (post-test) in both groups. The study received ethical approval from Yale University's Institutional Review Board.

5.2 Measures

Perceived Scientific Consensus. Consistent with van der Linden et al. (2015) we measured perceived consensus on a slider scale, ranging from 0% to 100% (*M* = 67.32, SD = 22.26). Participants were asked; "*To the best of your knowledge, what percentage of climate scientists have concluded that human-caused global warming is happening?"*

Belief in Global Warming[2]. "*How strongly do you believe that global warming is or is not happening*?" Response options were given on a continuum (*M* = 5.25, SD = 1.75), ranging from 1 (I strongly believe that global warming is not happening), 4 (I am unsure whether or not global warming is happening) to 7 (I strongly believe global warming IS happening). For subgroup analysis, three prior attitude groups were created using equal thirds of the scale value ($1/3^{rd} * 7$) so that the first group ranges from 0 to 2.33 and so on.[3]

Human-Causation. "*Assuming global warming IS happening: How much of it do you believe is caused by human activities, natural changes in the environment, or a combination of both?"* Response options (*M* = 4.96, SD = 1.61) ranged from 1 (I believe that global warming is caused mostly by natural changes in the environment), 4 (caused equally by natural changes and human activities) to 7 (caused mostly by human activities).

Worry about Global Warming. On a scale from 1 to 7 (*M* = 4.70, SD = 1.82), "*How worried are you about global warming?"* Response options ranged from 1 (I am not at all worried about global warming), 4 (neutral) to 7 (I am very worried about global warming).

[2] For the remaining measures, we made one change in contrast to van der Linden et al. (2015): instead of 0-100 scales we adopted 7-point scales to facilitate more straightforward comparisons with other research.

[3] Results are entirely robust to whether tertiles are used based on the distribution of the data or scale groupings.

Support for Action on Global Warming. On a scale from 1 to 7 (M = 5.46, SD = 1.55), *"Do you think people should be doing more or less to reduce climate change?"* Responses ranged from 1 (Much less), 4 (Same amount) to 7 (Much more).

Political Party and Ideology. We assessed ideology on a 5-point scale (very conservative, conservative, moderate, liberal, very liberal, M = 2.85, SD = 1.12) as well as political party affiliation (Republican, Democrat, Independent). For mediation analyses, political ideology was recoded so that higher scores reflect greater conservatism.

6. Results

We start with an overview of the main effects of the consensus treatment (vs. control) on changes (post-pre) in each of the dependent variables. Following a significant MANOVA on the five dependent variables, $F(5, 6295) = 246.02$, $p < 0.001$, Wilk's $\Lambda = 0.84$, univariate t-tests (revised $\alpha = 0.01$) indicated a significant main effect of the consensus treatment on all key dependent variables ($p < 0.001$). Results comparing change scores across conditions are listed in Table 1 and visualized in Figures 2-3. As expected, there is a large initial effect on perceived scientific consensus ($d = 0.88$), followed by significant effects on the belief that global warming is happening ($d = 0.14$), human-caused ($d = 0.23$), how much people worry about the issue ($d = 0.11$) and whether they support more public action ($d = 0.09$).

The pattern of main effects is consistent with the general observation that effect-sizes decrease in size as a function of how distal the variable is to the (consensus) treatment. We further investigated the main effect of the treatment ($M_{diff} = 16.81$, SE = 0.40) on perceived scientific consensus by political ideology, party identification, and prior belief in global warming (visualized in Figure 3). As can be observed from the trends in Figure 3, a between-subjects ANOVA on the post-pre difference score revealed a significant main effect and interaction pattern across all measures of ideology, party ID, and prior attitudes such that the effect of the experimental treatment on perceived scientific consensus $F(1, 6{,}299) = 1224.34$, MSE = 337.46, $p < 0.001$, $\eta^2 = 0.16$ (main effect), is stronger for conservatives $F(2, 6{,}295) = 11.63$, MSE = 334.90, $p < 0.001$, $\eta^2 = 0.004$ (interaction), Republicans $F(2, 5{,}187) = 16.25$, MSE = 328.72, $p < 0.001$, $\eta^2 = 0.006$ (interaction), and those with lower prior belief in global warming $F(2, 6{,}295) = 35.52$, MSE = 329.64, $p < 0.001$, $\eta^2 = 0.01$ (interaction). Notably, this interaction did not reliably occur for any of the other personal belief variables (all *p*s> 0.30). Separate plots of the pre and post test means for each group similarly reveal that the greatest gains (relative to baseline) occur for conservatives (please see Supplementary Figures 1-4).

Table 1. Main Effects of Consensus Message on Key Dependent Variables.

Dependent variables (*N* = 6,301)	Consensus Treatment Δ Post-Pre (*n* = 3,150)	Control Group Δ Post-Pre (*n* = 3,151)	Cohen's *d* 95% CI	BF_{10}
Perceived Scientific Consensus (0% - 100%)	**16.81***** (16.03, 17.59)	0.62 (0.15, 1.08)	0.88 (0.83, 0.93)	1.07e+241
Belief GW is Happening (1-7)	**0.21***** (0.18, 0.25)	0.08 (0.05, 0.11)	0.14 (0.09, 0.19)	252,765
Belief GW is Human-Caused (1-7)	**0.27***** (0.24, 0.30)	0.07 (0.04, 0.10)	0.23 (0.18, 0.28)	6.70e+15
Worry about Global warming (1-7)	**0.28***** (0.25, 0.31)	0.18 (0.16, 0.21)	0.11 (0.06, 0.16)	628.90
Support for Public Action (1-7)	**0.11***** (0.08, 0.14)	0.03 (0.00, 0.06)	0.09 (0.04, 0.14)	13.07

Note: 95% confidence intervals in parentheses. All mean comparisons significant at $^{***}p < 0.001$ (bold face). Cohen's *d* is a standardized measure of effect size (Cohen, 1988). Bayes factors between 10 and 30 are considered "strong evidence" while values > 30 indicate very strong evidence (Kruschke & Liddell, 2018).

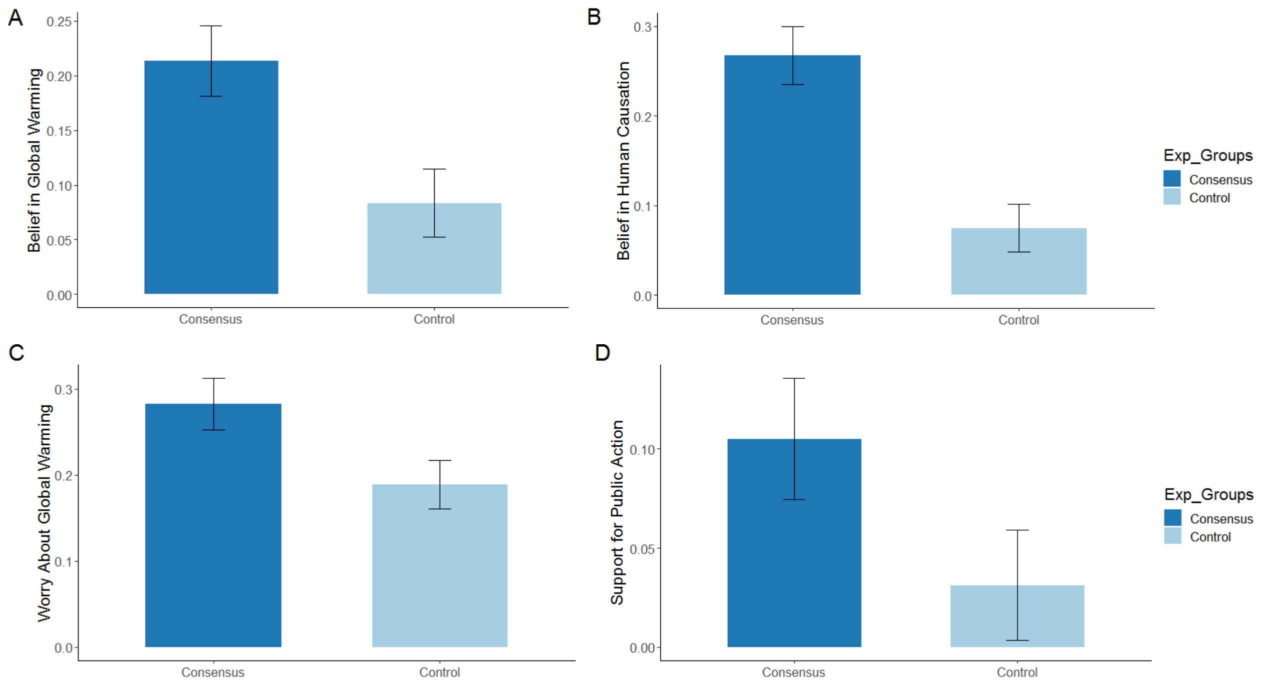

Figure 2. Main effects (post-pre) by experimental condition for belief that global warming is happening (panel A), human-caused (panel B), worry (C), and support for public action (D).

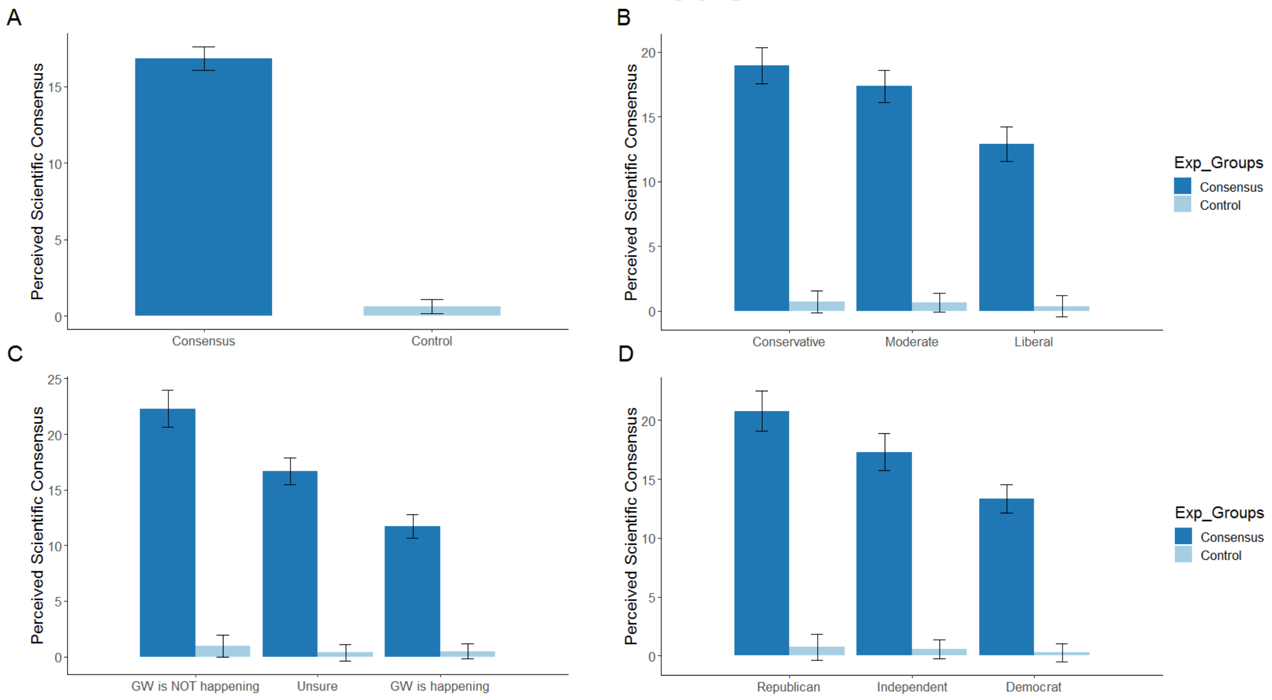

Figure 3. Main effect (post-pre) on perceived scientific consensus (0%-100%) in percentage points (panel A) by political ideology (panel B), prior attitudes toward GW (panel C), and Party ID (panel D). Sample sizes for political ideology; conservative (*n* = 2,258), moderate (*n* = 2,470) and liberal (*n* = 1,573), prior attitude; GW is not happening (*n* = 645), unsure (*n* = 1,395) and GW is happening (*n* = 4,261), political party ID; Republican (*n* = 1,491), Democrat (*n* = 2,076), and Independent (*n* = 1,626).

Having established significant main effects on all mediating and outcome variables, we proceed with replicating the GBM path relationships in the Structural Equation Model (SEM) outlined by van der Linden et al. (2015) using the same variables and model specification. All mediation analyses were conducted in STATA 14.2's SEM module (StataCorp, 2015) using maximum likelihood estimation. It is important to note that although mediation models are frequently estimated on observational data (Stone-Romero et al., 2018), all variables in the model represent post-pre differences in beliefs *conditional* on experimental assignment, which allows for stronger conclusions about causal mediation (Bullock et al., 2010).

Main results are visually displayed in Figure 4 and indicate good model fit and confirm significant direct effects for all path relationships in the model. The breakdowns of all indirect, direct, and total effects are listed in Tables 2-3. In general, the pattern of results is consistent with the model reported by van der Linden et al. (2015): an experimentally induced change in perceived scientific consensus significantly predicts post-pre changes in the belief that climate change is happening, human-caused, and a worrisome threat. In turn, changes in these key cognitions and emotions predict greater support for public action.

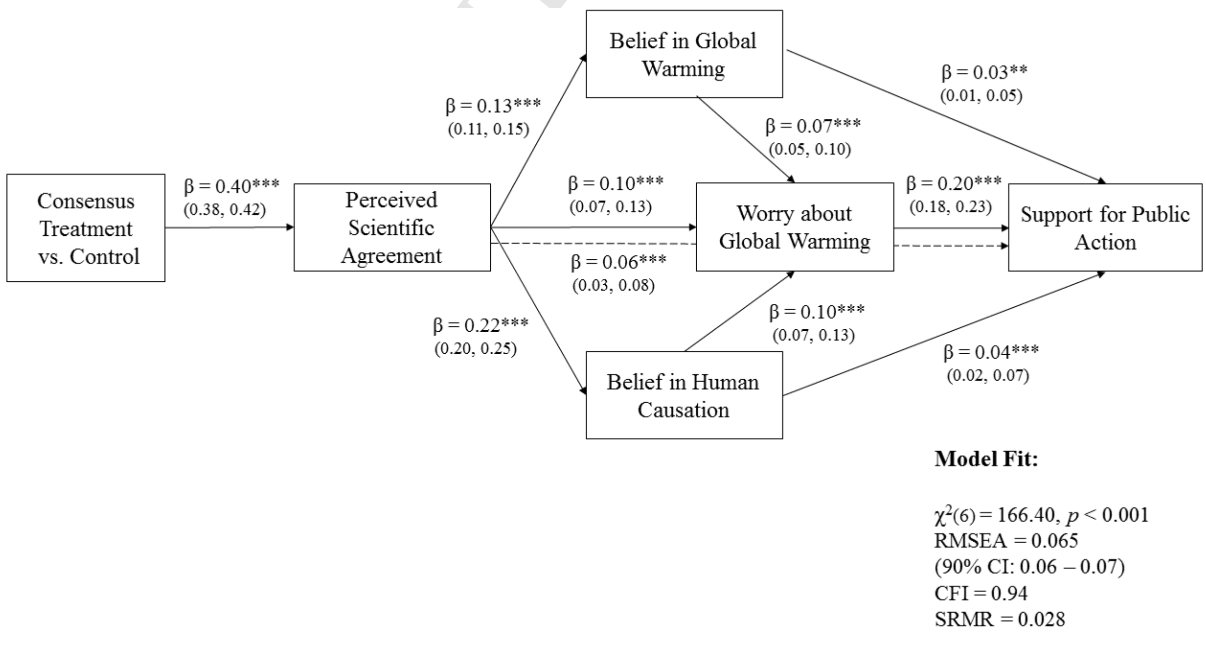

Figure 4. Gateway Belief Model (GBM). *Note*: Coefficients are standardized and 95% confidence intervals are provided in parentheses. N = 6,301. $^{***}p$< 0.001, $^{**}p$<0.01.

For ease of interpretation, the direct paths between experimental assignment and all other variables in the model are non-significant (all *p*s > 0.11) and not visually depicted. In other words, the GBM is a two-stage sequential mediation model: the effect of experimental condition on all cognitive and affective judgments is fully mediated by the large initial changes in PSC (stage 1). In turn, the effect of higher PSC on support for public action is mediated by smaller subsequent changes in key personal beliefs (stage 2)[4]. Although van der Linden et al. (2015) reported full mediation in their original study, it is noteworthy that in addition to a significant indirect effect (β = 0.04, 95%CI; 0.03, 0.05, Table 2), a significant direct effect of PSC on public support for action remains (dotted lines), even when controlling for all key personal beliefs in the model (β = 0.06, 95%CI; 0.03, 0.08, Table 3).

Lastly, we investigated the role of political ideology. Although van der Linden et al. (2015) reported an exploratory interaction between ideology and the consensus treatment (on PSC), they did not explore the possibility of cascading indirect effects. As shown in Figure 4, we reliably replicated this interaction, finding that after exposure to the scientific consensus message, conservatives show greater changes in perceived consensus than liberals. When both ideology and an interaction between ideology and condition are included in the model[5], the direct effect of the interaction on perceived consensus is significant (β = 0.05, 95% CI; 0.03, 0.07). Importantly, there are also smaller, but significant indirect effects flowing from the interaction to all key beliefs, including support for public action (Table 4). The interaction did not have a significant direct effect on any other variable in the model (all *p*s > 0.18).

[4] The coefficients are not influenced by the inclusion of covariates (gender, age, education, ideology).
[5] All variables are observed and the interaction was standardized before entered into the mediation model.

Table 2. SEM model parameters (direct and total effects)

Model path relationships	β_{direct}	**95% C.I.**	β_{total}	**95% C.I.**
Condition → PSC	0.40	0.38, 0.42	0.40	0.38, 0.42
PSC → Belief in GW	0.13	0.11, 0.15	0.13	0.11, 0.15
PSC → Belief in HC	0.22	0.20, 0.25	0.22	0.20, 0.25
PSC → Worry	0.10	0.07, 0.13	0.13	0.11, 0.16
Belief in GW → Worry	0.07	0.05, 0.10	0.07	0.05, 0.10
Belief in HC → Worry	0.10	0.07, 0.13	0.10	0.07, 0.13
PSC → Public Action	0.06	0.03, 0.08	0.10	0.07, 0.12
Belief in GW → Public Action	0.03	0.01, 0.05	0.04	0.02, 0.06
Belief in HC → Public Action	0.04	0.02, 0.07	0.06	0.04, 0.09
Worry → Public Action	0.20	0.18, 0.23	0.20	0.18, 0.23

Note: PSC = Perceived Scientific Consensus; GW = Global Warming; HC = Human Causation; standardized regression coefficients. N = 6,301.

Table 3. SEM model parameters (indirect effects of PSC and condition)

Model path relationships	**β**	**95% C.I.**
Condition → Belief in GW	0.05	0.04, 0.06
Condition → Belief in HC	0.09	0.08, 0.19
Condition → Worry	0.05	0.04, 0.06
Condition → Public Action	0.04	0.03, 0.05
PSC → Public Action	0.04	0.03, 0.05
Belief in GW → Public Action	0.01	0.01, 0.02
Belief in HC → Public Action	0.02	0.01, 0.03

Note: Condition = consensus message (vs. control), PSC = Perceived Scientific Consensus; GW = Global Warming; HC = Human Causation; standardized regression coefficients. *N* = 6,301. Indirect effects ran through multiple mediators.

Table 4. SEM model parameters (with ideology)

Model path relationships	β_{direct}	**95% C.I.**	$\beta_{indirect\ of\ PSC}$	**95% C.I.**
ID*condition → PSC	0.05	0.03, 0.07		-
ID*condition → Belief in GW	0.01	-0.01, 0.03	0.007	0.003, 0.010
ID*condition → Belief in HC	-0.01	-0.04, 0.01	0.011	0.006, 0.016
ID*condition → Worry	-0.02	-0.05, 0.01	0.007	0.003, 0.001
ID*condition → Public Action	-0.01	-0.03, 0.01	0.005	0.002, 0.007

Note: ID = political ideology (conservative), condition = consensus message, PSC = Perceived Scientific Consensus; GW = Global Warming; HC = Human Causation; standardized regression coefficients. *N* = 6,301. The indirect effects are for the ID*condition → PSC path (on all other variables in the model).

7. Discussion

The current research makes at least two interrelated contributions to the literature. First, in contrast to partial mediation tests, we conducted a direct confirmatory replication of the GBM by van der Linden et al. (2015) using a large, high-powered, and balanced national sample. This is important because separate partial mediation tests conducted on non-representative (observational) data can inflate Type 1 and 2 errors (van der Linden, Leiserowitz, & Maibach, 2018). This also allowed us to extend theoretical development of the Gateway Belief Model and address several key criticisms. Second, we extend prior research by investigating the consistency of interaction effects between perceived scientific consensus, Party ID, political ideology, and prior attitudes towards global warming.

7.1 *Replicating the Gateway Belief Model (GBM)*

In terms of model specification, all path relationships were significant and the model did not need any modifications to achieve good model fit. The low “lack of fit” (e.g. RMSEA) and high “goodness of fit” (e.g. CFI) indices were identical if not descriptively better than in the original study, providing further evidence for the robust nature of the theorized causal relationships as identified by key prior research on this topic (Ding et al., 2011; McCright et al., 2013; van der Linden et al., 2015). Another point of consistency between van der Linden et al. (2015) and the current model is that while both processes are influenced by perceived scientific consensus, affective judgments (worry) appear more influential than cognitive judgments (e.g. the belief that global warming is happening and human-caused) in driving public support for action. Importantly, this finding is consistent with a large literature on “risk as feelings” vs. “risk as analysis” (Slovic et al., 2004) and the role of emotion (worry) in global warming policy support specifically (Smith & Leiserowitz, 2014).

Yet, one primary difference between the original study and the current replication is the significant direct effect of perceived scientific consensus on support for public action in the mediation model. The source of this difference is likely due to the fact that this consensus experiment had significantly stronger main effects on all key personal belief variables, including support for action (which was partially but not fully mediated by the inclusion of PSC). This finding strengthens the conceptual link between perceived scientific consensus and support for action. Moreover, because the effect-sizes decrease in size the further the construct is removed from the consensus statement, prior research may have had insufficient power to detect these substantially smaller direct effects (Rucker et al., 2011). Another interesting point of difference is that the current study used the term “global warming” whereas van der Linden et al. (2015) used “climate change”. On one hand, given the well-established effects of labeling on public perception (Schuldt, 2016), we acknowledge that framing effects could influence the results. On the other hand, it is encouraging that wording differences did not seem to influence key findings. In fact, our model can be regarded as a conservative test given that the public is known to perceive greater scientific consensus when the term “climate change” is used vs. “global warming” (Schuldt, Roh, & Schwarz, 2015).

7.2 *Consensus neutralizes conflict: A non-identity threating cognition*

We advance two potential explanations for the interaction between ideology and exposure to the scientific consensus message. First, the rate of belief change could be explained by a potential ceiling effect among liberals given their relatively higher baseline perceptions of the consensus (76% vs. 62%). However, this doesn’t explain the motivational incentive for conservatives to update their beliefs in light of strong political polarization. Accordingly, we theorize that expert consensus-perceptions (perceptions of what other, non-political groups believe) are a non-identity threatening cognition. In other words, it is easier to change perceptions of what scientists believe than it is to overhaul one's ideological worldview, given the stability of ideology over the lifespan (Sears & Funk, 1999). Indeed, people's willingness to update their beliefs about what other people believe, otherwise known as "meta" or "second-order" climate beliefs has been underestimated (Mildenberger & Tingley, 2017; van Boven et al., 2018), presumably because such beliefs are less threatening and can serve as a "gateway" to changing other beliefs. Moreover, in the long-term, changing norms is important in itself because changes in perceived norms represent shifts in people's understanding of society and its overall direction (Tankard & Paluck, 2016).

In addition, conservatives are unlikely to take cues from liberals on politically polarized issues and vice versa. In other words, the intergroup nature of the climate change conflict calls for neutral mediators (Pearson & Schuldt, 2018; Swim & Bloodhart, 2018). Scientists are one referent group that, on average, are trusted sources of information about global warming (Leiserowitz et al., 2013) and a majority of the US public regard scientists as ideologically-neutral (Pew, 2015b). Importantly, consistent with other research (Frimer, Gaucher, & Schaefer, 2014), this study finds that both groups are willing to conform to ideologically-neutral outgroups (experts). Although conservatives are known to value obedience to authority more than liberals (Jost et al., 2018), this relationship may be mediated by known partisan differences around trust in climate scientists (Kennedy & Funk, 2016). Accordingly, it is likely that conservatives would be even more receptive if the scientific consensus was presented by a prototypical in-group member (e.g. Benegal & Scruggs, 2018).

Second, Krosnick and Macinnis (2015) argue that selective exposure to different media content could play a bigger role in accounting for the divergence in Americans views on global warming than motivated reasoning. In other words, perhaps conservatives are just less familiar with the scientific consensus. This is not implausible given that for decades, vested-interest groups have orchestrated influential disinformation campaigns to purposefully cast doubt on the reality of human-caused global warming (Elsasser & Dunlap, 2013; Oreskes & Conway, 2010; Cook et al., 2018). This hypothesis is corroborated by evidence that the knowlede gap about the scientific consensus—although high in general—is substantially higher among conservatives (Leiserowitz et al., 2017). Importantly, experimental research finds that both false media balance and misinformation can easily neutralize and distort people's perception of expert consensus (Bolsen & Druckman, 2018; Cook et al., 2017; Koehler, 2016; van der Linden et al., 2017). This is consequential because higher domain knowledge is known to reduce ideological biases (Guy et al, 2014). In short, the observed interaction is likely the result of both selective exposure and the fact that updating second-order normative beliefs is psychologically less threatening.

7.3 *The consensus-heuristic: Accuracy vs. motivated reasoning*

At a more general level, our findings contribute to a growing literature which shows that people use consensus cues as a heuristic to help form judgments about whether or not the position advocated in a communication is valid (Darke et al., 1998; Cialdini et al., 1991; Lewandowsky et al., 2013; Panagopoulos & Harrison, 2016; Mutz, 1998; Schultz et al., 2007). The current results are especially interesting because the persuasive power of scientific consensus benefits from two heuristics in that "consensus implies correctness" *and* "statements from experts can be trusted" (Chaiken, Liberman, & Eagly, 1989; Cialdini et al., 2015). In other words, when it comes to social norms, there can be a clear divergence between "going along *vs*. getting it right" (Chenn et al., 1996). Yet, in the case of expert consensus both motivations are satisfied, as going along with the (expert) crowd also offers a higher likelihood of getting it right (Budescu & Chen, 2014; Cook et al., 2018; Mannes, Soll, & Larrick, 2014). Neurological research even finds that people experience reward-signals when they learn that they are in agreement with experts (Campbell-Meiklejohn et al., 2010).

At the same time, defense-motivations can lead people to selectively deploy heuristics in a way that is congenial to their prior attitudes (Chen et al., 1996; van der Linden et al., 2017). In fact, a large literature in social and political psychology shows people selectively attend to evidence, assimilate information in a way that reinforces prior beliefs, and are motivated to reject information that threatens their worldviews (Bolsen & Druckman, 2014; Hart & Nisbet, 2012; Lewandowsky & Oberauer, 2016; Lord, Ross, & Lepper, 1979; Kahan, 2015; Kunda, 1990; Nickerson, 1998; Flynn, Nyhan, & Reifler, 2017; Taber & Lodge, 2006).

Importantly, however, in a large national sample, the current study finds no support for the belief polarization claim (Kahan et al., 2010), as the opinions of conservatives, liberals, and those with skeptical and supportive prior attitudes all converged towards the scientific consensus. In fact, exposure to the scientific consensus interacted positively with political ideology (conservativsm), including indirect effects on personal attitudes and support for action. These findings are consistent with a growing literature on consensus messaging (Brewer & McKnight et al., 2017; Cook et al., 2017; Lewandowsky et al., 2013 van der Linden et al., 2017), including more mixed cases where studies do not find evidence of a “boomerang”, “backfire” or “polarization” effect (Bolsen & Druckman, 2017; Dixon et al., 2017; Kobayashi, 2018b; Kerr & Wilson, 2018; Myers et al., 2012). This is not to say that there are no exceptions (e.g., see Cook & Lewandowsky, 2016) or that people do not engage in politically motivated reasoning. However, studies increasingly find that true belief polarization is a relatively rare phenomenon (Guess & Coppock, in press; Kuhn & Lao, 1996; Kobayashi, 2018b). Even Lee Ross (2012) commented on partisan motivated reasoning theories, suggesting that “we cannot assume that people persist in their views simply because of some emotional attachment to them” (p. 241). Indeed, motivated reasoning has a limit (Redlawsk et al., 2010) and the relative importance of accuracy versus directional goals is context dependent (Flyn, Nyhan, & Reifler, 2017). For example, a recent study investigating corrections across 52 political issues found no evidence of belief polarization (Wood & Porter, 2018). The authors conclude: "by and large, citizens heed factual information, even when such information challenges their ideological commitments" (p. 1). As such, our findings have important implications for more nuanced and contextualized debates about the role of accuracy and defense motivation in reasoning about evidence.

7.4 *Practical implications and future research*

Dixon (2016) correctly notes that important questions remain about how to best apply the Gateway Belief Model (GBM). For example, even if perceived scientific consensus acts as a gateway cognition, one might wonder about the practical importance of the cascading direct and indirect effects on personal attitudes and support for public action (Kahan, 2015; Kerr & Wilson, 2018). We outline three arguments in favor of the practical importance of the GBM.

Purely in terms of effect-sizes, the experimental main effects on the second-order variables (i.e. personal beliefs and support for public action) can be considered small (Cohen, 1988). Yet, it should be noted that, contextually, they are average and lie between the 50^{th} and 75^{th} percentile of all effects in media and persuasion research (Weber & Popova, 2012). Considering that the scientific consensus message does not specifically target worry or support for action, this could be considered impressive. The initial effect on perceived consensus (d = 0.88) is large and lies above the 95^{th} percentile of effect-sizes in media and persuasion psychology research (Weber & Popova, 2012). Furthermore, small effects can be considered meaningful, especially when a) the experimental manipulation is minimal and b) the dependent variable is difficult to influence (Prentice & Miller, 1992). We maintain that both of these conditions are satisfied here as the experimental manipulation is extremely minimal and public opinion on climate change (let alone policy-support) is notoriously difficult to change (Gifford, 2011). Moreover, as Kahan and Braman (2003) note, small effects matter when scaled at population level; "*individual opinions influence political outcomes through aggregation. Even a modest amount of variation in opinion across individuals will profoundly influence collective deliberations*" (p. 1406). To contextualize this, a *d* of 0.15 roughly translates to a change in public support from 50% to 54%—recent elections have hung on less (e.g. Brexit 51.9% vs. 48.1%).

One could counter-argue that although the scientific consensus on global warming has been around for decades, little has happened (Kahan, 2015). Yet, this point a) ignores experimental evidence on the potent role of misinformation in neutralizing the effect of the scientific consensus (Aklin & Urpelainen, 2014; Cook et al., 2017; van der Linden et al., 2017) and b) is contradicted by evidence that public perceptions of the scientific consensus and corresponding beliefs that climate change is human-caused have been increasing since 2010 while polarization on these beliefs has decreased (Cook et al., 2018; Hamilton, 2016).

A final critique concerns the fact that the GBM is not sensitive to individual differences. Yet, the extent to which it is useful to consider individual differences in the GBM remains unclear. For example, the interaction between ideology and the scientific consensus may not generalize across all issues (c.f., Dixon, 2016; van der Linden, Clarke, & Maibach, 2015). Similarly, it could be argued that the effects may be conditional on trust in climate scientists given the important role of trust (Harris et al., 2018), yet research to date has not found that inclusion of trust, perceived credibility of scientists, or deference to scientific authority produces meaningful moderation effects in the GBM (Chinn et al., 2018; Dixon, 2016; Kobayashi, 2018a). Furthermore, as a general rule, it should be illustrated that making the model substantially more complex by adding individual difference moderators is worth the trade-off by corresponding increases in model fit, explanatory, or predictive power.

Lastly, although the measures adopted here have been used in prior research, we acknowledge the limitations of using single-items as measurement constructs. In particular, we note that our conceptualization of support for public action is broad-stroke and future work on the GBM would benefit from measuring personal engagement and support for more specific climate change mitigation policies (e.g. see Ding et al., 2011). We encourage future research to improve the ecological validity of consensus message experiments, for example, by contextualizing the scientific consensus within politicized debates (Bolsen & Druckman, 2015; Cook et al., 2017; van der Linden et al., 2017), by modelling the decay of the consensus effect over time, and by examining geographical variation in scientific belief change (Zhang et al., 2018). Lastly, our mediation model is guided by prior and replicated theoretical relationships that provide a good fit to the data and we demonstrate causal effects of the consensus treatment on all key mediators and outcome variables. However, we still cannot fully ascertain a temporal chain where cascading changes in key beliefs (M) *cause* higher support for public action (Y) as separate experiments would need to be conducted to independently manipulate the $M \rightarrow Y$ paths (Stone-Romero et al., 2008). Accordingly, we encourage future research to validate the predictions of the GBM in real-world field settings.

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Supplementary Information for

The Gateway Belief Model: A Large-Scale Replication and Extension

1. Supplementary Tables

Supplementary Table 1: Sample Characteristics

Demographics	*Control (p)*	*Treatment (p)*	*Total (p)*
Gender			
Male	0.45	0.46	0.46
Female	0.55	0.54	0.54
Age			
18-24	0.14	0.14	0.14
25-34	0.22	0.23	0.22
35-44	0.16	0.16	0.16
45-64	0.34	0.35	0.34
65 +	0.14	0.14	0.14
Education			
Less than high school	0.05	0.05	0.05
High school graduate	0.32	0.33	0.33
Some college	0.33	0.32	0.32
Bachelor's degree	0.18	0.18	0.18
Graduate or higher	0.12	0.12	0.12
Ethnicity			
Black, non-Hispanic	0.08	0.09	0.09
White, non-Hispanic	0.73	0.72	0.73
Hispanic	0.12	0.12	0.12
Other, non-Hispanic	0.07	0.07	0.07
Political Ideology			
Very conservative	0.13	0.13	0.13
Somewhat conservative	0.23	0.22	0.23
Moderate	0.38	0.40	0.39
Somewhat liberal	0.16	0.16	0.16
Very liberal	0.09	0.09	0.09
Region			
Northeast	0.19	0.19	0.19
Midwest	0.22	0.22	0.22
South	0.37	0.37	0.37
West	0.22	0.22	0.22

Note: Proportion of respondents in each category in the treatment and control groups and overall sample, respectively. Balance tests indicate no statistically significant differences between the two groups (*ps* > .5).

Supplementary Table 2: Descriptive Statistics of Key Measures (by Condition)

Descriptive statistics	Pre-test Control	Pre-test Treatment	Sample Overall
Perceived scientific consensus	67.02 (66.24, 67.80)	67.62 (66.84, 68.39)	67.32 (66.77, 67.87)
Belief in climate change	5.21 (5.15, 5.28)	5.29 (5.23, 5.35)	5.25 (5.21, 5.30)
Belief in human causation	4.95 (4.89, 5.00)	4.97 (4.92, 5.03)	4.96 (4.92, 5.00)
Worry about climate change	4.66 (4.60, 4.73)	4.74 (4.68, 4.81)	4.70 (4.66, 4.75)
Support for public action	5.44 (5.39, 5.50)	5.48 (5.43, 5.53)	5.46 (5.42, 5.50)

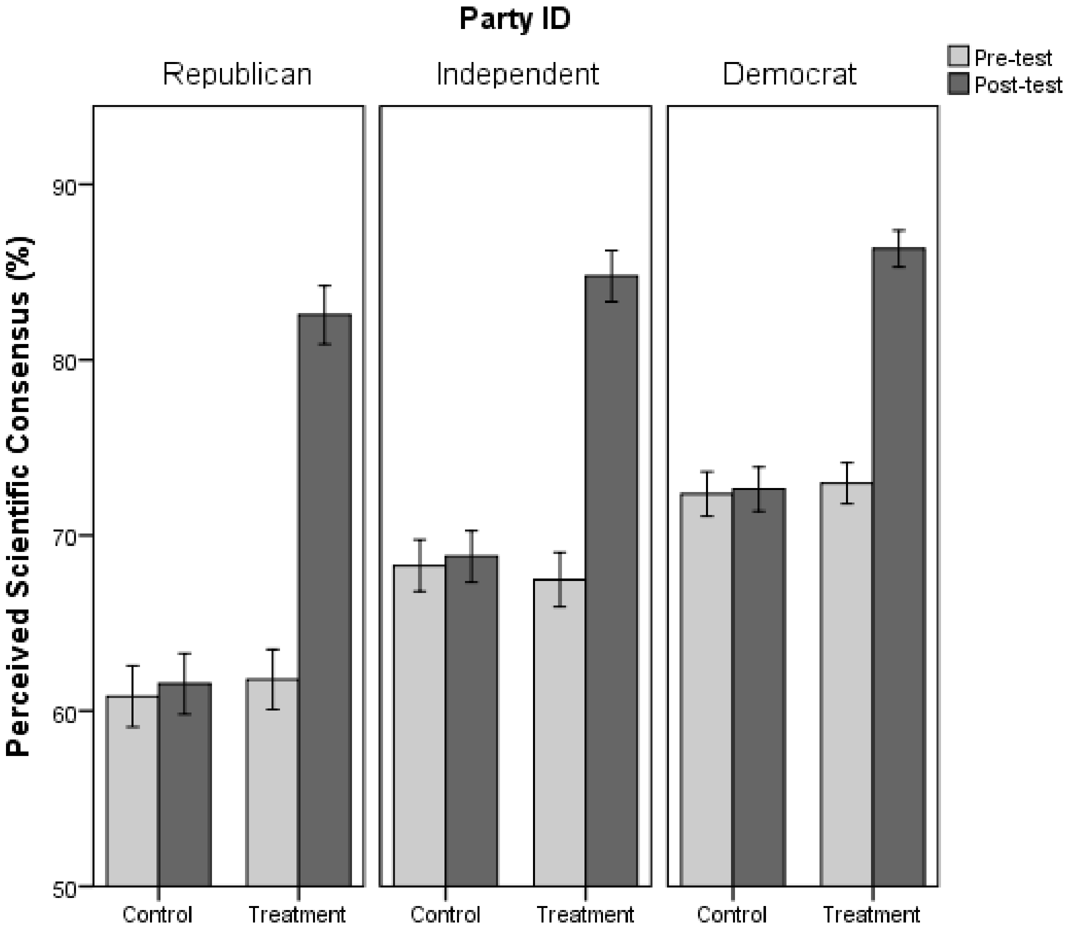
Note: Balance tests indicate no significant pre-test differences between the treatment and control conditions on any of the key mediator or outcome variables (*ps*> 0.27). The largest standardized difference is 0.045 (worry). The 95% (overlapping) confidence intervals are provided in parentheses. N = 6,301 (n = 3,151 control).

Supplementary Table 3: Intercorrelations of the difference scores (post-pre)

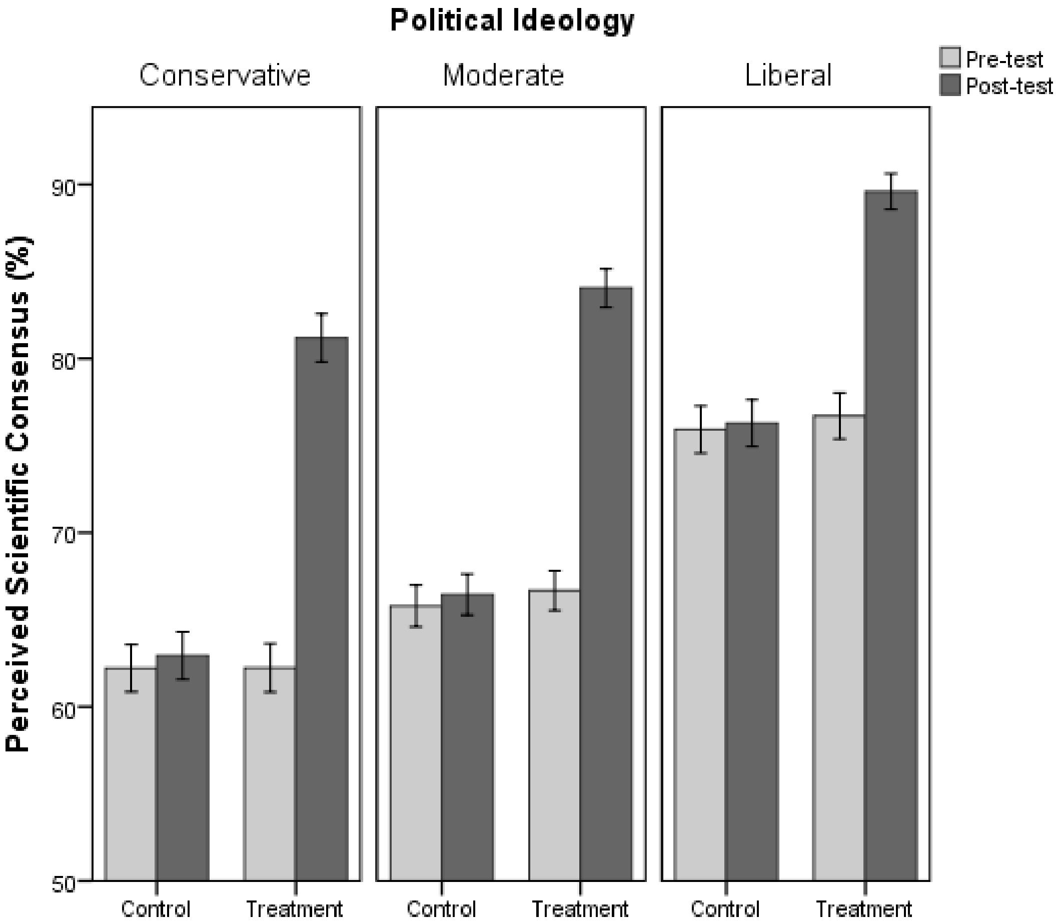
		1.	2.	3.	4.	5.
1.	Δ Perceived Scientific Consensus	-				
2.	Δ Belief in Climate Change	0.13***	-			
3.	Δ Belief in Human Causation	0.23***	0.17***	-		
4.	Δ Worry about Climate Change	0.13***	0.11***	0.14***	-	
5.	Δ Support for Public Action	0.10***	0.06***	0.09***	0.22***	-

Note: Difference scores were computed by subtracting the pre-test from the post-treatment score for each of the given variables. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Supplementary Figure 1: Pre and Post-test scores by Condition and Party ID

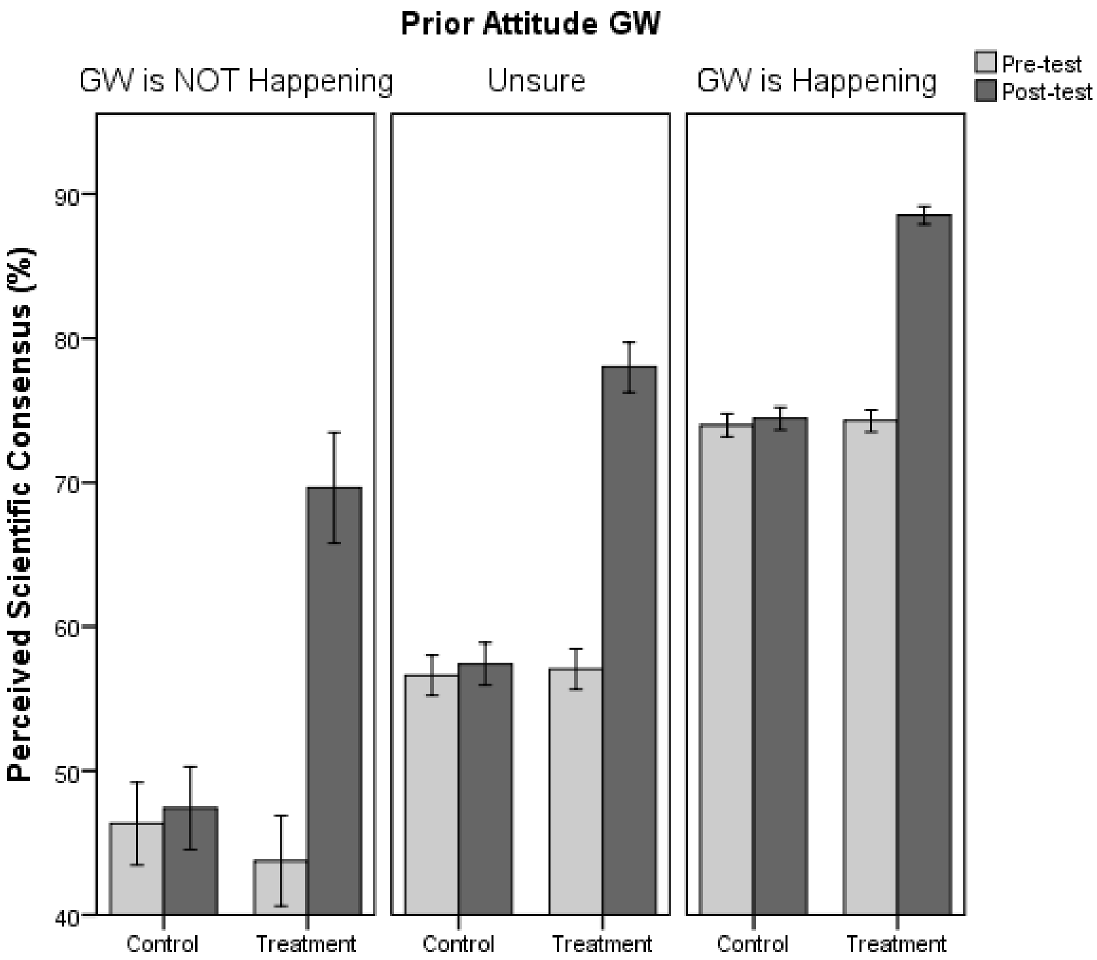


Supplementary Figure 2: Pre and Post-test scores by Condition and Ideology

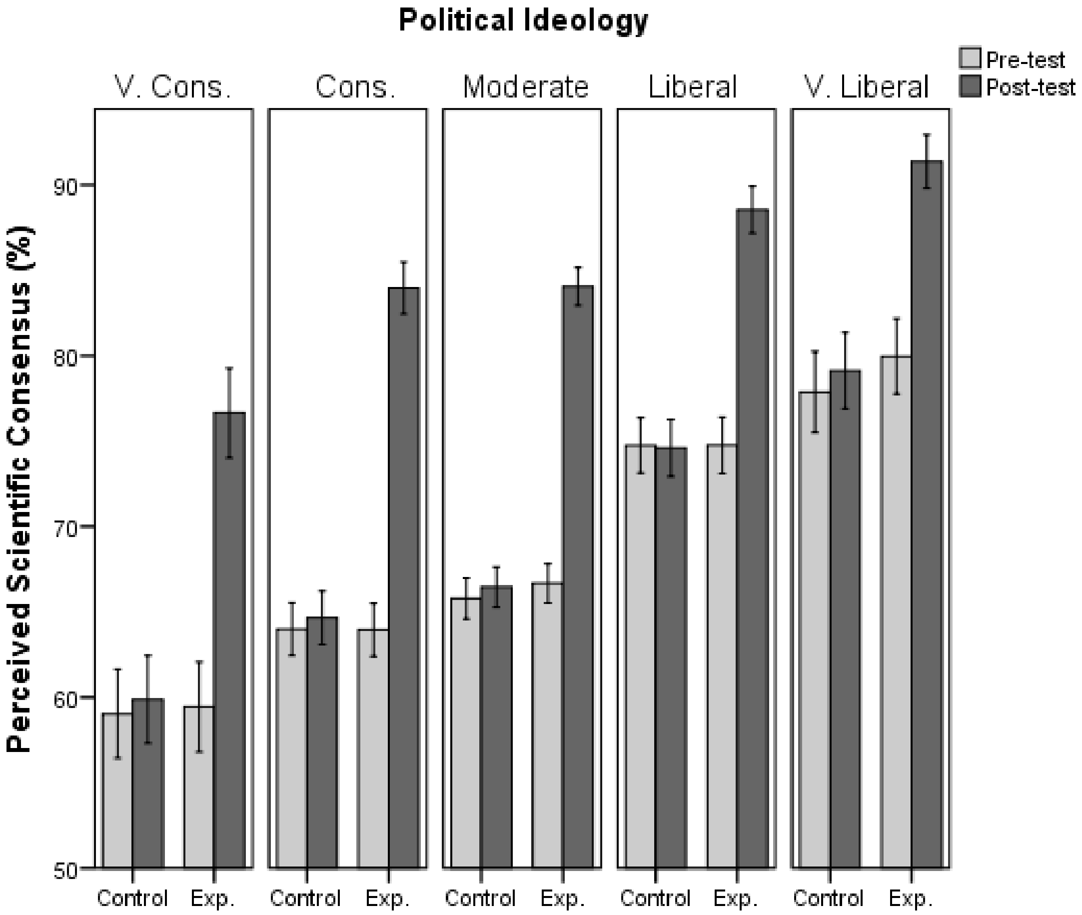


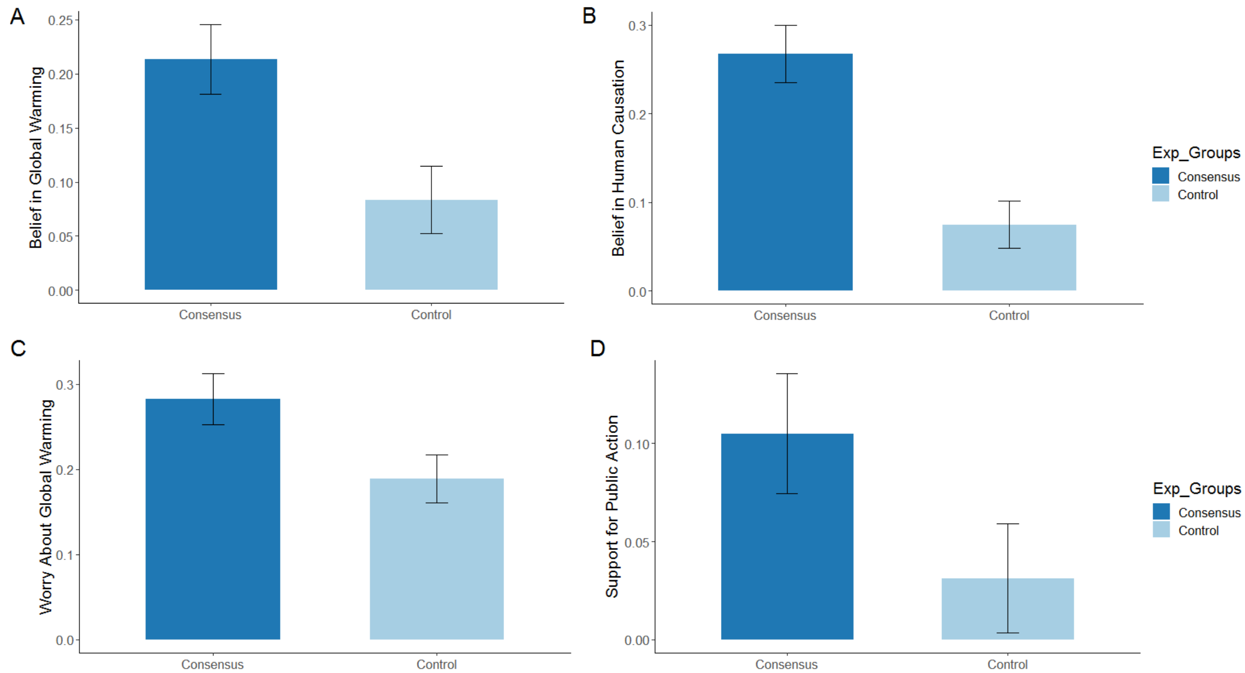
Political Ideology
Conservative
Moderate
Liberal
Pre-test
Post-test
Perceived Scientific Consensus (%)
90
80
70
60
50
Control
Treatment
Control
Treatment
Control
Treatment

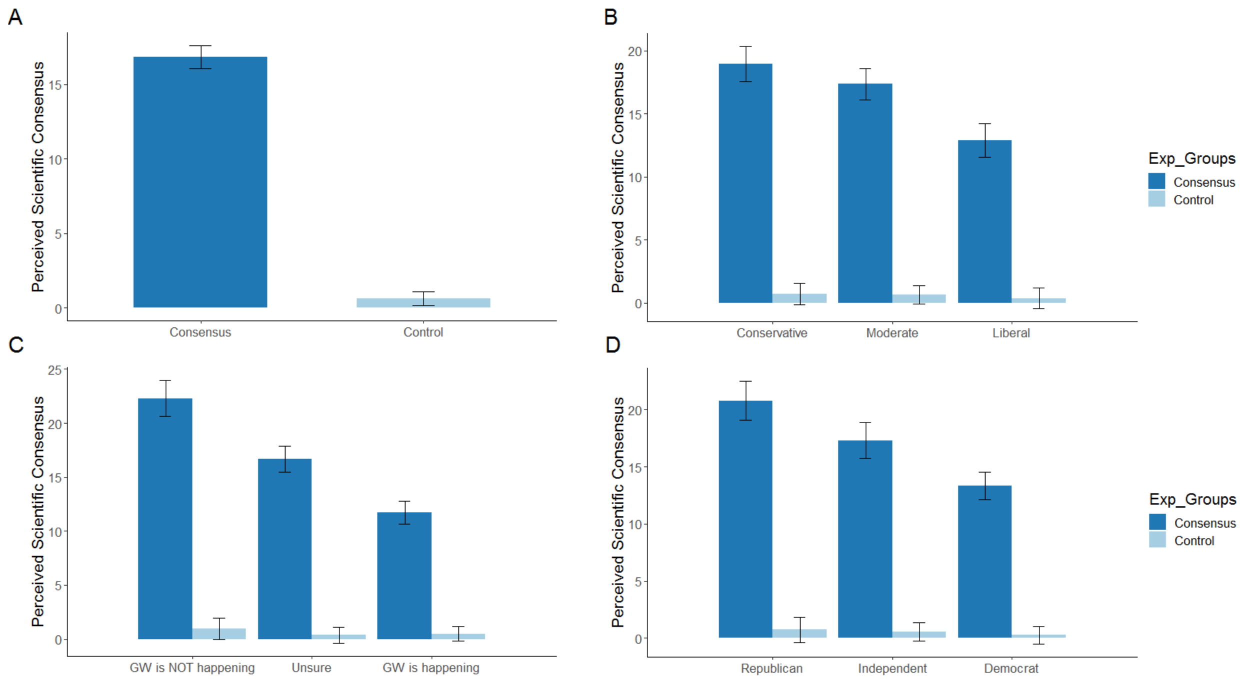
Supplementary Figure 3: Pre and Post-test scores by Condition and Prior Attitude

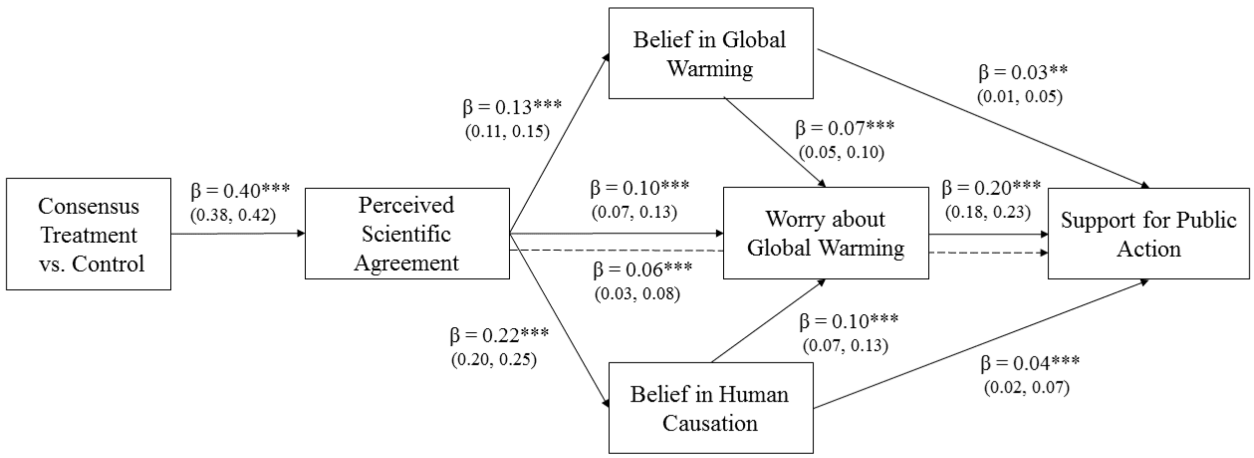


Supplementary Figure 4: Pre and Post-test scores by Condition and Ideology (5-point)




A
Belief in Global Warming
0.00
0.05
0.10
0.15
0.20
0.25
Consensus
Control
B
Belief in Human Causation
0.0
0.1
0.2
0.3
Consensus
Control
Exp_Groups
Consensus
Control
C
Worry About Global Warming
0.0
0.1
0.2
0.3
Consensus
Control
D
Support for Public Action
0.00
0.05
0.10
Consensus
Control
Exp_Groups
Consensus
Control


A
Perceived Scientific Consensus
15
10
5
0
Consensus
Control
B
Perceived Scientific Consensus
20
15
10
5
0
Conservative
Moderate
Liberal
Exp_Groups
Consensus
Control
C
Perceived Scientific Consensus
25
20
15
10
5
0
GW is NOT happening
Unsure
GW is happening
D
Perceived Scientific Consensus
20
15
10
5
0
Republican
Independent
Democrat
Exp_Groups
Consensus
Control



Model Fit:

$\chi^2(6) = 166.40$, $p < 0.001$
RMSEA = 0.065
(90% CI: 0.06 – 0.07)
CFI = 0.94
SRMR = 0.028

- Using a large national sample, this study replicates the Gateway Belief Model (GBM)
- Exposure to a consensus message increased perceived scientific consensus (PSC)
- A change in PSC subsequently predicted (smaller) changes in private attitudes
- Changes in these attitudes were in turn associated with greater support for action
- Main effects on PSC were greater for conservatives and reduced motivated cognition