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The relationship between personal experience and belief in the reality of global warming

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In this paper, we address the chicken-or-egg question posed by two alternative explanations for the relationship between perceived personal experience of global warming and belief certainty that global warming is happening: Do observable climate impacts create opportunities for people to become more certain of the reality of global warming, or does prior belief certainty shape people's perceptions of impacts through a process of motivated reasoning[1]? We use data from a nationally representative sample of Americans surveyed first in 2008 and again in 2011; these longitudinal data allow us to evaluate the causal relationships between belief certainty and perceived experience, assessing the impact of each on the other over time[2]. Among the full survey sample, we found that both processes occurred: 'experiential learning', where perceived personal experience of global warming led to increased belief certainty, and 'motivated reasoning', where high belief certainty influenced perceptions of personal experience. We then tested and confirmed the hypothesis that motivated reasoning occurs primarily among people who are already highly engaged in the issue whereas experiential learning occurs primarily among people who are less engaged in the issue, which is particularly important given that approximately 75% of American adults currently have low levels of engagement[3,4].

Climate change is affecting every region by increasing the frequency and/or intensity of heat waves, droughts, precipitation, floods, hurricanes, and forest fires, and through impacts on ecosystems and species, including human health[5]. Yet, most Americans perceive climate change as a problem distant in time and space, and do not recognize its indicators and impacts in their own localities[4,6]. Moreover, despite widespread agreement among climate scientists that human-caused climate change is occurring[7] only two-thirds (66%) of Americans adults correctly understand that 'global warming is happening', and nearly half of these are only 'somewhat sure' (42%) or 'not at all sure' (5%) of their answer; moreover, only a third believe that they or their families will be harmed[4]. Low levels of belief certainty and perceived threat, in turn, indicate low levels of engagement with the issue, which is strongly associated with reduced levels of support for taking action to address the problem[8].

One possible explanation for these low levels of belief certainty—and perceptions of the threat as distant—is that climate change is difficult to perceive directly; 'climate' itself is a statistical abstraction, even though its impacts can be quite tangible[9]. Current theories of cognitive science suggest that learning about abstractions requires analytical information processing, which involves cognitive effort—a scarce commodity, which people expend sparingly[10]. Both low motivation to think about climate change and low ability to comprehend scientific information[11] can impede people's processing of the charts, graphs and models in the climate scientist's toolkit.

By contrast, experiential processing—learning through experience—is much more likely to occur: it happens automatically, effortlessly and instantly, and has strength and immediacy that analytical information lacks. Peoples' impressions of climate change are probably shaped in large measure by their strong propensity for experiential processing, yet information about climate change is often presented in abstract analytical terms that are hard for people to process and connect to their own lives[12]. Common in both scientific and media reports[13], abstractions make for pallid education, and are less convincing than the vividness of personal experience.

Indeed, people who say they have personally experienced global warming are far more likely to be engaged with the issue than people who say they have not[1,14,15]. More than a quarter of the American public believe they have personally experienced the effects of global warming[4], and that belief is strongly associated with higher global warming risk perceptions[16], worry[17], and response motivation[18]. This pattern of relationships suggests the possibility that as individuals experience the effects of global warming, they become more certain that global warming is occurring.

However, a rival hypothesis suggests that perceptions of personal experience stem from prior beliefs through a process of motivated reasoning rather than from impartially detecting changes in their local environment. The literature on motivated reasoning in general—and cultural cognition in particular[19]—has demonstrated that people's prior beliefs about climate change can strongly influence how they interpret changes in environmental conditions (see also literature on Bayesian updating for a competing perspective[20]).

People tend to seek (or avoid) and process information—often using mental shortcuts—in a manner that is favourable to their preferred conclusions[21]. Evidence that is consistent with the desired attitude is accepted at face value, while conflicting evidence is ignored, dismissed, or subjected to critical review[22]. Value-inconsistent information can lead to 'boomerang' effects (that is, strengthening prior beliefs)[23], and can be avoided, forgotten, or distorted[24], particularly in situations where an individual feels powerless to reduce a potential threat[22].

There is considerable evidence that motivated reasoning influences some people's global warming beliefs. Political ideology, egalitarianism, and individualism, for example, are strongly associated

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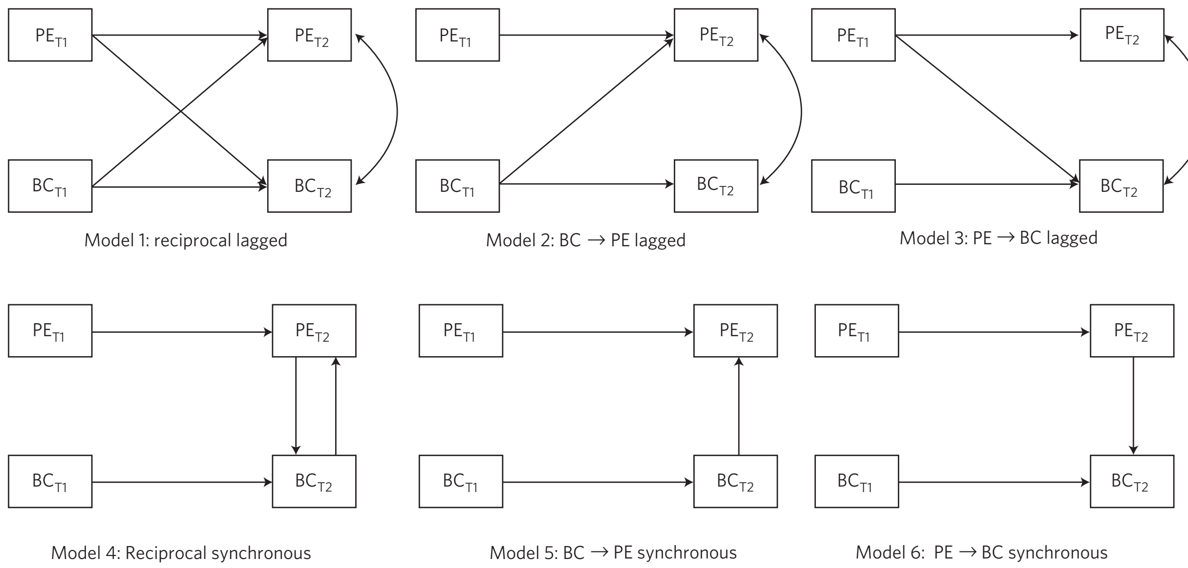

Figure 1 | Tested models. Models 1–3 test the influence of personal experience and belief certainty at T1 on their T2 counterparts; as they are nested, they are able to be directly tested against one another. Models 4–6 test the influence of personal experience and belief certainty on each other within T2, while controlling for T1 influences. Models 4–6 are also nested, and thus are tested directly against one another.

with interpretations of 'Climategate'[25], and with perceptions of the scientific consensus on global warming[14,19]. Research with farmers found biased weather recall, consistent with the farmers' beliefs about climate change; convinced farmers (in both directions—those convinced global warming is or is not happening) were only accurate in their perceptions of locally warming conditions when environmental conditions matched their expectations[15,26]. A study of Phoenix residents found that social variables, including political ideology, predicted perceptions of temperature change in the region, but that detectable temperature variations predicted perceptions of neighbourhood changes[27]. Taken together, these results suggest that people with strongly held beliefs are likely to engage in motivated reasoning about global warming; ambiguous, distal and abstract information is more easily subjected to interpretations consistent with prior beliefs, although personal experience may trump prior beliefs for interpretation of events close to home.

Until now, investigations of the relationship between perceived personal experience and belief certainty in global warming have relied on cross-sectional data, which cannot determine which came first: perceptions of personal experience or beliefs about the reality of climate change.

In this study, however, we used within-subject longitudinal data (where respondents were interviewed at two time points: fall 2008 and spring 2011), which permits a stronger assessment of causality than does data collected at a single point in time[2]. We investigated whether perceived personal experience (PE) leads to belief certainty (BC) or whether belief certainty leads to perceived personal experience (PE was assessed with a single statement—'I have personally experienced the effects of global warming.'—and a four-point response scale ranging from '1' = strongly disagree to '4' = strongly agree. BC—a scale created from two questions (described below)—ranged from 0 (extremely sure global warming is not happening) to 8 (extremely sure global warming is happening)).

Using a model comparison approach, we tested six different structural equation models (Fig. 1). Specifically, we tested three relationships between PE and BC: a reciprocal relationship model, where there is mutual influence between PE and BC; a motivated reasoning model where belief certainty influences perceived personal experience; and an experiential learning model where perceived personal experience influences belief certainty. Moreover, we tested each of these relationships in two ways—in lagged models (the influence of time 1 (T1) variables on time 2 (T2) variables) and in synchronous models (the relationships between T2 variables, controlling for T1 values). We compared the model fits of these six models to see which causal relationship best fits the data. In all models, we controlled for gender, education, income, and political ideology (see Methods for details).

We found that belief certainty at both T1 and T2 was positively associated with perceived personal experience at T2, in all models in which this relationship was estimated—even after controlling for perceived personal experience at T1 (Table 1). Similarly, perceived personal experience at both time points was positively related to belief certainty at T2, even after controlling for belief certainty at T1.

We tested the models that were nested against each other using Chi-square (χ^2) difference tests. For the lagged nested models, Model 1 fits the data significantly better than either Model 2 ($\Delta\chi^1(1) = 23.84$, $p < 0.001$) or Model 3 ($\Delta\chi^1(1) = 29.64$, $p < 0.001$). Furthermore, for the synchronous nested models, Model 4 fits the data significantly better than either Model 5 ($\Delta\chi^1(1) = 9.52$, $p < 0.01$) or Model 6 ($\Delta\chi^1(1) = 16.76$, $p < 0.001$); thus, these χ^2 difference tests show that the reciprocal model has a superior fit, regardless of whether tested as lagged or synchronous. Among the remaining fit indices, the reciprocal models (Models 1 and 4) also had the best fit, indicating that, among our full population of respondents, perceived personal experience was influencing belief certainty, and belief certainty was influencing perceived personal experience.

Next, to determine if segments of the population who were highly engaged in the issue at T1 demonstrated a motivated reasoning pattern of response (that is, belief certainty influencing perceived personal experience), and if segments with low levels of issue engagement at T1 demonstrated an experiential learning pattern of response (that is, perceived personal experience influencing belief certainty), we chose the synchronous reciprocal model (Model 4) and fit a two-group (high versus low engagement) multiple-groups model (see Methods for a description of how the two engagement groups were constructed)[28]. Thus, we fit three further models—one allowing all paths to differ between the two engagement levels, one forcing the path between PE and BC to be equal between the two groups, and one forcing the path between BC and PE to be equal. Both constrained models demonstrated a

Table 1 | Model comparisons.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Personal experience, T2						
BC, T1	0.07§ (0.01)	0.08* (0.01)	—	—	—	—
BC, T2	—	—	—	0.09* (0.02)	0.14* (0.01)	—
PE, T1	0.34* (0.03)	0.29* (0.03)	0.40* (0.03)	0.33* (0.03)	0.28* (0.03)	0.40* (0.03)
Gender	−0.01 (0.05)	−0.00 (0.04)	0.00 (0.05)	−0.01 (0.05)	−0.01 (0.04)	0.00 (0.05)
Education	−0.02 (0.01)	−0.02 (0.01)	−0.01 (0.01)	−0.02 (0.01)	−0.03‡ (0.01)	−0.01 (0.01)
Income	−0.01‡ (0.01)	−0.01‡ (0.01)	−0.01‡ (0.01)	−0.01§ (0.01)	−0.01 (0.01)	−0.01‡ (0.01)
Ideology	−0.12* (0.02)	−0.12* (0.02)	−0.15* (0.02)	−0.09* (0.02)	−0.06* (0.02)	−0.15* (0.02)
Belief certainty, T2						
PE, T1	0.54* (0.03)	—	0.49* (0.03)	—	—	—
PE, T2	—	—	—	0.55* (0.03)	—	0.82† (0.07)
BC, T1	0.37* (0.07)	0.60* (0.03)	0.42* (0.07)	0.40* (0.12)	0.60* (0.03)	0.50* (0.03)
Gender	−0.01 (0.11)	0.00 (0.11)	0.00 (0.11)	0.00 (0.11)	0.00 (0.11)	0.00 (0.10)
Education	0.08† (0.03)	0.09† (0.03)	0.09† (0.03)	0.09† (0.03)	0.09† (0.03)	0.10† (0.03)
Income	−0.03§ (0.01)	−0.03‡ (0.02)	−0.03§ (0.01)	−0.02 (0.01)	−0.03‡ (0.02)	−0.02 (0.01)
Ideology	−0.39* (0.04)	−0.42* (0.04)	−0.41* (0.04)	−0.36* (0.04)	−0.42* (0.04)	−0.30* (0.04)
Measures of fit						
χ^2 (d.f.)	—	23.84 (1)*	29.64 (1)*	14.66 (1)*	24.18 (2)*	31.42 (2)*
CFI	—	0.980	0.975	**0.988**	**0.981**	0.974
AIC	**26,682**	26,704	26,710	**26,695**	26,702	26,710
BIC	**26,766**	26,782	26,788	**26,774**	26,776	26,783
RMSEA	—	0.152	0.171	**0.118**	**0.106**	0.122

*$p < 0.001$. †$p < 0.01$. ‡$p < 0.05$. §$p < 0.10$. Note: Bolded entries indicate that the model ranked either first or second on that fit measure. Standard errors are in parentheses. The following measures of fit were employed: Confirmatory Fit Index (CFI); Akaike Information Criterion (AIC); Bayesian Information Criterion (BIC); and the Root Mean Square Error of Approximation (RMSEA).

Table 2 | Multiple-groups analysis.

	High engagement	Low engagement
Personal experience, T2		
Belief certainty, T2	0.15* (0.03)	0.04* (0.03)
Personal experience, T1	0.20* (0.05)	0.36* (0.04)
Gender	−0.09 (0.08)	0.02 (0.05)
Education	−0.02 (0.02)	−0.02 (0.02)
Income	−0.03† (0.01)	−0.00 (0.01)
Ideology	−0.10† (0.03)	−0.09* (0.03)
Belief certainty, T2		
Personal experience, T2	−0.32 (0.22)	0.67* (0.16)
Belief certainty, T1	0.77* (0.05)	0.45* (0.04)
Gender	0.08 (0.20)	−0.06 (0.13)
Education	0.017 (0.06)	0.13* (0.04)
Income	−0.05‡ (0.03)	−0.02 (0.02)
Ideology	−0.10† (0.03)	−0.36* (0.00)

*$p < 0.001$. †$p < 0.01$. ‡$p < 0.10$. Note: Standardized coefficients from an unconstrained multiple-groups structural equation model. Standard errors are in parentheses.

significantly worse fit than the unconstrained model, indicating that the paths significantly differed between the two engagement groups (constraining PE → BC, $\Delta\chi^2(1) = 15.86$, $p < 0.001$; constraining BC → PE, $\Delta\chi^2(1) = 7.34$, $p < 0.01$).

The experiential learning relationship was positive and significant for the low engagement segments of the population (see Table 2; standardized $\beta = 0.67$, $p < 0.001$) and not significant for the highly engaged segments (standardized $\beta = -0.32$, $p = 0.151$). Conversely, the motivated reasoning relationship was positive and significant for the highly engaged audience segments (standardized $\beta = 0.16$, $p < 0.001$) and of lesser magnitude, but also positive and significant, for the less engaged audience segments (standardized $\beta = 0.04$, $p < 0.01$).

These findings suggest that for the American adult population as a whole, the answer to the 'chicken-or-egg' question—regarding the relationship between perceived personal experience of global warming and belief certainty that global warming is happening—is that both hypotheses are correct. Americans' interpretations of global warming are influenced by both their perceived personal experience and their prior beliefs. Perhaps more importantly, we find that people who have low engagement in the issue of global warming (approximately 75% of the population) are more likely to be influenced by their perceived personal experience of global warming than by their prior beliefs, whereas those Americans who are highly engaged in the issue (on both sides of the issue) are more likely to interpret their perceived personal experience in a manner that strengthens their pre-existing beliefs (that is, using motivated reasoning). Further research that explores in finer detail how people perceive personal experience with global warming would add more richness to our understanding of this relationship[1].

These findings suggest that place-based climate change education strategies—which highlight the local impacts of climate change in a manner that can be experienced by people with their senses—hold considerable potential to help large numbers of Americans come to understand the issue in a manner more consistent with the state-of-the-science. Such strategies might include TV weathercasters using extreme weather events as an opportunity to educate their viewers about the increasing frequency and/or intensity of such events, park interpreters and agricultural extension agents describing evidence of climate change impacts *in situ*, and public health professionals drawing attention to the local health impacts of climate change in a given community[29]. Selecting highly trusted sources as educators for experiential learning strategies is key, as some messages have the potential to backfire among those segments of the public actively engaged in countering climate science[23,30]. As the directly observable and experienced local impacts of global climate change continue to increase, these 'teachable moments' will become more common, and more dramatic.

Such focusing events can make the invisible processes of climate change visible, and render the abstract concrete, but these events do not explain themselves. Turning observable local impacts into experiential learning opportunities often requires that trusted communicators—who have access to large cross-sections of the public—provide scientifically accurate interpretations that connect the dots from changes in local weather patterns, environmental conditions, and extreme weather events to climate change.

Methods

Data for this study are drawn from a nationally representative within-subject online panel maintained by Knowledge Networks. Knowledge Networks recruits their panel using random digit dialling and provides small incentives as well as a free netbook and Internet service to those segments of the population without computers to ensure their representation in the panel. The surveys reported here measured respondents' climate change beliefs, risk perceptions, policy preferences, and related behaviours. The first wave of data was collected in the fall of 2008 (N_{T1} = 2,164, completion rate = 54%, cumulative response rate 1 = 6.6%; ref. 31). All first wave respondents who remained as participants in Knowledge Networks' 2011 general panel (N = 1,301) were re-contacted in June of 2011, and 1,036 participated in the second wave of data collection (T2 completion rate = 80%, cumulative response rate 1 = 6.4%).

Measurement.

Global warming belief certainty. Respondents were first asked whether they thought global warming was happening, with options being yes, no, or I don't know. Individuals who answered yes or no responded to a follow up question asking how sure they were about their position (0 = not at all sure, 3 = extremely sure). Responses to these items were combined to create a final belief certainty measure, ranging from those individuals who chose 'no' to the first question and 'extremely sure' to the second question as '0' (extremely sure global warming is not happening) to those who chose 'yes' and 'extremely sure' as '8' (extremely sure global warming is happening); those who responded 'don't know' to the first question were coded as '4' (M_{T1} = 5.81, SD_{T1} = 2.19; M_{T2} = 5.09, SD_{T2} = 2.43).

Perceived personal experience of global warming. Perceived personal experience of global warming was assessed with the following item: 'I have personally experienced the effects of global warming.' measured on a four point scale ranging from '1' = strongly disagree to '4' = strongly agree (M_{T1} = 2.12, SD_{T1} = 0.84; M_{T2} = 1.99, SD_{T2} = 0.87).

Engagement with global warming. Engagement with global warming—a construct that has cognitive, affective and behavioural dimensions[32]—was identified in a prior analysis of the T1 sample[3]. Using latent class analysis on 36 measures of global warming-related attitudes, beliefs, knowledge, preferences, and behaviours, six groups of respondents differing in their engagement with global warming were identified, subsequently termed Global Warming's Six Americas. One group—named the Alarmed (n = 187 and 18% prevalence among those who completed the T2 survey)—was the most convinced that global warming is a problem (that is, high cognitive engagement), most worried about the problem (that is, high affective engagement), and most likely to report behavioural responses to the problem (that is, high behavioural engagement). The Concerned (343, 33%) and the Cautious (201, 19%) have markedly lower cognitive, affective and behavioural indicators of engagement. The Disengaged (85, 8%) have very low levels of issue engagement, and typically say they 'don't know' if global warming is occurring, or not. The Doubtful (133, 13%) tend not to believe that global warming is occurring, and have low levels of cognitive and affective engagement in the issue. Finally, the Dismissive (84, 8%) are highly engaged in the issue, rejecting its reality and strongly opposing action. Participants in the Alarmed and Dismissive segments at T1 were categorized as having high issue engagement and those in the middle segments were categorized as having low engagement (84% of those who were classified as 'low engagement' at T1 remained low engagement at T2 and 66% of those who were classified as 'high engagement' at T1 remained high engagement at T2).

Assessment of model fit.

To assess which model was preferred, we employed several measures of fit (see Table 1). For all measures, except the CFI, lower values indicate a better fit. Nested models (Models 1–3 and Models 4–6) were compared using the χ^2 difference test, which is able to assess whether the differences in model fit are attributable to chance.

Multiple-groups models.

First, an unconstrained model was tested (using the synchronous reciprocal model, Model 4), allowing all parameters, including variance, to vary freely between the two engagement levels. Standard errors for the highly engaged segments were higher than for the less engaged segments, reflecting both higher variances and smaller sample size for that group. Next, two constrained models were fitted, one model constraining the path from personal experience to belief certainty to be equal between the two groups, and one model constraining the path from belief certainty to personal experience to be equal between the two groups, in an effort to see if model fit decreased as the paths were constrained. χ^2 values between the unconstrained and constrained models were compared to see if model fit decreased significantly as a result of constraining the paths.

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References

1. Akerlof, K., Maibach, W. W., Fitzgerald, D., Cedeno, A. Y. & Neuman, A. Do people 'personally experience' global warming, and if so how, and does it matter? *Glob. Env. Change* http://dx.doi.org/10.1016/j.gloenvcha.2012.07.006 (in the press).
2. Bullock, H. E., Harlow, L. L. & Mulaik, S. A. Causation issues in structural equation modeling research. *Struct. Equ. Modeling* **13,** 253–267.
3. Maibach, E., Leiserowitz, A., Roser-Renouf, C. & Mertz, C. K. Identifying like-minded audiences for global warming public engagement campaigns: An audience segmentation analysis and tool development. *PLoS ONE* **6,** e17571 (2011).
4. Leiserowitz, A., Maibach, E., Roser-Renouf, C. & Hmielowski, J. *Global Warming's Six Americas, March 2012 & Nov. 2011* (Yale Project on Climate Change Communication, 2012).
5. Karl, T. R., Melillo, J. M. & Peterson, T. C. (eds) *Global Climate Change Impacts in the United States* (Cambridge Univ. Press, 2009).
6. Leiserowitz, A. American risk perceptions: Is climate change dangerous? *Risk Anal.* **25,** 1433–1442 (2005).
7. Anderegg, W. R. L., Prall, J. W., Harold, J. & Schneider, S. H. Expert credibility in climate change. *Proc. Natl Acad. Sci. USA* **107,** 12107–12109 (2010).
8. Roser-Renouf, C., Maibach, E., Leiserowitz, A. & Zhao, X. The Genesis of Climate Change Activism: From Key Beliefs to Political Advocacy Int. Commun. Assoc. Annual Conference (2011).
9. Weber, E. U. & Stern, P. C. Public understanding of climate change in the United States. *Am. Psychologist* **66,** 315–328 (2011).
10. Fiske, S. T. & Taylor, S. E. *Social Cognition* 2nd edn (McGraw-Hill, 1991).
11. Miller, J. D. Public understanding of, and attitudes toward, scientific research: What we know and what we need to know. *Public Underst. Sci.* **13,** 273–294 (2004).
12. Marx, S.M. *et al.* Communication and mental processes: Experiential and analytic processing of uncertain climate information. *Glob. Environ. Change* **17,** 47–58 (2007).
13. Lejarraga, T. When experience is better than description: Time delays and complexity. *J. Behav. Decis. Making* **23,** 100–116 (2010).
14. Leiserowitz, A. Climate change risk perception and policy preferences: The role of affect, imagery, and values. *Climatic Change* **77,** 45–72 (2006).
15. Weber, E. U. What shapes perceptions of climate change? *WIREs Clim. Change* **1,** 332–342 (2010).
16. Brody, S. D., Zahran, S., Vedlitz, A. & Grover, H. Examining the relationship between physical vulnerability and public perceptions of global climate change in the United States. *Env. Behav.* **40,** 72–95 (2008).
17. Spence, A., Poortinga, W., Butler, C. & Pidgeon, N. S. Perceptions of climate change and willingness to save energy related to flood experience. *Nature Clim. Change* **1,** 46–49 (2011).
18. Leiserowitz, A. & Broad, K. *Florida: Public Opinion on Climate Change* (Yale Project on Climate Change, 2008).
19. Kahan, D. M. *et al. The Tragedy of the Risk-Perception Commons: Culture Conflict, Rationality Conflict, and Climate Change* Temple University Legal Studies Research Paper No. 2011-26 (2011); available at http://dx.doi.org/10.2139/ssrn.1871503 (2011).
20. El-Gamal, M. A. & Grether, D. M. Are people Bayesian? Uncovering behavioral strategies. *J. Am. Stat. Assoc.* **90,** 1137–1145 (1995).
21. Kunda, Z. The case for motivated reasoning. *Psychol. Bull.* **3,** 480–498 (1990).
22. Dawson, E., Gilovich, T. & Regan, D. T. Motivated reasoning and performance on the Wason selection task. *Pers. Soc. Psychol. Bull.* **28,** 1379–1387 (2002).

23. Hart, P. S. & Nisbet, E. C. Boomerang effects in science communication: How motivated reasoning and identity cues amplify opinion polarization about climate mitigation policies. *Commun. Res.* **39,** 701–723 (2011).
24. Taber, C. S. & Lodge, M. Motivated skepticism in the evaluation of political beliefs. *Am. J. Polit. Sci.* **50,** 755–769 (2006).
25. Leiserowitz, A., Maibach, E., Roser-Renouf, C., Smith, N. & Dawson, E. Climategate, public opinion, and the loss of trust. (in the press); accessed July 23, 2012 from http://www.climatechangecommunication.org/images/files/Climategate_PublicOpinion_andLossofTrust(1).pdf.
26. Weber, E. U. & Sonka, S. in *Farmers' Decision Making: A Descriptive Approach* (eds Jacobsen, B. H., Pedersen, D. E., Christensen, J. & Rasmussen, S.) 201–218 (SJFI, 1994).
27. Ruddell, D., Harlan, S. L., Grossman-Clarke, S. & Chowell, G. Scales of perception: Public awareness of regional and neighborhood climates. *Climatic Change* **3,** 1–27 (2011).
28. Kline, R. B. *Principles and Practice of Structural Equation Modeling* 3rd edn (The Guilford Press, 2010).
29. Maibach, E. W., Nisbet, M., Baldwin, P. & Diao, G. Reframing climate change as a public health issue: An exploratory study of public reactions. *BMC Public Health* **10,** 1–11 (2010).
30. Myers, T.A., Nisbet, M.C., Maibach, E. W. & Leiserowitz, A. A public health frame arouses hopeful emotions about climate change: A letter. *Climatic Change* **113,** 1105–1112 (2012).
31. Callegaro, M. & DiSogra, C. Computing response metrics for online panels. *Public Opin. Quart.* **72,** 1008–1032 (2008).
32. Lorenzoni, I., Nicholson-Cole, S. & Whitmarsh, L. Barriers perceived to engaging with climate change among the UK public and their policy implications. *Glob. Env. Change* **17,** 445–459 (2007).

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Author contributions

This study was designed by T.A.M., E.W.M., C.R-R., K.A. and A.A.L. The survey was conducted by E.W.M., C.R-R. and A.A.L.. The analysis was conducted by T.A.M. All authors contributed to the writing of the manuscript.

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Competing financial interests

The authors declare no competing financial interests.