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THREE INVESTIGATIONS INTO THE DYNAMICS AND IMPLICATIONS OF IDENTITY-PROTECTIVE COGNITION FOR PUBLIC RESPONSES TO ENVIRONMENTAL PROBLEMS

Daniel A. Chapman
University of Massachusetts Amherst

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**THREE INVESTIGATIONS INTO THE DYNAMICS AND IMPLICATIONS OF
IDENTITY-PROTECTIVE COGNITION FOR PUBLIC RESPONSES TO
ENVIRONMENTAL PROBLEMS**

A Dissertation Presented

by

DANIEL A. CHAPMAN

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

September 2018

Psychology

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Approved as to style and content by:

Brian Lickel, Chair

Ezra Markowitz, Member

Jeffrey Starns, Member

Brian Schaffner, Member

Caren Rotello, Department Chair
Psychological and Brain Sciences

DEDICATION

To Alicia, Martin, Kim, Lauren, Calla, and Bruce. I would not be here today without your enduring support.

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I would like to acknowledge the support of my primary advisors and collaborators throughout my graduate studies, Brian Lickel and Ezra Markowitz. Their support has been vital in this process in a way that no brief description can do justice to. I also thank Brian Schaffner and Jeff Starns, for their flexibility and insights while serving as members on my dissertation committee.

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ABSTRACT

THREE INVESTIGATIONS INTO THE DYNAMICS AND IMPLICATIONS OF IDENTITY-PROTECTIVE COGNITION FOR PUBLIC RESPONSES TO ENVIRONMENTAL PROBLEMS

SEPTEMBER 2018

DANIEL A. CHAPMAN, B.A., MILLERSVILLE UNIVERSITY

M.A., UNIVERSITY OF MASSACHUSETTS AMHERST

Ph.D., UNIVERSITY OF MASSACHUSETTS AMHERST

Directed by: Professor Brian Lickel

In the case of responding to climate change and related environmental problems, opinions about the best course of action have become starkly polarized along ideological lines. The identity-protective cognition thesis posits that when individuals experience a sense of challenge to these identities, they are motivated to engage in cognitive shortcuts and other reasoning processes to protect these identities against threat. In this research, I discuss three investigations into identity-protective cognition in the context of responding to environmental problems, applying the broader identity-protective cognition framework to a diverse set of theoretical and practical questions. Chapter 2 highlights research exploring the effect of motivated reasoning on responses to natural disasters linked with climate change. Chapter 3 looks at how brand and environmental identities influence responses to corporate environmental scandals that are personally relevant and require individual-level action. Chapter 4 extends this research paradigm by exploring public responses to visual imagery used to depict climate change across three countries, while also examining how identity-protective processes shape these responses. In addition to

the theoretical and practical contributions for environmental engagement, explicit emphasis is placed on the use of full Bayesian inference for quantitative environmental decision making research. Implications for theory, methodology, and practice are considered.

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CHAPTER 1

INTRODUCTION

A persistent problem in the practice of science communication is identifying the most effective strategies to communicate complicated scientific evidence in ways that are digestible by non-expert audiences. In cases where the scientific evidence points to risks that demand public attention and response, it is paramount that politicians and the public at large are well-informed, or at minimum willing to heed to the advice of domain experts. As such, the need for a public capable of recognizing, and ideally being motivated to respond to the risks posed by global challenges such as climate change cannot be understated.

While a herculean task in and of itself, the difficulties in motivating public action are compounded when scientific evidence carries politically contentious implications, such as increased government regulation, or when an issue stance becomes synonymous with one particular political leaning. Views on climate change, for example, consistently rank as one of the most polarizing issues in American political discourse:

Democratically-leaning individuals and politicians are on average more supportive of public action on climate change than those who are Republican-leaning (Egan & Mullin, 2017). As this well-documented political polarization continues to carry implications for collective responses to climate change both nationally and internationally, the underlying social and cognitive processes driving this phenomenon warrant sustained attention.

Furthermore, as similar polarization processes appear to be emerging among other scientific issues (e.g., mandatory vaccination), it is important to better understand their roots in order to develop effective responses (Drummond & Fischhoff, 2017).

Here, I focus my efforts on the role of identity-protective cognition in influencing individuals' responses to climate change and other environmental problems. Identity-protective cognition is a broad theoretical perspective which aims to make sense of the ways in which individuals' identities, worldviews, and ideological affiliations 'pollute' risk communication by biasing public acceptance and response to risk-relevant information (Kahan, 2017; Kahan, Braman, Gastil, Slovic, & Mertz, 2007). While the implications of identity-protective cognition apply to and vary by different subjects (e.g., gun control), the research emphasis in the work described here is placed squarely on the implications as they pertain to environmental problems, especially climate change.

I begin by outlining the state of research on political polarization on climate change and other environmental issues, particularly in Anglophone nations where attitudes on these issues have become nearly synonymous with political identities. I then briefly consider several positions on the role of education and ideological beliefs in public acceptance of anthropogenic climate change. The aforementioned overview is followed by discussion of the underlying premises of identity-protective cognition and its roots in cultural theories of risk and motivated reasoning. Key questions of interest are identified, and the impetus for my research is explicated.

Political Polarization and Environmental Problems

There is well-documented evidence that, at least in industrialized Anglophone nations, public attitudes on the issue of climate change are heavily polarized along political lines (Dunlap, McRight, & Yarosh, 2016; Pugliese & Ray, 2011). Conservatives exhibit higher rates of climate change skepticism and lower rates of support for policy action, whereas the opposite tends to be true for liberals (Egan & Mullin, 2017). Indeed,

this polarization has been observed among both laypersons and politicians in countries such as the United States, United Kingdom, and Germany, among others (Pugliese & Ray, 2011).

In the United States, a review of polling research found that as recently as 2015, roughly 84% of Democrats compared with nearly 40% of Republicans reported worrying about climate change ‘a great deal’ or a ‘fair amount; this polarization has fluctuated over the years, but the central pattern has been quite consistent (Egan & Mullin, 2017). In fact, despite small reductions observed since 2011 (Saad, 2017), the divide appears to be increasing again in the wake of the 2016 U.S. Presidential Election (Brenan, 2018). This bifurcation of opinion has proven detrimental to coordinated societal action, exemplified by stalled environmental legislation and the recent decision of the United States to withdraw from the Paris Climate Agreement (Volcovici, 2017). The observed pattern in Anglophone nations differs compared with much of the global political theater, where public concern about climate change appears to be less polarized (Capstick, Whitmarsh, Poortinga, Pidgeon, & Upham, 2015; Pugliese & Ray, 2011). However, limited high-resolution temporal data for many nations makes inferences about these latter trends tentative.

Further, the polarization in Anglophone nations stands decidedly at odds with the dominant view of national and international scientific organizations, such as the American Association for the Advancement of Science and the Intergovernmental Panel on Climate Change, both of which endorse the major scientific opinion on anthropogenic contributions to climate change. Recent analyses of the scientific literature on climate change suggest that there is substantial consensus among domain experts, ranging

upwards of 90-100%, with regard to the existence of anthropogenic climate change (Cook et al., 2016).

More troubling, evidence indicates that the climate change divide generalizes in large part to other environmental opinions: the partisan divide over environmental concern is stronger now than it has been in recent memory (Brenan, 2018). Further, other evidence suggests that partisan identities carry more predictive value for environmental preferences than economic concerns, an often-cited determining factor (Mildenberger & Leiserowitz, 2017). Thus, polarization over environmental problems tracks closely with rates for climate change concern. Considering the prominent place of climate change in modern public discourse relative to other environmental issues, it is perhaps not surprising that opinions on climate change have had psychological consequences for opinions on other environmental problems.

Dual Perspectives on Environmental Attitude Polarization

Given the clear divide between the opinions of scientific experts and the concerns of the general public (particularly among conservative-leaning ideologues), it is important to identify both its roots and implications. A variety of research perspectives have emerged on this topic, most specifically centered on the role of education and knowledge, and the role of ideological identities.

One of the dominant perspectives in much of the history of science communication has been that it is the lack of effective and persistent education on the scientific evidence for climate change that is largely to blame for public inaction on climate and environmental problems (Kahan et al., 2012; Kahan, Peters, Dawson, &

Slovic, 2017). This, ‘knowledge-deficit’ position presents a sensible and appealing perspective: if public inaction is due primarily to a lack of knowledge or insufficient risk-related information, then an antidote to this polarization is to take measures to increase education about the factual basis of climate change. Stated differently, a knowledge-deficit position argues that public underestimation of the necessity to tackle climate change and environmental problems stems from a lack of knowledge among portions of society that are skeptical and/or unconcerned about the problem.

As just one example of this knowledge-deficit perspective, a recent study found that greater domain-specific knowledge about the causes of climate change (but not other aspects of climate change knowledge) was associated with greater concern about climate change among a large U.S. sample of respondents, even while accounting for ideological differences (Shi, Visschers, Siegrist & Arvai, 2016). And, when making decisions about other immediately self-relevant risks (e.g., medical risks), individuals tend to heed to expert judgments on the best course of action, provided the best communication techniques are utilized (Trevena et al., 2013). However, other evidence suggests that this idealized picture of knowledge and deference to expertise may be hindered by political polarization on climate change and related environmental issues.

Kahan and colleagues (2012), for example, found that greater knowledge was in fact associated with greater, rather than less, polarization among partisans, standing in direct contrast to the predictions of a knowledge-deficit position. High-knowledge liberals and high-knowledge conservatives exhibited the greatest (rather than smallest) degrees of divergence in their beliefs about climate change. This finding has been replicated in a host of contexts and data sets (see, for example, Funk, 2017; Funk &

Kennedy, 2016; Kahan et al., 2017). Recent evidence on the role of science literacy and education also indicates that higher levels of these characteristics are associated with greater polarization on a host of controversial scientific issues (Drummond & Fischhoff, 2017).

Further, a meta-analysis of social science research on climate change beliefs found that identities and worldviews, such as one's political ideology or cultural values, are stronger predictors of climate change concern than predictors such as education level or knowledge about climate change (Hornsey et al., 2016). Research on the role of party cues in shaping climate change opinion also suggests that the electorate's view of climate change aligns closely with the representatives of their political party or dominant political affiliation (Guber, 2017).

Some scholars have claimed that educating the public on the 90-100% scientific consensus on climate change can in fact function as a 'gateway' belief, overcoming polarization and motivating greater concern, especially among moderates and conservatives (van der Linden, Leiserowitz, Feinberg, & Maibach, 2015). Yet, while public awareness of scientific consensus has risen since 2015 (Hamilton, 2018), other aforementioned research indicates that polarization is in fact on the rise again, at least in the United States (Brenan, 2018). Furthermore, the research forming the foundation for this 'gateway' perspective has been challenged due to questionable analytic decisions (Kahan, 2017).

Thus, the roles of knowledge and awareness of scientific consensus in motivating judgments of climate change risks appear to have become polluted by ideological affiliations. This position reflects a second, alternative thesis, rooted in the idea that

individuals tend to align their opinion on contentious issues such as climate change with those carrying similar ideological proclivities (e.g., conservatives aligning with the opinions of conservative opinion leaders), and are motivated to construe information in ways that minimize challenges to their worldview (Kahan et al., 2017). The identity-protective cognition thesis provides a more plausible explanation of the observed data on ideology and environmental polarization, making it a desirable alternative framework to the knowledge-deficit position.

Identity-Protective Cognition and Environmental Engagement

The identity-protective cognition thesis (ICT) holds the perspective that the public is generally capable of reasoning about risk-relevant information, but this capacity becomes obfuscated by conflict over cultural values and politicized identities (Kahan et al., 2007; Kahan et al., 2017). When applied to the case of climate change, this suggests that those on the political left and right hold different relevant cultural values (e.g., on the role of government intervention and regulation), and that individuals alter their purported opinions in ways that align with or signal support for the dominant position of those who share their worldview. For example, Campbell and Kay (2014) found that conservatives in the United States had less polarizing reactions to information about climate change and environmental problems when there was also suggestion that the solutions were not necessarily regulation-based.

The ICT is not unique in offering this perspective, but rather draws on substantial backing from theory and research on motivated reasoning (Kunda, 1990) and the cultural theory of risk (Douglas & Wildavsky, 1982). Cultural theory provides a theoretical foundation for making sense of the influence of cultural values on the evaluation of risk-

relevant information, offering a group-grid delineation of cultural values that vary within and across individuals to shape judgments of risks (Kahan, 2012). The group-grid framework outlines four worldview dimensions: egalitarian and communitarian (low grid, high group), as well as hierarchical and individualist (high grid, low group).

Greater hierarchical and individualistic attitudes are typically thought of as being related to lower environmental risk perceptions, whereas egalitarian and communitarian values are associated with greater risk perceptions (e.g., Kahan, Jenkins-Smith & Braman, 2011). In support of this, Kahan et al. (2011) found empirical evidence that egalitarians and communitarians were more concerned about climate change than hierarchicalists and individualists. Furthermore, when asked to judge the credibility of a scientist depending on which view they held on the risk of climate change (low vs. high), respondents' estimates of credibility were polarized along these worldview distinctions. Importantly, this effect was observed while holding the credentials of the scientist constant across treatment condition.

Cultural theory is not without valid theoretical and empirical criticisms (Kahan, 2012). For example, there is disagreement about the precise definitions and measurement of cultural worldviews, and in practice there has not been consistency in how these are analyzed quantitatively (e.g., combining hierarchical/individualist measures when they're highly correlated, testing interaction effects). The degree to which the characteristics of these values emerge similarly across cultures is also not well established when it comes to grounded empirical measurement. However the chief role of cultural theory in the ICT is perhaps not to make definitive statements about the specific cultural values present in societies (hierarchical, egalitarian, etc.), but rather to provide a guiding basis for

examining how values and ideologies influence risk judgments through motivated reasoning processes (Kahan, 2012; Kahan et al., 2017).

Motivated reasoning refers to a broad set of psychological findings demonstrating that individuals possess the capacity and motivation to selectively attend to and utilize information congruent with their preferred views or outcomes (Kunda, 1990; Ditto & Lopez, 1992; Rodriguez, Moskowitz, Salem, & Ditto, 2017). Revisiting the earlier example, Kahan et al. (2011) found that respondents selectively construed the credibility of a scientific expert when the expert offered a message incongruent with their own views. This process confers an ideologically-convenient approach to avoiding having one's core values challenged with high frequency. At the societal level, such motivated responses are ubiquitous, and may not be at the forefront of conscious awareness; individuals generally prefer to affiliate with people holder similar values to their own, and tend to seek out information that validates rather than questions one's own views.

Importantly, scholars do not claim that the ICT applies to all, or even most policy and decision-relevant issues. Kahan and colleagues (2017) explicitly note the rare appearance of ICT across the issue spectrum, and the circumstances of its emergence may vary considerably from issue to issue. These are dimensions of ICT that are not yet well understood. Yet, the public polarization over climate change and environmental issues offers a unique and robust test case for exploring the ICT's dimensions, and how it might apply to other issues. In spite of the growth in this area, questions of both theoretical and practical importance remain. In the research I describe here, I focus on three questions spanning different contexts and scales.

Unanswered Questions Motivating this Research

First, the potential for downstream, second-order effects of identity-protective cognition have not been thoroughly explored. That is, it is not yet well established whether the motivated reasoning processes that bias climate change attitudes have implications for other topics that have become associated with climate change in public discourse. For example, if an extreme weather event is explicitly framed as being caused by climate change, does this influence how the public, especially conservatives and climate change skeptics, perceive the disaster and disaster victims? Chapter 2 will provide more background on this area, and will discuss a survey experiment that was designed to evaluate this question.

Second, only limited research has looked at how those with greater identification as environmentalists respond to environmental disasters (e.g., Clayton, Koehn, & Grover, 2013). Work in this domain has not comprehensively explored whether characteristics of a specific environmental problem, such as personal relevance or the activation of other valued social identities, modulate how identities affect responses. Relatedly, a largely understudied topic in the context of social identity and motivated reasoning research is the degree to which multiple identities may be simultaneously active and interact to influence decision making. Chapter 3 will provide evidence from a survey study examining these questions in the context of an ongoing (at the time of this writing) environmental scandal.

Third, while there is a growing interest in the role of visual imagery in persuasive communication about climate change (for a review, see Wang, Corner, Chapman & Markowitz, 2018), this research has not yet been brought into conversation with the ICT

literature. Thus, it is not known whether the polarizing effects of ICT emerge similarly when individuals are reacting to visual imagery as when they are reacting to primarily text-based mediums. It is also unknown if presenting certain types of visual imagery may more effectively overcome the effects of identity-protective cognition. Chapter 4 will provide an overview on research into climate change visual imagery and public perceptions, and will describe a cross-national investigation containing findings on how the public responds to climate change imagery. Importantly, this work draws on both qualitative and quantitative data to understand perceptions of imagery, which is accompanied by a follow-up set of statistical models exploring the influence of cultural worldviews and political identities in particular.

Overview of Dissertation Content

To recap, the following chapters provide a comprehensive description of three different examinations into the dynamics and implications of ICT for responding to environmental problems. Specifically, I am to address:

1. What is the effect of identity-protective cognition on humanitarian responses to climate-linked extreme weather events?
2. How does identity-protective cognition influence judgments of personal responsibility for environmental scandals?
3. How does the public respond to visual imagery used to depict climate change, and how are responses influenced by the type of image and cultural worldviews of the respondents?

While these investigations are each unique in their approach and the particular questions addressed, they share a common goal of better understanding the theoretical and practical implications of identity-protective cognition, particularly as it pertains to climate change and other instances of environmental degradation. As such, each chapter is written to stand as its own complete document, drawing from distinct literatures and carrying different implications. Between each chapter covering empirical research, a bridge is provided to more comprehensively synthesize each set of findings and theoretical perspectives together and provide fluent transitions.

In Chapter 2, I discuss the findings of an online survey experiment examining how motivated reasoning processes associated with climate change skepticism influence public responses to humanitarian disasters that become explicitly associated with climate change. The research discussed in this chapter was recently published as Chapman and Lickel (2016), and is reproduced here as it appeared in print (see Appendix A for full citation, in accordance with the publisher's copyright regulations). These findings suggest that the implications of ICT and political polarization over climate change extend beyond the issue itself to also influence public responses to complex problems such as natural disasters, which are frequently linked to climate change in public discourse. In addition to the full original paper, additional follow-up analyses are included, and discussion is offered in the bridge reflecting on recent research by scholars which supports and extends these findings.

Chapter 3 describes research conducted in the aftermath of the recent Volkswagen diesel emissions scandal to examine how affected owners' social identities influence their perceptions of culpability in the scandal and willingness to take steps to ameliorate the

problem. In particular, this work examines how environmental and brand identities interact to produce important insights into how owners of affected vehicles conceptualize their responsibility for contributing to and addressing the harmful environmental effects of the scandal. In addition to the interesting theoretical insights regarding interactive processes, this work also carries practical implications for understanding responses to an unexpected and ongoing environmental scandal. The bridge from Chapter 3 to Chapter 4 extrapolates from the interactive identity findings to broader implications for ICT.

The majority of quantitative research has investigated ICT as provoked through text-based mediums, such as the framing research described in Chapter 2. Chapter 4 will report on a large multi-national examination of the role of visual imagery in shaping public perceptions of climate change. The content for this chapter stems from a recent mixed-methods publication (Chapman, Corner, Webster & Markowitz, 2016; see Appendix A for full citation and publication details), and is reproduced in full as it appeared in print. While the main body of research in Chapter 4 was not specifically designed to tap into ICT, it is included both for transparency into the research process and due to the interesting and valuable contextual insights it provides regarding climate change imagery. The data set from this paper also contains Kahan et al.'s (2011) cultural worldviews scales, which were not reported on fully in Chapman et al. (2016) due to the size and scope of the original publication (i.e., to provide a descriptive overview of general imagery principles). Chapter 4 thus includes a detailed addendum containing new analyses to explore the role of cultural worldviews and political ideology in influencing climate change skepticism, perceptions of climate change imagery, and perceived threats from climate change.

The addendum for Chapter 4 presents conceptually driven models focusing on estimation and measurement uncertainty rather than hypothesis testing. These analyses incorporate Bayesian hierarchical regression, a technique that has received limited attention in this literature, in order demonstrate its potential utility in pushing ICT research into the future. This is a particularly warranted demonstration given the conceptual value of thinking about motivated reasoning processes more broadly from a Bayesian perspective (Kahan, 2016). These analyses explore the relationship among the cultural worldviews, as well as their variability across nations, the types of climate change imagery presented (e.g., images of causes, impacts, or solutions), political ideology, and various demographics. Bayesian hierarchical models were used to predict a subset of survey responses to the climate change imagery (e.g., support for policy, emotional response) from these predictors. In concluding, I integrate and summarize the findings, implications, and limitations of each study, as well as consider key points—both theoretical and practical—engendered by this work.

A Note on Analytic Philosophy and Bayesian Inference

I rely on a combination of frequentist (i.e., significance testing, sampling-based inference) and Bayesian analytic approaches. A mixture of approaches was used for several reasons. As noted prior, two of the chapters stem from work that has been previously published. In the interest of transparency and completeness, this work is reproduced exactly as it appeared in published form, using frequentist analyses such as null hypothesis significance testing (NHST) and confidence interval-based estimation. Since the publication of these works, I have begun primarily adopting a Bayesian approach to probability and statistical inference, the rationale for which is described at

length below. Therefore, I also provide a Bayesian re-analysis of the work discussed in Chapter 2. The results in Chapter 3 are described from a Bayesian perspective throughout. In addition to providing the frequentist results of the published work in Chapter 4, new analyses complimenting this work were performed using Bayesian hierarchical regression modeling.

Background on Bayesian and Frequentist Inference

While Bayesian views on probability have been around since the 1700's (Bayes, 1764), computing limitations prevented large-scale application. Modern computing advances and the development of Markov Chain Monte Carlo, coupled with increasingly efficient algorithms (e.g., Hamiltonian Monte-Carlo), have vastly increased the feasibility of Bayesian analysis for applied research. Bayesian data analysis has a variety of benefits making it a desirable alternative to frequentist maximum likelihood approaches for many applications (Gelman, 2017). While a full description of the approach of Bayesian statistics and philosophies of probability are beyond the scope of this document (see, e.g., Gelman & Shalizi, 2013), it is worth noting several important properties to guide the reader in interpreting Bayesian models. Simplified, Bayesian data analysis is the process of combining prior information (priors) with new observations (the likelihood) to generate full distributions (posteriors) of plausible estimates for quantities of interest (i.e., $\text{prior} \times \text{likelihood} = \text{posterior}$).

More formally, Bayesian data analysis relies on the application of Bayes' theorem for statistical inference. Bayes theorem states:

$$P(\theta|D) = \frac{P(D|\theta) \times P(\theta)}{P(D)}$$

$P(\theta|D)$ describes the posterior probability of an unknown parameter, θ (theta), given the data, D . $P(D|\theta)$ denotes the marginal likelihood of observing D from a model with θ . $P(\theta)$ encodes prior information formally about the parameters of interest, and $P(D)$ reflects the evidence accumulated in the data (Kruschke, 2014).

The Role of Priors in Bayesian Inference

Bayesian analyses directly encode and make explicit the uncertainty and degree of subjectivity in statistical models. This is done both through the necessity of directly specifying reasonable priors, and the generation of full distributions of plausible posterior estimates. Priors may represent specific ‘beliefs’ about plausible values informed by past research, or may fulfill other goals, such as ruling out strictly implausible values and improving model convergence (Gelman & Shalizi, 2013; McElreath, 2016). In this research, I generally follow recommendations derived from Gelman et al. (2013; see also, Gelman, 2006) and the Stan Development Team (2018) to develop prior specifications. Research by these teams and others suggests that using priors which provide enough information to improve estimation and convergence but that do not overly restrict parameters to specific prior findings typically produce more accurate estimates than overly restrictive or vague priors (see Betancourt, 2017). This philosophy of prior specification is commonly referred to as the specification of ‘weakly informative’ priors, or ‘regularizing’ priors. A similar conclusion for using these types of priors, though for slightly different theoretical reasons (e.g., maximum entropy), is arrived at by McElreath (2016).

While the addition of priors is often a source of consternation among those unfamiliar with this approach, priors are always involved in statistical modelling, whether

the researcher is fully aware of them or not. Frequentist ordinary least squares regression, for instance, technically includes the ‘prior’ that all possible outcome values are uniformly plausible, whether it be, for example, -100 or 2. And, methods such as LASSO and ridge regression place restrictions on the size (and inclusion) of parameter values to help avoid overfitting. While using so-called ‘non-informative’ priors might sound like a more reasonable approach when prior knowledge is limited, these can lead to misleading estimates or cause model convergence problems depending on the amount of data and the models specified (Betancourt, 2017). Furthermore, treating all values as equally plausible *a priori*, technically is not a ‘non-informative’ prior as it does encode a belief, so the name may be more misnomer than reality.

Therefore, at the absolute minimum, Bayesian approaches allow the researcher to include some information to improve estimation and accuracy (e.g., restricting the most plausible regression coefficients to be between, say, -2 and +2 on a standardized scale). This approach is valuable when prior information is minimal and it is reasonable to rule out large values. For instance, a linear interaction between two standardized ($M = 0$, $SD = 1$) scales containing varying measurement error is unlikely to produce effects larger than 2 units on a 1-5 outcome scale, purely based on the characteristics of such measurement. This is especially pertinent in the context of hierarchical regression (aka hierarchical modeling, multi-level modelling, mixed effects modeling).

Whereas non-Bayesian hierarchical regression typically requires a considerable amount of data to provide even rough estimates of multi-level structures (e.g., recommendations for having 6-to-8 or more groupings to estimate a hierarchical effect), Bayesian hierarchical regression is capable of estimating models with fewer restrictions,

in part due to the ability of specifying regularizing priors to enable model convergence (Gelman & Hill, 2006; McElreath, 2016). Indeed, the algorithms involved in frequentist hierarchical models based on maximum likelihood estimation may produce implausible estimates, or may not converge at all on an acceptable solution when few groups are estimated and variability is low. The partial pooling of variance in Bayesian hierarchical models tends to produce more stable, conservative estimates than non-hierarchical models or non-Bayesian implementations as well (McElreath, 2016).

Bayesian Posterior Distributions and Uncertainty Intervals

Bayesian data analysis generates entire distributions of plausible outcome estimates rather than single maximum likelihood point estimates. What this offers is the opportunity to evaluate a full range of plausible values with different degrees of assigned probability, conditional on the model specified. Evaluation of the full posterior distributions and other model characteristics, particularly through visual representations (Gabry, Simpson, Vehtari, Betancourt & Gelman, 2018), can help to better understand the range and uncertainty of parameter values. In contrast, the traditional form of quantifying estimation uncertainty in frequentist methods is to use the standard error to calculate 95% confidence intervals (95% CI) around an estimate of interest. However, these intervals are notoriously difficult to properly interpret given their basis in long-run sampling assumptions, even by seasoned researchers; such confidence intervals are frequently given probabilistic interpretations about plausible values that are not warranted (Morey, Hoekstra, Rouder, Lee, & Wagenmakers, 2016). For instance, if a confidence interval ranges from .05 to .65 for a regression estimate of .32, values at the ends of this interval are equally as plausible as values closer to the maximum likelihood estimate.

In contrast, Bayesian data analysis allows the researcher to correctly apply probabilistic interpretations across a full distribution of plausible values. When summarization is desired, highest posterior density intervals (*HPDI*) can be used, as these have a direct probabilistic interpretation: the 95% HPDI's include the range of values that capture 95% of the posterior density, with values closer to the center of the distribution capturing greater probability than values at the tails. However, it is important to emphasize that using 95% HPDI intervals, as opposed to 90%, 89%, or 50% is arbitrary, as these are simply summaries of the full distributions and are not connected to hypothesis testing or error rate calculations (McElreath, 2016).

The Philosophy of Bayesian Estimation in Comparison to Other Approaches

This form of full Bayesian inference stands in decided contrast to misapplications of null-hypothesis significance testing (NHST). The binary-decision making induced by such approaches, while most valuable when applied carefully and strictly, is not adequately designed to address the questions of interest for the majority of the work described in this manuscript, and arguably of the social sciences more broadly (see Gelman, 2017 for a discussion). Amidst a pervasive crisis of confidence in the published literature primarily based on NHST (e.g., Open Science Collaboration, 2015), alternatives that shift the analysts perspective back toward quantifying predictions and uncertainty, rather than relying on binary decisions, are desirable. Indeed, several statisticians and researchers summarized this sentiment well in a recent proposal to abandon 'statistical significance' altogether (McShane, Gal, Gelman, Robert, & Tackett, 2018). Substantive interpretation of the Bayesian models in this manuscript, derived from this perspective.

For a similar rationale, I opt to not compute ‘Bayes Factors’ for the models estimated (Jeffreys, 1961; Kass & Raftery, 1993). In spite of their growing popularity in the psychological sciences, a number of Bayesian statisticians and researchers caution against the use of Bayes Factors and demonstrate potential problems in their use/interpretation (e.g., Gelman & Carlin, 2017; Kruschke, 2014; Robert, 2016; Stern, 2017). For example, Bayes Factors have been shown to be much more sensitive to the prior specifications of each model compared, whereas this is not typically the case for estimation-based approaches (Kruschke, 2014; Gelman et al., 2013). Furthermore, while not in any way a natural byproduct of their computation (see, e.g., Morey, Romeijn & Rouder, 2016), the use of the size of a Bayes Factor to declare ‘significance’ or importance through the use of qualitative labels (e.g., Jeffreys, 1961; Wetzels et al., 2011) runs the risk of inducing the same binary decision-making that plagues NHST. Bayes factors are perhaps most useful when the researcher has two or more specific hypothesized models to compare (as opposed to comparing against a non-informative ‘null’ model). Furthermore, if the analyst has the knowledge to specify priors in this way, there is arguably little extra value gained from reporting Bayes Factors above and beyond what can be gleaned from interval estimation of the parameters of interest, as these directly quantify effects on the relevant scale. Nevertheless, an admirable goal of future research on ICT would be to develop informative priors to enable implementation of Bayes Factors and other likelihood-based comparisons, alongside estimation approaches.

The Philosophy of Model Interpretation in the Current Research

As noted prior, I focus the most substantive portion of my model interpretations on the full posterior distributions, depicting the range of plausible values generated by the

model for parameters of interest. Posterior predictive checks (i.e., evaluating whether the model predictions accurately reflect the distribution of the outcome measure), MCMC diagnostics (e.g., effective sample size, trace plots, R_{hat}), and related model checks were performed, and were satisfactory for all models reported unless otherwise noted. Most of the technical output of these steps are omitted from the text purely for the sake of length and clarity, though a description of these as they relate to each model can be found in Appendix B.

Evaluation of the full Bayesian posterior distributions is accompanied by a discussion of model comparisons based on estimated out-of-sample predictive performance where relevant. In contrast to the use of Bayes Factors or related means of comparing models, I focus here on estimated out-of-sample predictive performance through the use of information theory approaches, in part to emphasize the ultimate goal of having generative models to accurately predict outcomes of interest in future observations (Yarkoni & Westfall, 2017). Making modelling decisions based on statistical significance is actively discouraged, and using an out-of-sample predictive approach is known to help better mitigate the risk of overfitting statistical models (McElreath, 2016). However, it is important to take these estimates in a cautionary manner, and avoid making strong model decisions (e.g., choosing the ‘best’ model to interpret and fully discarding others) based on such comparisons (Gelman & Rubin, 1995).

While this approach to inference may not seem fully satisfying to some readers given the prevalence of NHST in the social sciences, selection through NHST is more likely to give the analyst an illusion of statistical certainty than an accurate understanding

of true model performance. Further, information criteria approaches may help put potentially interesting theoretical findings within a broader context; ‘significant’ interaction effects, for instance, may do little to improve prediction estimates in some cases (i.e., statistical significance overstates practical significance). In this work, I rely primarily on leave-one-out cross-validation comparisons as an information criterion (LOO IC) to estimate out-of-sample performance. In contrast of other related methods (e.g., splitting data into training and testing sets, or using AIC/DIC), Bayesian LOO approximates out-of-sample fit calculations while leaving one data point out per iteration (Vehtari et al. 2017). This approach is computationally intensive, but demonstrates superior accuracy to other methods such as AIC while also allowing efficient use of all data collected.

Therefore, I report LOO IC when aiming to compare related models (e.g., comparing models with or without a theoretically informed interaction term) and to roughly estimate out-of-sample predictive performance. The ‘loo’ package for R was used for computing LOO IC, which also calculates difference scores between models as well as a standard error of this estimate (see Vehtari et al. 2017). Given the relatively large samples employed in this research, the reader may loosely interpret better model performance by models with lower LOO IC scores, particularly when the size of the difference between LOO IC scores is larger than 2 or more standard errors. However, this is not a formal statistical test and has no connection to NHST, and should thus not be interpreted as such when making model decisions.

Paul Bürkner’s ‘brms’ package for R (Burkner, 2017), which harnesses the Stan programming language (Carpenter et al., 2017) to conduct full Bayesian inference, was

used for all Bayesian analyses reported. Stan uses Hamiltonian Monte Carlo with a No-U-Turn Sampler, an efficient and flexible approach to Bayesian analysis when compared with older samplers such as JAGS/BUGS (Carpenter et al. 2017). The ‘bayesplot’ package (Gabry & Mahr, 2017) was used along with ‘brms’ to graphically depict the posterior distributions and decompose model interactions where relevant. There are a variety of considerations involved in the specification of priors and the aforementioned sampling algorithms. To avoid repetition and provide an easy reference point, a full technical description of the models, including all prior specifications and any adjustments to Markov Chain Monte Carlo sampling can be found in the Appendix B.

CHAPTER 2

CLIMATE CHANGE AND DISASTERS

Introduction

Climate research is beginning to link extreme weather events to climate change, and the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment report warns that climate change could result in increased incidences or intensity of heat waves, heavy precipitation events, and droughts (IPCC, 2013). While it is not possible to directly attribute any single disaster to climate change in the immediate aftermath, media outlets often discuss this link in the wake of natural disasters (e.g., typhoon Haiyan; Sobel, 2013; Vidal & Carrington, 2013). As scientific consensus about the risks of climate change has grown more solid, research has also documented an increase in ideological polarization of public attitudes about climate change (Guber, 2013; McCright & Dunlap, 2011). This polarization affects individuals' decision making on environmentally related issues. For example, recent research has shown that framing product purchases in pro-environment terms (e.g., "Protect the Environment") can actually result in reduced intentions for purchasing the product among those likely to be skeptical of climate change (Gromet, Kunreuther, & Larrick, 2013).

In the current research, we investigated whether individuals' preexisting ideological beliefs about climate change might influence how they perceive natural disasters (in particular, food deprivation due to drought) and associated relief efforts when these events are framed as caused by climate change. We incorporate prior findings from the motivated reasoning literature and propose a distinct *second order* motivated reasoning effect: Ideological biases might extend beyond the interpretation of evidence

about an issue itself (i.e., direct motivated reasoning effects) and have second-order effects on how individuals construe information about world events framed in light of this polarizing issue (e.g., influencing reactions to a natural disaster when it is linked to climate change).

A wealth of past research on motivated reasoning indicates that people are often not even handed evaluators of facts and evidence and instead construe information to justify their preferred beliefs and outcomes (Kunda, 1990; Uhlmann, Pizarro, Tannenbaum, & Ditto, 2009). These motivational processes have been found to influence outcomes ranging from attitudes about capital punishment (Liu & Ditto, 2013) to demands for justice for torture victims (Leidner, Castano, Zaiser, & Giner-Sorolla, 2010). Important for the current study, research on motivated reasoning and the related process of cultural cognition also suggests that individuals construe scientific information in ideologically motivated ways (Kahan, 2013). Individuals' beliefs about climate change and perceptions of scientific consensus are, according to this research, molded in part by their preexisting beliefs; ideology and worldviews, rather than scientific illiteracy, may be to blame for low levels of public concern about climate change (Hart & Nisbet, 2012; Kahan et al., 2011; Kahan et al., 2012). Beliefs about the benefits and risks of technological advances also appear to be shaped by ideological motives, which influences attitudes toward important policy issues such as the use of nanotechnology (Kahan, Braman, Slovic, Gastil, & Cohen, 2009) and nuclear energy (de Groot, Steg, & Poortinga, 2013).

This ever-growing body of literature demonstrates the power of ideological biases in affecting judgments of information relevant to public policy, scientific knowledge, and

risk perception. What has not yet been explored is whether the ideological biases one holds about a polarizing issue such as climate change could also have secondary effects on how individuals respond to world events, such as natural or technological disasters, that are framed as being caused by this issue (e.g., reactions to victims of a drought that is linked to climate change). Although misconstruing facts about climate science itself bears a direct motivational link to the ideology of climate change skeptics, their perceptions of victim need following a natural disaster should not logically be influenced by whether the disaster is linked to climate change or not. We propose that this disaster framing might motivate skeptics to disengage from helping the victims by downplaying the severity of the disaster and endorsing beliefs that aid will be ineffective. Thus, not only should climate change skepticism influence the perceptions of whether the cause of the disaster is anthropogenic or not, but it should also have distal (i.e., not logically connected), second-order effects on how they perceive the victims and need for aid following a disaster framed as being caused by climate change.

To test this hypothesis, we examined participants' attitudes toward disaster victims after reading about a famine ostensibly caused by anthropogenic climate change compared to a famine caused by "normal" droughts. We predicted that those skeptical of climate change would be motivated to construe information about victim need and the effects of the disaster differently when it is framed as resulting from climate change. Due to the inconsistency of this disaster framing with their ideology, we hypothesized that skeptics would react against this frame by utilizing any aid-related justifications that would allow them to disengage from the helping context and downplay the disaster, such as perceiving less need for outside aid, blaming the victims, and describing aid as

ineffective or corrupt. Given the conceptual and empirical link between aid justifications and donation decisions (e.g., Zagefka, Noor, Brown, Hopthrow, & Randsley de Moura, 2012), we predicted that the increase in negative justifications would in turn predict less positive attitudes toward donating to relief efforts. Conversely, for those low in skepticism, we predicted that this disaster framing could increase positive justifications (e.g., greater perceived need) since the climate change framing is consistent with non-skeptics' beliefs that current climate changes are at least partially human caused. Furthermore, while we expected a significant relationship between political conservatism and climate change beliefs (e.g., McCright & Dunlap, 2011), we predicted that participants' climate change beliefs (rather than political ideology) would form the specific motivational foundation for disengagement from a disaster scenario framed as related to climate change. Therefore, we measured individuals' beliefs about climate change as well as political ideology to test the relative influence of each on reactions to victims of a disaster linked (or not) to climate change.

Methods

Participants

We recruited participants with the goal of having 100 participants in each of the two conditions. Because we did not know the effect size for this manipulation, we couldn't conduct a formal power analysis, but we chose 100 participants per condition as a conservative sample size. We knew from past experience that we would have some attrition (due to inattention to the manipulation, etc.) in our MTurk sample. On the day on which our MTurk sample size was over 200, we let the study continue for the remainder of the day. At this point, we had a sample of 235. Prior to analysis, 24 participants were

excluded for either indicating on a self-report measure that they did not take the study seriously or for spending unusually short or long amounts of time reading the manipulation materials (less than 15 s or greater than 18 min). The final sample used for analyses consisted of the remaining 211 participants ($M_{age} = 36.79$, $SD = 13.39$; 51.7% male; 82% White; 100% U.S. citizens). Participants were paid 50 cents for completing the study.

Materials and Procedure

The study was described to participants as a survey of individuals' attitudes toward relief efforts after disasters. All participants completed a consent form prior to participation and were debriefed using an online form at the end of the survey. During the study, participants read a news article containing the manipulation and then answered a series of survey questions about justifications for or against helping the victims, attitudes about donating, and climate change beliefs. At the end of the study, participants answered demographic questions (age, sex, etc.).

The news article described a famine in Sub-Saharan Africa caused by a series of severe droughts (adapted from Zagefka, Noor, Brown, Randsley de Moura, & Hoptthrow, 2011). We manipulated whether the famine was caused by severe droughts (control condition) or by severe droughts linked to climate change (climate change condition). Other than the climate change manipulation, content was constant across conditions.

After reading the news story, participants completed a set of dependent measures and individual difference measures. To determine whether linking the droughts and famine to climate change increased the degree to which participants perceived the disaster as human caused, two questions regarding perceived cause of the disaster were

included at the end of the survey (e.g., “To what extent do you think the disaster mentioned in the article was caused by human actions,” 1 = *not at all*, 7 = *very much*). These 2 items were combined into a composite with higher scores indicating greater belief that the disaster was human caused ($M = 3.57$, $SD = 1.55$, $\alpha = .78$).

Donation decision justifications and attitudes about donating

After the manipulation, participants responded to measures addressing their attitudes toward donating to relief operations as well as their justifications to provide or withhold aid. These measures were adapted from recent research by Zagefka and colleagues and are described at length subsequently (for a complete discussion, see Zagefka et al., 2012; Zagefka et al., 2011). All donation-related measures were scored on 7-point scales (1 = *strongly disagree*, 7 = *strongly agree*). Table 1 displays the correlations between climate change skepticism, conservatism, and each of the donation-related measures.

Participants first responded to a measure of donation attitudes, which assessed their intentions to donate as well as their beliefs that donating to the victims was the right thing to do in this disaster context. These attitudes about donating were assessed with a 5-item composite (e.g., “I would be willing to give donations to the victims of this disaster,” $M = 4.60$, $SD = 1.32$, $\alpha = .91$). This measure was coded such that higher scores indicated more positive attitudes toward donating.

We then measured justifications to provide or withhold donations using five interrelated constructs, each of which have been demonstrated to influence donation decisions in past research on natural and human-caused disaster events (see Zagefka et al., 2012; Zagefka et al., 2011, for a detailed discussion). Zagefka, Noor, Brown,

Hopthrow, and Randsley de Moura (2012) found that when asked to provide rationales for donating (or not) to various disasters, participants' most frequently cited rationales included those relating to perceptions of need, perceived impact of donations, beliefs about how much others have donated, the cause of the disaster, and victim blaming. Also frequently mentioned were beliefs about the extent to which victims were seen as helping themselves, which has been shown in experimental research to also play an important role in aid decisions (Zagefka, et al., 2011). Given these findings and the additional experimental research by Zagefka and colleagues, we selected these five constructs (excluding "cause of the disaster," as this was our manipulation) to include as our measures of donation justifications. Theoretically, these constructs broadly encapsulate perceptions of the disaster victims (e.g., are the victims to blame, are they taking steps to help themselves) as well as beliefs about the efficacy of donating to the relief efforts (e.g., is aid likely to reach those most in need, are enough other people likely donating). All five measures of donation justifications were coded such that higher scores indicated greater justifications to withhold donations (e.g., greater victim blame, less perceived victim need).

Two items measured perceived need of relief donations, which were designed to address the perceived severity of the disaster and the necessity for donations to help the victims (e.g., "I believe that there is a huge need for outside help after this disaster," $M = 2.68$, $SD = 1.20$, $r = .70$). Four items measured victim blaming, focusing on the extent to which the victims were perceived as at fault for their current situation (e.g., "I think the victims of the disaster might have been responsible for their plight themselves at least to some extent," $M = 2.18$, $SD = 1.26$, $\alpha = .94$).

Perceived victim self-help was also measured with 4 items focusing on perceptions of whether the victims were actively trying to improve their situation or not (e.g., “I believe that the victims did everything humanly possible to improve their situation the best they could,” $M = 2.72$, $SD = 1.26$, $\alpha = .91$).

Two items measured participants’ beliefs about donation sufficiency (i.e., do donations by others make personal donations unnecessary? “I believe that so many other people have or will still donate to the victims of this disaster that my own help is unnecessary,” $M = 3.19$, $SD = 1.40$, $r = .85$). These items addressed assumptions about how others are or are not responding to the disaster (for an extended discussion, see Zagefka et al., 2012). Participants then responded to 4 items assessing their beliefs about donation impacts, including whether they believed that aid would be effective and reach those most in need (e.g., “I believe that money donated to the victims of this disaster most likely doesn’t reach the victims, but just benefits corrupt politicians and fanatics in power positions,” $M = 3.57$, $SD = 1.40$, $\alpha = .92$).

Climate change skepticism and political ideology

After the donation-related measures, participants responded to a battery of items designed by the researchers to assess attitudes related to climate change. Five items were designed to assess general climate change beliefs (e.g., “I am certain that climate change is happening”). These 5 belief items, which served as our measure of climate change skepticism, were scored on 9-point scales (1 = *strongly disagree*, 9 = *strongly agree*) and coded such that higher scores indicate greater skepticism and less concern about climate change ($M = 3.38$, $SD = 2.03$, $\alpha = .93$). As expected, scores on climate change skepticism were not influenced by the climate change framing ($M = 3.42$ in climate change

condition, $M = 3.34$ in control, $t(209) = -.29$, *ns*). At the end of the study, we also included a single item measure of political ideology (1 = *very liberal*, 6 = *very conservative*; $M = 3.05$, $SD = 1.34$). Conservatism and climate change skepticism were positively correlated, $r(208) = .55$. In addition, as exploratory measures, we included four other brief measures regarding climate change policies, attitudes about America's contribution to climate change, identification with environmentalism, and perceived geographical distance of climate change effects.

Table 1. Correlations between climate change skepticism, conservatism and donation-related measures.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Climate Change Skepticism (1)	1							
Conservatism (2)	.55***	1						
Donation Justifications Composite (3)	.44***	.26***	1					
Attitudes about Donating (4)	-.34** *	-.17*	-.67** *	1				
Low Perceived Need (5)	.42***	.18**	.74***	-.72** *	1			
Donation Sufficiency (6)	.31***	.12 [†]	.65***	-.47** *	.42***	1		

Donation Impacts (7)	.17**	.08	.72***	-.51** *	.46***	.40***	1	
Victim Blaming (8)	.36***	.29***	.70***	-.28** *	.37***	.20**	.28** *	1
Low Victim Self-Help (9)	.33***	.28***	.76***	-.40** *	.44***	.23***	.38** *	.71***

Note. †p = .09. *p ≤ .05. **p ≤ .01. ***p ≤ .001.

Results

The Effects of Disaster Framing on Beliefs about Disaster Cause

We first tested whether framing the droughts and famine as the product of climate change significantly affected the degree to which participants attributed the disaster to human causes. Participants in the climate change condition ($M = 4.19$, $SD = 1.54$, $n = 101$) were significantly more likely to attribute the disaster to human causes, $t(209) = -6.08$, $p < .001$, 95% confidence interval (CI) = $-1.59, -0.812$, Cohen's $d = .83$, than in the control condition ($M = 2.99$, $SD = 1.33$, $n = 110$). As predicted, there was also a significant interaction between skepticism and condition (0 = *control condition*, 1 = *climate change condition*) on perceptions of the disaster as human caused, controlling for political ideology ($b = -.31$, $SE = 0.08$, $t = -3.68$, $p < .001$, 95% CI = $-0.475, -0.144$). In the control condition, skepticism did not predict attributions of the disaster to human causes ($b = -.10$, $SE = 0.06$, ns). Conversely, skepticism was strongly associated with disaster attributions in the climate change condition, such that higher skepticism was

associated with lower belief that the disaster was attributable to human causes ($b = -.41, SE = 0.07, t = -6.11, p < .001, 95\% CI = -0.539, -0.276$).

The Impact of Disaster Framing on Donation Justifications

Given our prediction that there would be an overall second-order motivated reasoning effect whereby linking the disaster to climate change would cause climate change skeptics to utilize any justification to withhold aid presented to them as a means of disengaging from the helping context, we opted to create a global composite of the five justification measures (perceived need, donation sufficiency, donation impacts, victim blaming, and perceived self-help). Combining these five scales together formed a reliable composite ($M = 2.87, SD = 0.93, \alpha = .76$), with higher scores indicating greater justifications for withholding donations.

However, to provide a thorough examination of this second-order motivated reasoning prediction, we also tested for the interaction between climate change skepticism and condition on each of the justification measures individually (see Table 2). Consistent with our hypothesis, in each case, we observed the predicted interaction pattern between climate change skepticism and disaster framing that mirrors the results of the full justifications composite.

Table 2. The interaction between climate change skepticism and experimental condition on the individual donation justification measures.

Variable	<i>b</i>	<i>SE</i>	95% Confidence Intervals	
			Lower	Upper
Low Perceived Need				
Overall Interaction	.17*	.07	.029	.319
Climate Change Condition	.36***	.06	.245	.475
Control Condition	.19***	.06	.075	.298

Donation Sufficiency				
Overall Interaction	.18*	.09	.004	.362
Climate Change Condition	.34***	.07	.195	.478
Control Condition	.15*	.07	.016	.291
Donation Impacts				
Overall Interaction	.24**	.09	.058	.426
Climate Change Condition	.26***	.07	.111	.403
Control Condition	.02	.07	-.126	.157
Victim Blaming				
Overall Interaction	.26***	.08	.102	.411
Climate Change Condition	.31***	.06	.190	.435
Control Condition	.06	.06	-.062	.174
Low Victim Self-Help				
Overall Interaction	.15 [†]	.08	-.008	.308
Climate Change Condition	.24***	.07	.113	.364
Control Condition	.09	.06	-.033	.210

Note. [†] $p < .07$. * $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

When examining the full composite, there was a significant interaction between climate change skepticism and condition (controlling for political ideology) on justifications to withhold aid, consistent with our predictions ($b = .20$, $SE = 0.06$, $t = 3.62$, $p < .001$, 95% CI = 0.092, 0.310).¹ In the climate change condition, climate change

¹ When examined in isolation, political ideology (i.e., conservatism) showed a generally similar (though weaker) pattern as climate change skepticism. However, when controlling for climate change skepticism, there was no longer a coherent relationship between political ideology and the outcome measures. Conversely, the patterns for climate change skepticism were robust both when examined alone and when controlling for political ideology.

skepticism strongly predicted greater justifications for withholding aid ($b = .30$, $SE = 0.04$, $t = 6.84$, $p < .001$, 95% CI = 0.214, 0.388). Skepticism also predicted greater justifications to withhold aid in the control condition, although to a lesser extent ($b = .10$, $SE = 0.04$, $t = 2.35$, $p = .02$, 95% CI = 0.016, 0.184). Figure 1 displays the interaction between skepticism and framing condition on the donation justifications composite.

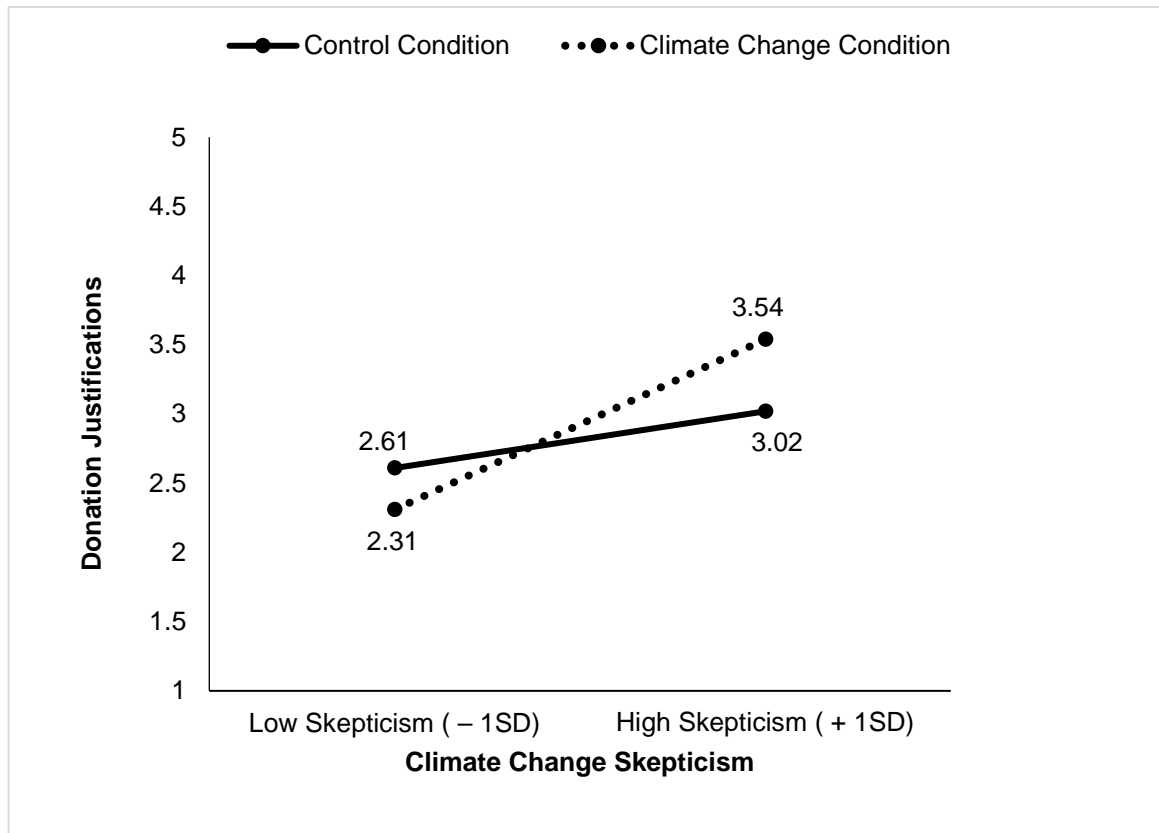


Figure 1. Donation justifications scores as a function of the interaction between climate change skepticism and experimental condition.

As predicted, there was a significant effect for those high in skepticism when comparing the climate change condition and the control condition, with skeptics (+1 *SD* on skepticism) exhibiting more negative donation justification attitudes in the climate change condition ($M = 3.54$) than in the control condition ($M = 3.02$; $b = .52$, $SE = 0.16$, $t = 3.27$, $p = .001$, 95% CI = 0.207, 0.835). There was also a marginal

effect for those low in skepticism ($-1 SD$) in the opposite direction such that non-skeptics exhibited less negative justifications in the climate change condition ($M = 2.31$) than in the control condition ($M = 2.61$; $b = -.30$, $SE = 0.16$, $t = -1.87$, $p = .063$, 95% CI = $-0.613, 0.017$).

Moderated Mediation Analysis

Because past research has also outlined a link between the donation justification measures and actual attitudes about donating (Zagefka et al., 2012; Zagefka et al., 2011), we also tested whether the donation justifications would mediate the relationship between climate skepticism and participants' attitudes toward donating to relief efforts. To examine this prediction, we conducted moderated mediation analyses with the donation justification composite as a mediator between climate change skepticism and attitudes about donating. We tested moderation of both the indirect path from skepticism through donation justifications and the direct path from skepticism to attitudes about donating by experimental condition (Hayes, 2013; model 8).

Although recent methodological research on mediation (e.g., Hayes, 2009; Rucker, Preacher, Tormala, & Petty, 2011; Zhao, Lynch, & Chen, 2010) indicates that it is not required for there to be a significant overall relationship between the IV and distal outcome variable (in this case, donation attitudes), from our second-order motivated reasoning perspective, we also anticipated there would be an interaction between climate change skepticism and experimental condition on attitudes about donating that would mirror the effects shown for donation justifications. Thus, we tested for the interaction of climate skepticism and framing condition on donation attitudes, controlling for political ideology. Consistent with the findings for the donation

justification measures, there was a significant interaction on attitudes about donating ($b = -0.17$, $SE = 0.08$, $t = -2.06$, $p = .041$, 95% CI = $-0.336, -0.007$). In the climate change condition, greater climate change skepticism predicted less positive attitudes toward donating ($b = -0.32$, $SE = 0.07$, $t = -4.85$, $p < .001$, 95% CI = $-0.452, -0.191$). There was also a weaker (but significant) relationship in the control condition ($b = -0.15$, $SE = 0.06$, $t = -2.33$, $p = .021$, 95% CI = $-0.276, -0.023$). Thus, climate change skepticism predicts donation attitudes, and this relationship is significantly stronger in the climate change framing condition than the natural drought condition. Therefore, next we tested whether this relationship was mediated by the justifications for/against providing aid.

Using Hayes' PROCESS macro for SPSS 22 (Model 8), we conducted a moderated mediation analysis testing moderation (by experimental condition) of both the direct and indirect paths (i.e., mediated by donation justifications) from skepticism to donation attitudes. As predicted, Hayes' index of moderated mediation (which uses bootstrapping methods to test for moderated mediation, see Hayes, 2015) did not pass through zero (95% bootstrapped CIs ($b = -0.19$, $SE_{boot} = 0.06$, 95% CI = $-0.316, -0.071$)). This test indicates that the strength of the indirect effect from skepticism to attitudes about donating through donation justifications was significantly different in the climate change and natural drought conditions. Follow-up examination of each of these conditional indirect effects indicates that there was a significant indirect effect of skepticism on donation attitudes through donation decision justifications for participants in the climate change condition ($b = -0.28$, $SE_{boot} = 0.05$, 95% CI = $-0.393, -0.185$, 95% CIs generated using 10,000 bootstrapped samples). There was also a significant indirect effect in the natural drought condition, although to a lesser extent ($b = -0.09$, $SE_{boot} = .04$,

95% CI = -0.181, -0.008). Furthermore, after accounting for the indirect (i.e., mediated) effects, there was no significant conditional direct effect in the control ($b = -.06$, $SE_b = 0.05$, ns) or the climate change condition ($b = -.04$, $SE_b = 0.06$, ns).²

Discussion

The present research suggests that framing a disaster as caused by climate change can impact the degree to which individuals justify providing or withholding humanitarian support. Consistent with our second-order motivated reasoning hypothesis, participants high in climate change skepticism utilized greater justifications for withholding aid when the disaster was framed as climate change caused, which also had a negative effect on their attitudes toward donating to victims. These findings contribute to the growing literature on the role of motivated reasoning and ideology in the construal of scientific information and its effects on public policy (Kahan, 2013; Kahan et al., 2012; Roh, McComas, Rickard, & Decker, 2015). In particular, this study further extends the

² As the donation justifications theoretically fall within two broader, though highly related, categories of victim-specific justifications (e.g., victim blaming) and aid effectiveness-related justifications (e.g., donation sufficiency), at the suggestion of a reviewer we also factor analyzed all of the justification items using principle axis factoring, an oblimin rotation, and selected a two-factor solution. Examination of the factor loadings supported this theoretical structure of these constructs. The items for victim blaming and perceived victim self-help loaded highly together on one factor, while the items for donation sufficiency and donation impacts loaded together on a separate factor. The 2 items measuring perceived need cross loaded and were therefore not included in further composites and analyses described subsequently. Two separate composites were formed based on this analysis, both of which were highly reliable (victim-specific justifications: $\alpha = .94$, aid effectiveness-related justifications: $\alpha = .88$) and correlated, $r(209) = .37$, $p < .001$. Using these composites, we tested an additional moderated mediation analysis (again controlling for political ideology) entering the two new composites together as mediators. In this analysis, the conditional direct effect of skepticism on willingness to donate retained significance in the climate change ($b = -.13$, $SE = 0.06$, $p = .036$) and the control condition ($b = -.10$, $SE = 0.05$, $p = .05$). When entered simultaneously, the conditional indirect effect of the aid effectiveness composite was significantly different in the climate change condition compared with the control condition, indicating significant moderated mediation for this variable ($b = -.12$, $SE_{boot} = 0.05$, 95% CI = [-0.243, -0.032]). The index of moderated mediation for the victim-specific composite did not reach significance ($b = -.03$, $SE_{boot} = .02$, 95% CI = [-0.098, 0.001]).

implications of ideologically motivated construal by providing novel evidence for a second order motivated reasoning effect. The biases one holds about a politicized issue such as climate change can affect perceptions and responses to the distal consequences of disaster events that are framed as connected with this politicized issue.

As discussed previously, much of the literature on ideology and interpretation of scientific evidence has focused on how motivated reasoning processes affect the public's interpretation of scientific evidence (e.g., Kahan et al., 2011; Kahan et al., 2012). In this context, motivated construal of the scientific information is directly related to one's ideological beliefs (i.e., direct motivated reasoning effects). Our findings suggest that future work should also explore the potential for second order effects, whereby individuals construe information about world events differently depending on whether they are linked with a polarizing issue. This could possess significant implications for how scientific information about present and future risks is communicated to the public. It is rarely the case that the discussion of these issues in the media is free of ideological framings. Media speculation about climate change as the cause of recent natural disasters is commonplace. This is further exemplified in much of the recent dialogue regarding the ongoing (at the time of writing) droughts in California (e.g., Samenow, 2015). What our research suggests is that making this connection between the scientific evidence and a real disaster could have quite troublesome effects for how (certain) members of the public respond to these disasters.

Given the real possibility that some ongoing and future disasters are/will be, in fact, related to climate change, understanding how individuals reason about these events and construe disaster-related information in light of their ideological beliefs seems

particularly pertinent. Future research, therefore, should extend the scope of inquiry beyond the effects of worldview biases on the construal of scientific information to also examine how linking this information with real disasters affects individuals' responses to the victims of such events and their perceptions of future, related, disaster risks (e.g., likelihood of impending wildfires).

This study also contributes to research on the psychology of charitable giving by indicating that disagreement over a heavily divided political issue can affect helping behaviors. The issue of polarization of relief efforts as a product of dimensions of the disasters themselves has been largely unexplored in the literature. In the most relevant preexisting research, Zagefka et al. (2011) found that people look at human-caused disasters differently than “natural” disasters. In their work, famine caused by war generally led to less support for donations than a famine caused by naturally occurring drought. The current research shows the influence of beliefs about climate change is also important when droughts are framed as being caused by climate change. For climate change skeptics, in particular, support for aid was lower when the drought was caused by climate change. Intriguingly, there was also some evidence of an opposite effect for those low in skepticism showing particularly low levels of justifications for withholding aid when the drought was described as being caused by climate change. Although the current study showed that the framing effect was stronger for climate change skeptics, future research should examine in more detail the ways in which climate change framings may impact climate change believers as well as skeptics. Outside of the work of Zagefka and colleagues, there is still little known about how the different causes of disasters and

related dimensions of ideology influence the donation decision process and this is an important topic for future research.

These findings also possess implications for media portrayals of disaster events, particularly when large amounts of external public donations are required to respond to these events. These data suggest that organizations appealing for aid (and media outlets reporting on natural disasters) should be cautious of blending aid appeals with the discussion of contentious ideological topics, as it could result in an unintended backlash against the disaster victims. While our findings indicate that framing a natural disaster as the product of climate change may affect donations, future research should build on these findings by testing them in the context of future disasters as they unfold.

Although the scientific evidence about the role of human activity in causing climate change has reached consensus, there remains great uncertainty about the role of climate change in any specific weather event and even longer term patterns such as recurring drought. This inherent uncertainty means that many, if not all, events that may be caused by climate change will be subject to debate and divergent interpretations. As the current work shows, these interpretations and divergent perspectives may even affect people's perceptions of the victims of disaster events via motivated reasoning processes.

Bayesian Re-Analysis of Focal Models

Following publication, I re-evaluated the central results using a Bayesian estimation approach in order to generate full posterior distributions of estimates and inform future investigations. I re-estimated the two focal interaction models, one for the full negative justifications composite and the other for donation attitudes. The technical details of the model specifications and priors can be found in Appendix B. Stated

succinctly, the models were fit using weakly informative prior distributions on the regression coefficients and residual standard deviation, and the non-dummy coded predictors were standardized ($M = 0$, $SD = 1$). Figures 2 through 5 provide graphical depictions of the interactions and full posterior distributions. These results are highly consistent with those reported in the original analysis. However, model comparisons also shed additional light on strength of evidence accumulated.

In terms of predicting justifications for withholding aid to victims, the posterior median of the interaction term was .41, 95% HPDI = .18, .62. Figure 2 provides a graphical decomposition of the interaction (see Figure 3 for full posterior distributions). Using a Bayesian implementation of the R-squared statistic, this model accounted for roughly 25%, 95% HPDI = 16, 33 of the variance. However, when performing model comparison via LOO IC, the model including the interaction term was not considerably better than a model without the term ($LOO IC \text{ difference} = -11.15$, $SE = 8.12$). This focus on out-of-sample predictive performance highlights that, while theoretically informative, the interaction effect observed may be of limited importance for improving prediction.

However, additional research with an explicit focus on performance will help provide better clarity in this regard.

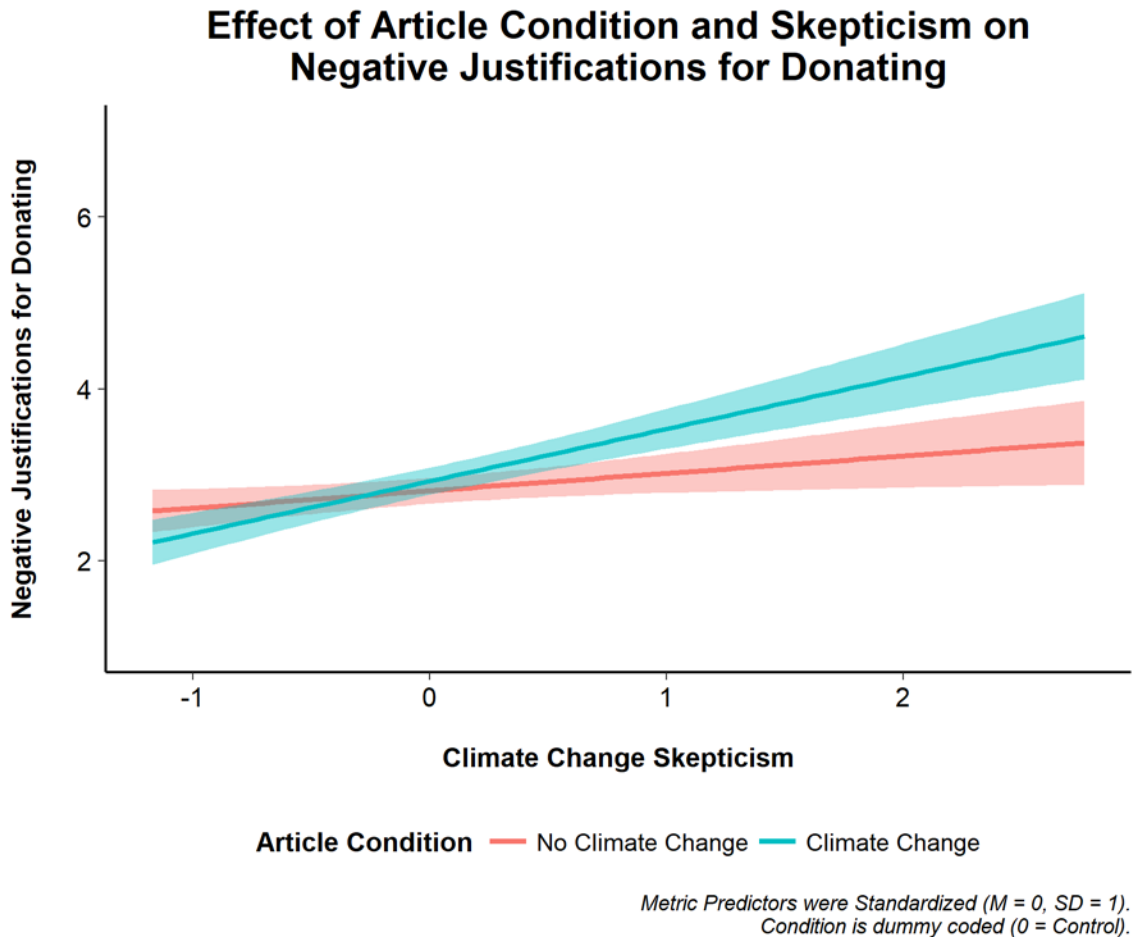


Figure 2. Effect of article condition and skepticism on negative justifications for donating. Results come from a Bayesian regression model. Lines represent posterior slopes in each condition. Shaded intervals are 95% fitted regression intervals.

For the donation attitudes outcome measure, the interaction model accounted for roughly 14% [.07, .22] of the variance. Figure 4 displays the decomposition of the interaction, and figure 5 displays the posterior distributions. In this model, the variability in the interaction estimate was considerable (*Posterior Median* = -.35, *95% HPDIs* = [- .67, < .01]). Values at or above zero cannot be fully ruled out for this estimate, although more than 90% of the posterior probability was below zero.

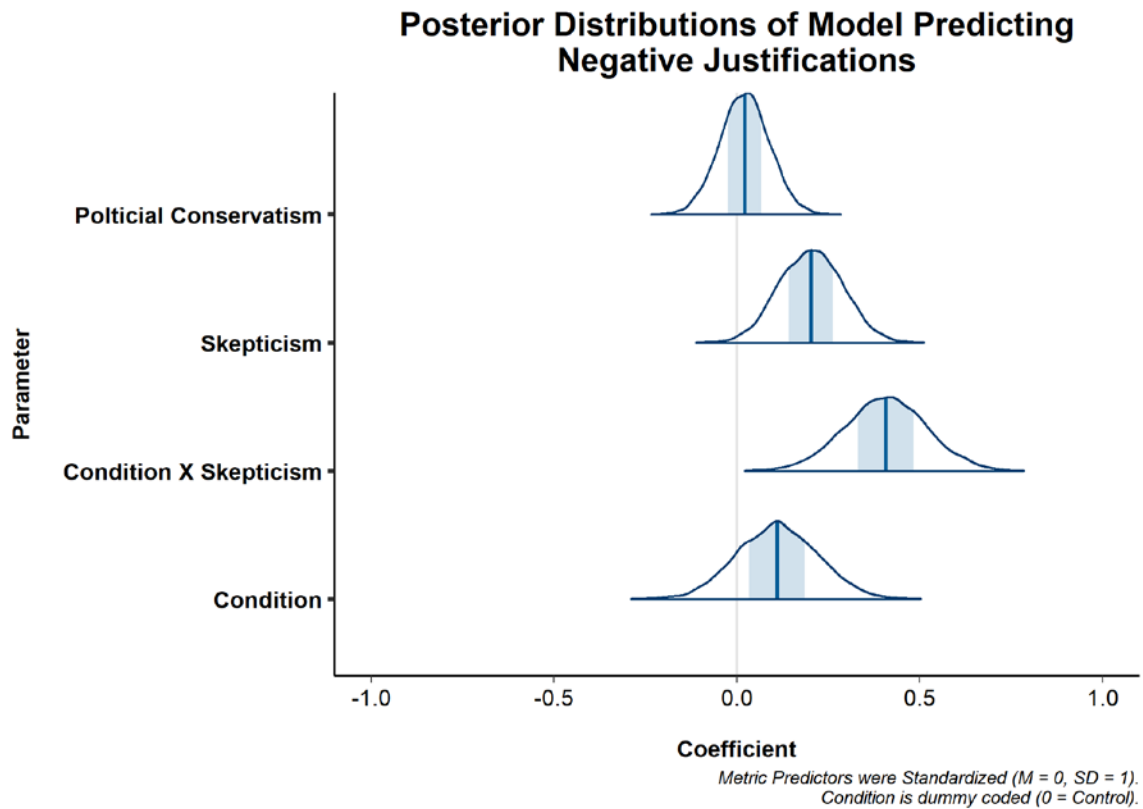
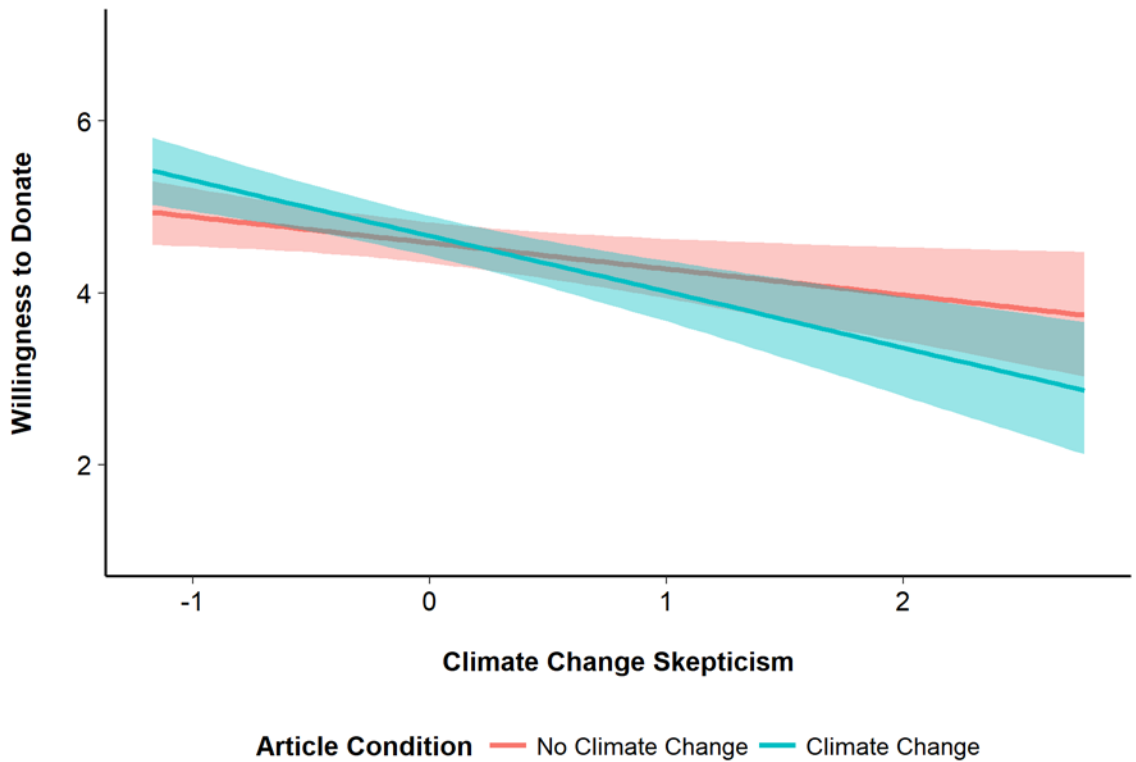


Figure 3. Posterior distributions of model predictive negative justifications. Full posterior distributions from Bayesian linear regression model. Vertical blue lines represent posterior medians and shaded intervals represent 50% posterior intervals.

When comparing the interaction model to a model removing the interaction term, LOO IC comparison suggested nearly indistinguishable predictive capacity for these two models ($LOO\ IC\ difference = -2.21$, $SE = 4.51$). Thus, while the interaction on willingness to donate met conventional standards of statistical significance from a frequentist perspective, a Bayesian re-analysis suggests both greater uncertainty and limited gains in terms of prediction.

Effect of Article Condition and Skepticism on Willingness to Donate



*Skepticism was Standardized (M = 0, SD = 1).
Lines Represent Posterior Slopes in Each Condition*

Figure 4. Effect of article condition and skepticism on willingness to donate. Results come from a Bayesian regression model. Lines represent posterior slopes in each condition. Shaded intervals are 95% fitted regression intervals.

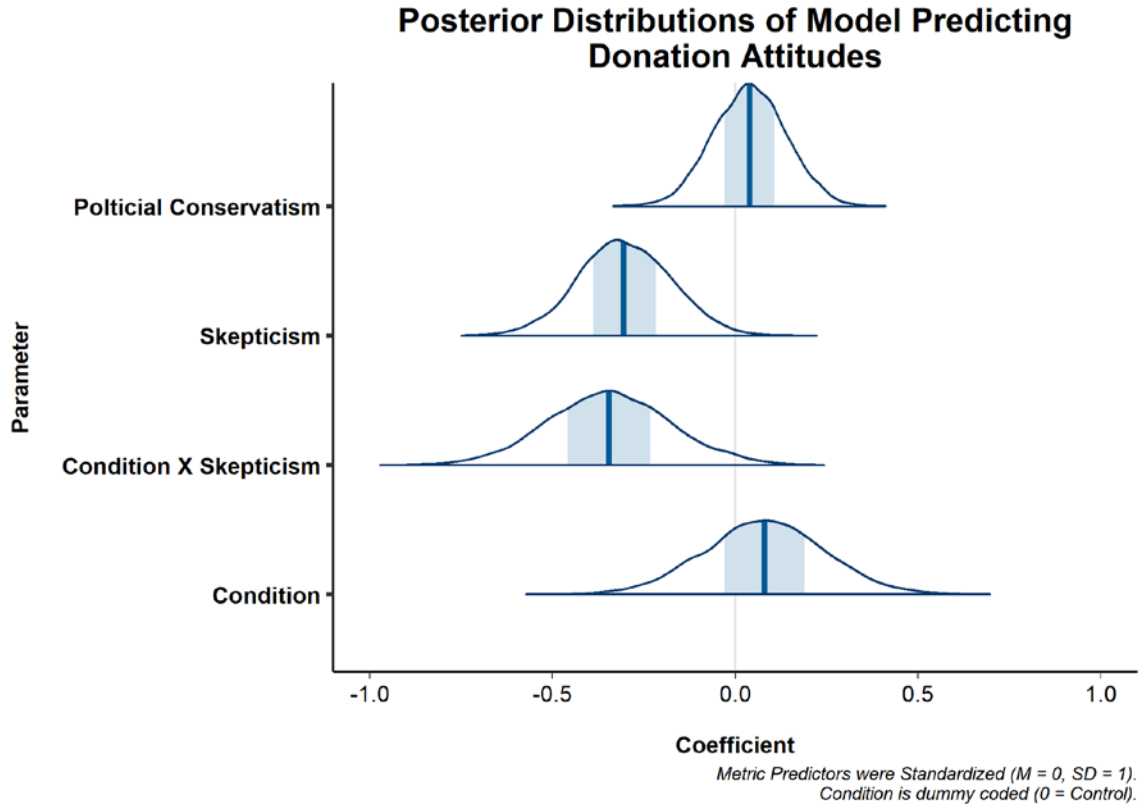


Figure 5. Posterior distributions of model predictive donation attitudes. Full posterior distributions from Bayesian linear regression model. Vertical blue lines represent posterior medians and shaded intervals represent 50% posterior intervals.

Bridge to Chapter 3

Since the initial publication of this work, other research teams have arrived at related conclusions using different approaches and contexts. Hine et al. (2016), for example, found that Australians dismissive of climate change as a public risk were more receptive to messages encouraging adaptation behaviors when climate change was not explicitly mentioned. Perhaps even more central is recent work by Kahan et al (2017). In their study, linking the Zika virus explicitly with either climate change or illegal immigration produced polarized public judgments of the risk of Zika along ideological lines. Stated differently, those on both the left and the right end of the ideological

spectrum engaged in identity-protective measures when faced with explanations for a public risk that were not in accordance with their predominant worldview. This work provides an interesting complement to the study discussed in Chapter 2. However, future work should continue to follow up on these findings and better understand their ecological validity and importance for public engagement.

Clearly, making explicit attributions to climate change is capable of activating ICT processes that generalize to other domains. In particular, Chapter 2 documented the pervasive influence of motivated reasoning when it interacts with firm ideological positions such as climate change skepticism. When considering Chapter 2 in conjunction with Kahan et al. (2017) and Hine et al. (2016), it is also clear that these types of ICT processes are not constrained to a particular ideological position. Those on both ends of the ideological spectrum holding a variety of different issue-specific attitudes may utilize ICT for different purposes. However, I would express caution about over-interpreting the results to date on this issue. For one, the research described has not been validated with ecologically-valid behavioral outcomes, and instead relies on self-reported attitudes and intentions. Further, the Bayesian model comparisons suggest that the interaction effect may not necessarily improve our capacity to predict donation attitudes or negative justifications. Future work should follow up these investigations with an emphasis on both of these issues.

Whereas the work in Chapter 2 focused on motivated reasoning using an experimental paradigm in relation to climate change attitudes and political identity, Chapter 3 shifts directions to examine how strongly held social identities influence judgments of responsibility and action intentions following a personally-relevant

environmental scandal. The work in Chapter 3 compliments the findings of Chapter 2 by exploring how multiple, potentially intertwined, social identities unrelated to climate change bias influence responses to environmental problems.

CHAPTER 3

INTERACTIVE IDENTITIES AND THE VOLKSWAGEN SCANDAL

Introduction

In September 2015, the Volkswagen Group (VW) admitted to intentionally programming the onboard software of their turbocharged direct injection (TDI) diesel vehicles to circumvent emissions regulations. This so-called “defeat device” results in nitrogen oxide (NO_x) emissions during vehicle use that significantly exceed regulatory limits imposed in the United States and many other countries. An estimated 500,000 vehicles operating in the United States and 11 million globally currently have the device installed, contributing to increases in global NO_x emissions (Gates, Ewing, Russel, & Watkins, 2016). VW’s intentional circumvention of emissions regulations is likely to have significant health and environmental impacts, including increased smog (United States Environmental Protection Agency, 1999), exacerbation of respiratory illnesses, and premature deaths (Barrett et al., 2016).

Perhaps less salient are impacts and implications of the scandal for the owners of affected vehicles. These include not only likely financial losses due to rapid depreciation of affected vehicles but also psychological and social impacts that can come along with being associated—fairly or not—with a harmful product, brand or identity (Trump, 2014). Moreover, the scandal places owners in a difficult situation regarding what to do with their vehicles that pit competing priorities and values against one another, including vehicle performance, cost, and environmental impact. These decisions will impact not only owners themselves but also their neighbors and others more broadly, given the negative impacts of NO_x emissions. Thus, the current emissions problem is an interesting

and challenging example of a social dilemma (Fudenberg, Rand, & Dreber, 2012; Rand, Arbesman, & Christakis, 2011; Rand, Dreber, Ellingsen, Fudenberg, & Nowak, 2009).

While ascribing responsibility to VW for misconduct is certainly warranted in this case, research demonstrates that a vital factor in motivating individual responses to social dilemmas is feeling a degree of personal responsibility for taking action (Iyengar, 1989; Van Lange, Joireman, Parks, & Van Dijk, 2013; Weiner, 2006). Existing literature on ascriptions of responsibility for causing and responding to environmental and public health problems is fairly limited, however, particularly research that concurrently examines how perceived responsibility both for causing and for responding to a problem influences behavior (Jang, 2013; Rickard, Yang, Seo, & Harrison, 2014; Yang, Seo, Rickard, & Harrison, 2015). Understanding whether and why owners ascribe personal responsibility for contributing to and solving the emissions problem is thus critical for supporting effective owner-driven responses.

We report findings from research conducted with owners of affected VW TDI vehicles in the United States in which we investigate one potentially powerful, yet complex, driver of both perceived responsibility and behavioral intentions: social identity. Drawing on research from psychology, marketing, and behavioral economics, we explore how the interaction of multiple contextually activated identities, i.e., environmental and brand identification, influences ascriptions of responsibility for contributing to the emissions problem and for repairing impacted vehicles, and how these perceptions influence intentions to fix vehicles in spite of potential personal costs of doing so.

Research indicates that the groups and causes people identify with powerfully shape how they interpret and respond to events related to those identities (Clayton & Opatow, 2003; Tajfel & Turner, 1986). Social identity processes may be important for collective action problems specifically because they can influence ascriptions of responsibility for responding to large-scale problems with diffuse causes and solutions. This should particularly be the case when the event, e.g., the VW emissions scandal, is linked to a relevant social identity with which a person strongly identifies (e.g., “environmentalist”, “VW TDI owner”). Being strongly identified with a group or identity implicated in an event often predicts polarized cognitive, affective, and behavioral responses (Brown, 2000). However, the strength and direction of that polarization, e.g., feeling increased personal responsibility versus denying responsibility, may be shaped by contextual factors and other relevant social identities that are concurrently activated (Doosje, Branscombe, Spears, & Manstead, 1998; Dumont, Yzerbyt, Wigholdus, & Gordijn, 2003; Johns, Schmader, & Lickel, 2005).

In the context of the VW emissions scandal, two social identities appear particularly relevant: identifying with the brand and vehicle type (e.g., VW TDI owner) and identifying as an environmentalist. Stronger identification with a brand is associated with greater loyalty, positive “word of mouth”, and repurchasing behaviors (Ahearne, Bhattacharya, & Thomas, 2005; Ashforth, Harrison & Corley, 2008; Bhattacharya & Sen, 2003; Hughes & Ahearne, 2010; Kuenzel & Halliday, 2008). However, little work has examined how transgressions by brands influence the personal behaviors of those highly identified with the brand (He, Li, & Harris, 2012). Most research has focused on how brand transgressions influence individuals’ perceptions of the brand itself (Aacker,

Fournier, & Brasel, 2004; Cheng, White, & Chaplin, 2012; Einwiller, Fedorikhin, Johnson, & Kamins, 2006), and not whether high identification with a brand may result in a greater sense of personal responsibility for the brand's actions.

Environmental identity, a form of social identity involving a sense of attachment to the natural world and greater perceived self-relevance of issues affecting the environment, is a strong predictor of responses to environmental issues (Clayton, 2003, 2012), including discrete crises (e.g., the 2010 Deepwater Horizon oil spill; Clayton, Koehn, & Grover, 2013), conflicts over resources (Colvin, Witt, & Lacey, 2015), and attitudes about climate change (Fielding & Hornsey, 2016). Greater environmental identity is associated with greater perceptions of harm from environmental disasters and greater characterizations of such disasters as injustices (Clayton et al., 2013).

One of the appeals of the VW TDI vehicles was the proclaimed combination of superior vehicle performance, low environmental impact and efficient fuel economy. The marketing of the vehicles as “clean diesel”—environmentally friendly and performance-oriented—likely made the car appealing to both environmentally conscious consumers and VW/Diesel enthusiasts seeking a more fuel-efficient, high performance vehicle. Thus, the community of VW TDI owners likely includes individuals who identify strongly as environmentalists, individuals who identify with the brand and vehicle type, and individuals who strongly self-associate with both of these identities.

Here we report findings from research conducted with 300 U.S. owners of affected VW TDI vehicles after news of the scandal broke in Fall 2015 and before VW and regulators released details of a potential mitigation plan. We expected that being highly identified as a VW/diesel owner may have different implications for one's

responses to the scandal depending on whether one has a strong versus weak environmental identity. We hypothesized that there would be an interactive relationship between holding environmentalist and VW/Diesel brand identities, such that VW/diesel ownership identification would be predictive of intentions to fix one's vehicle only amongst high environmental identifiers. Thus, we expected that the strength of brand/diesel owner identification would predict attributions of personal responsibility both for causing and solving the emissions problem, but only amongst those who are also strongly identified as environmentalists.

Methods

Participants

Owners in the United States of affected TDI vehicles manufactured between 2009 and 2016 by the Volkswagen Group (Volkswagen, Audi, Porsche) were recruited by Qualtrics.com through multiple panels. This sample was recruited from January through March of 2016, prior to the announcement of any settlement agreements between Volkswagen and the U.S. government regarding vehicles. Thus, we assessed affected owners' responses to the emissions scandal and their intended responses regarding their vehicles prior to any announced plan from the company or government agencies. All participants consented to participate through an online consent form and the study was approved by the University of Massachusetts Amherst Institutional Review Board (Protocol ID: 2015-2808).

Due to the specificity of the sample, we aimed to recruit as many affected VW owners as possible under our budget and a three month time frame. As such, our data collection stopping rule was determined by financial considerations and the amount of

time required for collecting data from this specialized sample. Data collection was stopped when Qualtrics.com obtained completed surveys from 300 participants ($M_{\text{age}} = 37.34$, $SD = 13.07$, $Minimum = 18$, $Maximum = 85$). More females ($n = 173$) than males ($n = 127$) participated, and a majority reported household incomes ranging from \$35,001 to \$100,000 USD ($n = 178$), while 38 respondents reported \$35,000 or less and 63 reported household incomes greater than \$100,000 in 2015 (non-disclosure: $n = 21$). Participants primarily identified as white/Caucasian ($n = 216$), with smaller numbers of African Americans ($n = 23$), Hispanics ($n = 20$), Asians ($n = 20$), and Native Americans ($n = 3$) also participating (3 reported “other”; Non-disclosure: $n = 15$). Forty-three of the 50 U.S. states were represented, with larger groupings of participants (n 's ≥ 15) residing in California ($n = 31$), New York ($n = 25$), Texas ($n = 20$), Pennsylvania ($n = 19$), Florida ($n = 18$), and Georgia ($n = 15$). A larger portion of our sample identified as Democrats ($n = 120$) than as Independents ($n = 91$) or Republicans ($n = 78$), while 11 identified as “other”. When asked to rate their political identification ranging from liberal to conservative (1 = *Very liberal*, 4 = *Moderate*, 7 = *Very conservative*), the majority identified as moderates ($n = 103$), and the sample overall was very slightly to the left on the political spectrum ($M = 3.72$, $SD = 1.65$).

In addition to basic demographic characteristics, specific vehicle-related demographics were also collected. The majority of the sample owned/leased a Volkswagen TDI vehicle ($n = 239$), followed by Audi TDI vehicles ($n = 53$), and Porsche ($n = 8$; Cayenne S, Diesel engine model only), ranging all eligible years (2009-2016). Our sample primarily consisted of vehicle owners ($n = 278$; lessees: $n = 22$) who were the primary driver of their vehicle ($n = 291$). Length of ownership of their current vehicle

ranged from less than 6 months up to 7 years, and for the majority of participants this was their first TDI engine vehicle ($n = 241$). As the Volkswagen Group had already begun issuing \$500 in dealer credits and \$500 prepaid Visa Debit Cards to some impacted owners at the time of the study, we also assessed whether participants had applied to receive any of these credits yet, and the majority had not (Not Received: $n = 189$, Received: $n = 85$, Not Sure: $n = 25$, Non-disclosure: $n = 1$).

Measures

After consenting to participate, participants were presented with a battery of items related to how they are perceiving (e.g., judgments of responsibility) and responding (e.g., where they have been receiving information and communicated about the scandal) to the scandal, their social identities, and their intended responses regarding their vehicles. The measures and results reported here only contain those pertaining to our hypotheses about social identity and ascriptions of personal responsibility. However, other measures were also included for exploratory purposes, for other unrelated hypotheses, and to inform future research questions, such as perceived self-knowledge and information acquisition, communication behaviors, concerns about reputation, perceptions of “clean diesel” technology, and trust in Volkswagen and government regulators. Information regarding these items can be provided by the authors upon request, and descriptive results of these measures can be found in Markowitz, Chapman, Guckian, & Lickel (2017).

Environmental and ownership identity

Three items assessed the extent to which each of the following characteristics were important to their sense of who they are as a person: environmentalists ($M = 4.49$, $SD = 1.75$), diesel-vehicle owners ($M = 3.37$, $SD = 1.85$), and owners of Volkswagen/Audi/Porsche vehicles ($M = 3.69$, $SD = 1.96$; 1 = *not at all important*, 7 = *extremely important*). All three identity items were positively correlated (r 's $> .3$). Due to a high degree of association between diesel and ownership identity, these two items were averaged together to create a single ownership composite measure that was used in all analyses ($M = 3.53$, $SD = 1.77$, $r = .735$). In addition, we also assessed their sense of social identity on other categories unrelated to the current analyses, such as the extent to which they identify as an American, as a team-player, and as a general car enthusiast.

Perceived personal responsibility

One item assessed the extent to which participants felt a sense of responsibility for contributing to the emission situation ($M = 2.32$, $SD = 1.87$; 1 = *not at all responsible*, 7 = *extremely responsible*). Participants rated the extent to which they felt a sense of personal responsibility for repairing impacted vehicles using a single item ($M = 3.16$, $SD = 2.05$; 1 = *not at all responsible*, 7 = *extremely responsible*). These questions were asked alongside a series of other targets of responsibility for exploratory purposes not reported here, including government regulators, VW, and other affected owners.

Intentions to fix affected vehicles

A single item measured participants' intentions to repair their affected vehicle once an approved repair is released ($M = 5.58$, $SD = 1.66$, 1 = *extremely unlikely*, 4 =

undecided, 7 = *extremely likely*; for more descriptive information on this measure, see Markowitz et al., 2017). A separate categorical item measured the timing at which they would repair their vehicle if the repair process were implemented, with responses ranging from “I wouldn’t get my car fixed” (1) to “I would be the first in line to get my vehicle fixed” (5). The mean score for this item was 3.59 (*SD* = 1.22), indicating that participants on average fell between the ranking of “I would wait a month or so” (3) and “I would wait a couple of weeks” (4).

Results

Table 3 displays the correlations between each of the measures used to test the hypotheses. Greater environmental identity was correlated with greater ascriptions of personal responsibility for contributing to the emissions problem and for fixing impacted vehicles. Environmental identity was positively associated with intentions to fix affected vehicles and motives to repair vehicles as soon as a fix becomes available. VW/Diesel identity and environmental identity were positively correlated, consistent with our proposition that the multiple identities VW owners may hold are not mutually exclusive or inherently oppositional. VW/Diesel identity was positively correlated with perceptions of responsibility for the cause and for fixing vehicles, but was not itself correlated with intentions to fix vehicles.

Table 3. Bivariate correlations between independent and dependent study measures.

	(1)	(2)	(3)	(4)	(5)	(6)
Environmental Identity (1)	1					
VW/Diesel Identity (2)	.44***	1				

Personal Responsibility for Emissions Problem (3)	.28***	.40***	1		
Personal Responsibility for Fixing affected Vehicles (4)	.31***	.29***	.62***	1	
Intentions to Fix Impacted Vehicles (5)	.18**	.09	.11*	.22***	1
Intended Timing of Getting Fix (6)	.19***	.03	.09	.26***	.53*** 1

Note. *** $p \leq .001$, ** $p \leq .01$, * $p \leq .05$

Perceived Responsibility for Contributing and for Fixing Affected Vehicles

Bayesian linear regression models were fit to examine the effects of VW/Diesel identity, environmental identity, and their interaction, on judgments of personal responsibility for contributing to the scandal. Prior specifications and model details are provided in Appendix B. After standardizing the predictors ($M = 0$, $SD = 1$), there was a moderately strong impact of VW/Diesel identity on judgments of personal responsibility for contributing to the scandal, *Posterior Median* = .56, *95% HPDI* = .34, .78. The effect of environmental identity was nearly half the size of the VW/Diesel effect, but also had a positive influence, *Posterior Median* = .30, *95% HPDI* = .09, .51. These two main effects were qualified by a positive interaction effect, leading to roughly a .3 unit increase in responsibility judgments, *Posterior Median* = .34, *95% HPDI* = .14, .53. Figure 6 plots the interaction effect and Figure 7 displays the full posterior distributions of key model parameters. The interaction decomposition indicates that as VW/Diesel identity increased, judgments of personal responsibility increased, specifically for those also higher in environmental identity. Overall, the model accounted for roughly 21% [14, 28] of the variance.

VW/Diesel and Environmental Identity Interaction: Responsibility for Contributing to Scandal

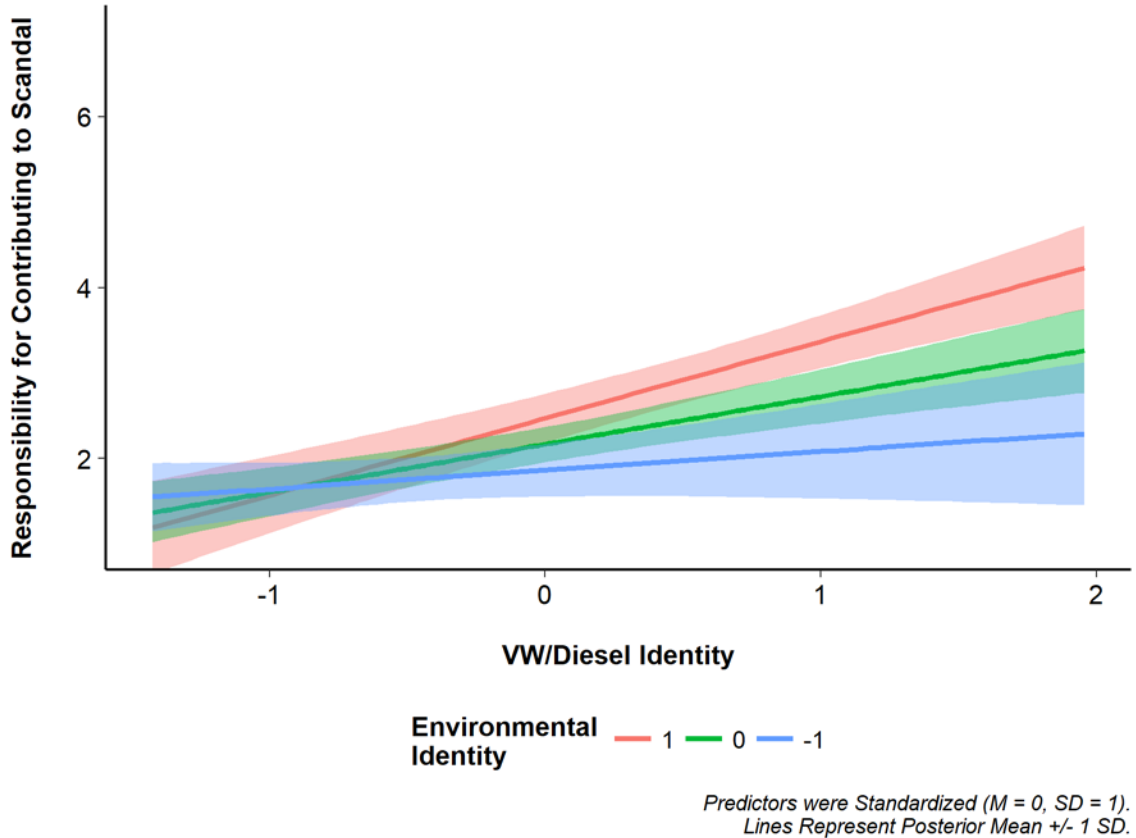


Figure 6. VW/diesel and environmental identity interaction: responsibility for contributing. Results come from a Bayesian regression model. Predictors were standardized for the analysis. Blue, green, and red lines thus represent -1 SD, the mean, and +1 SD, respectively. Shaded intervals are 95% fitted regression intervals.

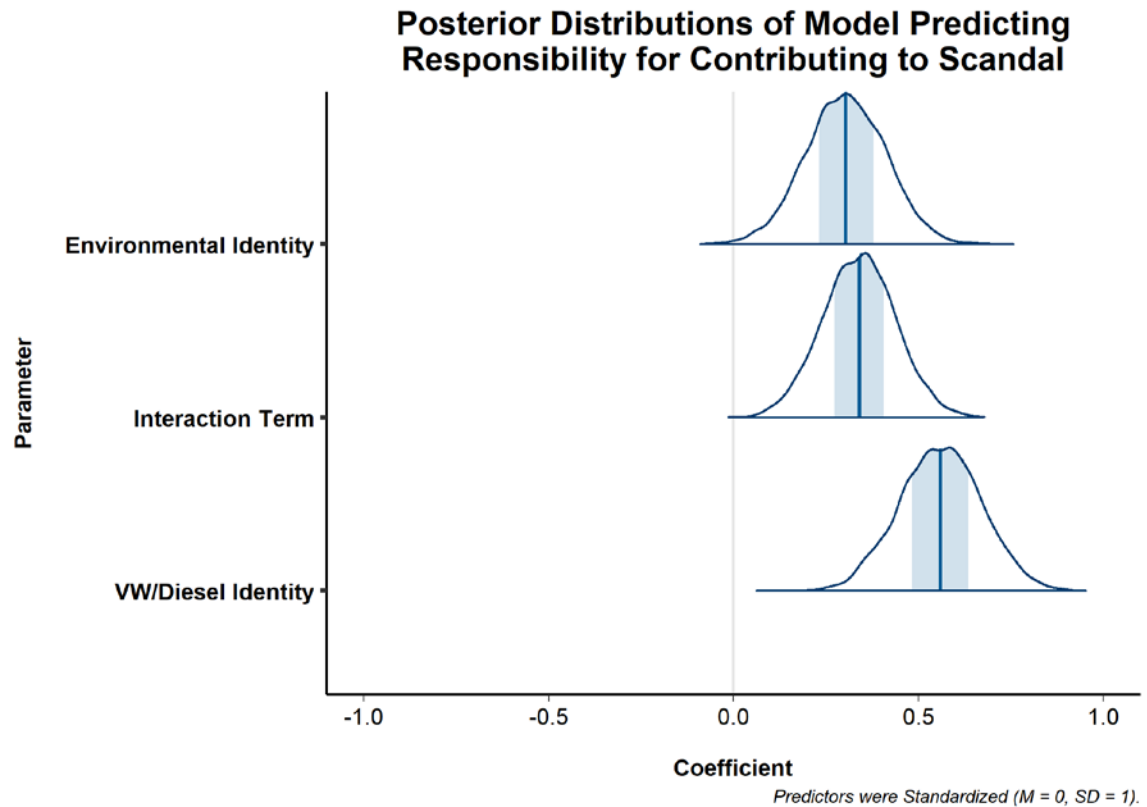


Figure 7. Posterior distributions of model predicting responsibility for contributing to scandal. Full posterior distributions from Bayesian linear regression model. Vertical blue lines represent posterior medians and shaded intervals represent 50% posterior intervals.

Judgments of personal responsibility for fixing affected vehicles was modelled in the same way as the previous analysis. Figures 8 and 9 provide the full posterior distributions for the model, which accounted for roughly 14%, (95% posterior interval = .8, .21) of the variance. However, the nature of the model effects were slightly different than the previously described model. In this case environmental identity was a stronger predictor (*Posterior Median* = .50, *95% HPDI* = .26, .74) than VW/Diesel identity (*Posterior Median* = .34, *95% HPDI* = .10, .59). The interaction effect was also noticeably weaker in magnitude, *Posterior Median* = .23, *95% HPDI* = .02, .44. Examining the plotted interaction effect highlights the similarity of effects between this analysis and the prior analysis, although a recognition of the magnitude and uncertainty

in the estimates are especially warranted in this case.

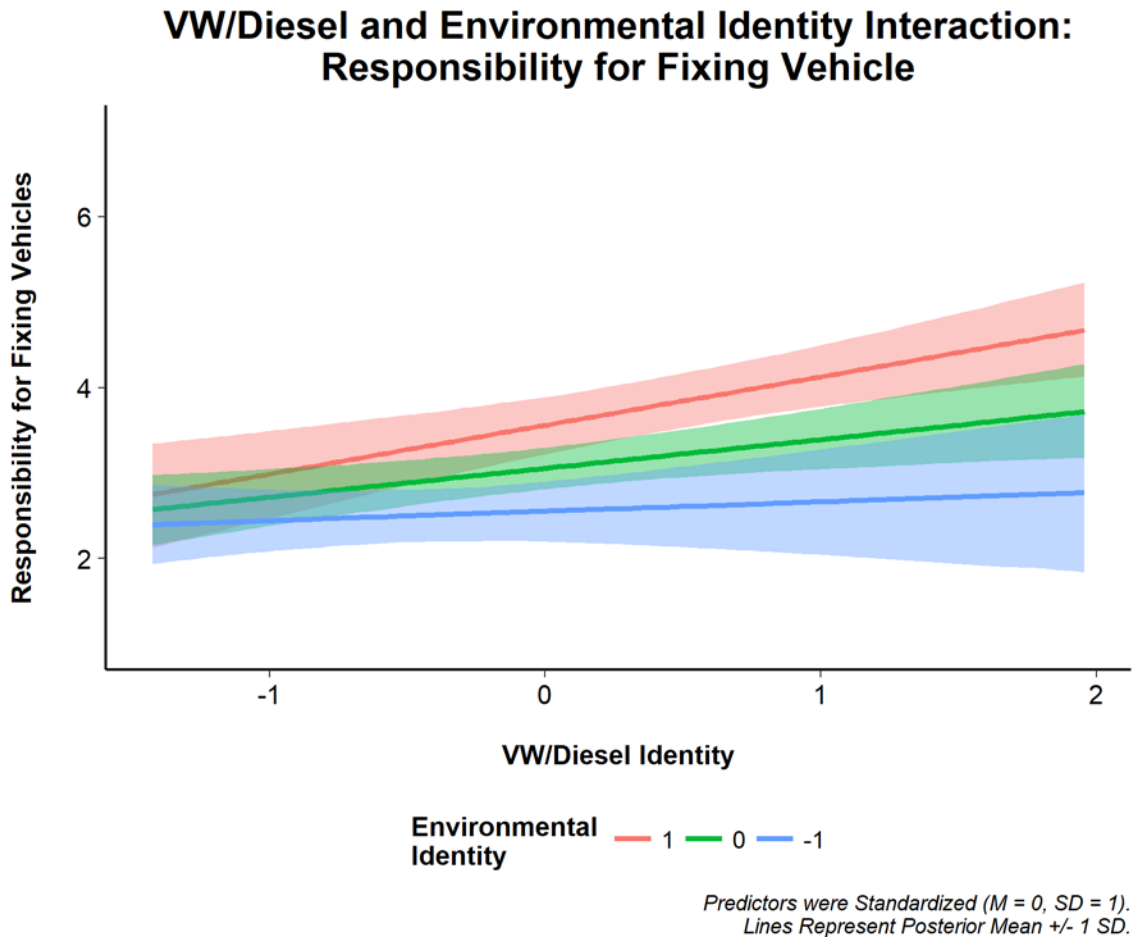


Figure 8. VW/diesel and environmental identity interaction: responsibility for fixing affected vehicle. Results come from a Bayesian regression model. Predictors were standardized for the analysis. Blue, green, and red lines thus represent -1 SD, the mean, and +1 SD, respectively. Shaded intervals are 95% fitted regression intervals.

Given the underlying conceptual similarity between these two items, I also analyzed a composite measure by taking the average of these two measures to evaluate the aggregated interaction estimate. Figures 10 and 11 again provide the posterior distributions and interaction plot. The model accounted for roughly 20% of the variance (95% posterior interval = 13, 28) and yielded similar effects to the earlier models. The overall estimate of the interaction effect was positive, although still with considerable

variation, *Posterior Median* = .28, *95% HPDI* = .10, .46. VW/Diesel Identity (*Posterior Median* = .46, *95% HPDI* = .25, .66) and environmental identity (*Posterior Median* = .40, *95% HPDI* = .21, .61) both had positive, stronger effects.

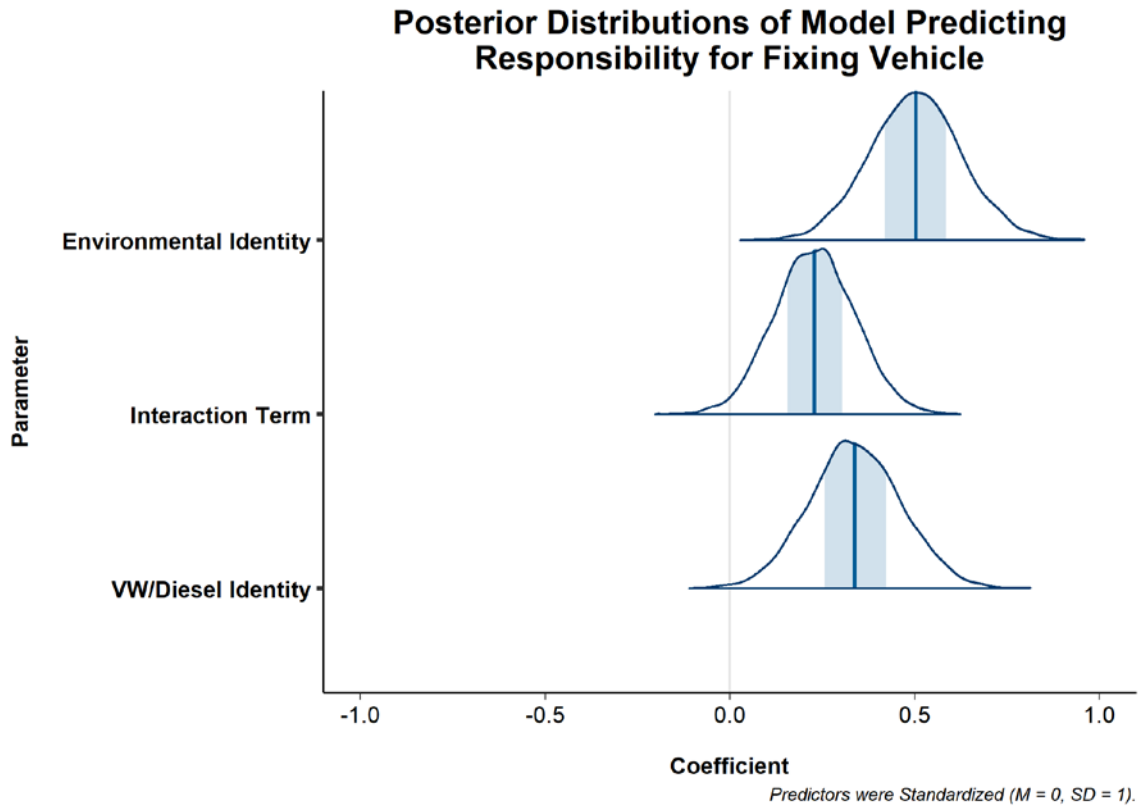


Figure 9. Posterior distributions of model predicting responsibility for fixing vehicle. Full posterior distributions from Bayesian linear regression model. Vertical blue lines represent posterior medians and shaded intervals represent 50% posterior intervals.

VW/Diesel and Environmental Identity Interaction: Responsibility Composite

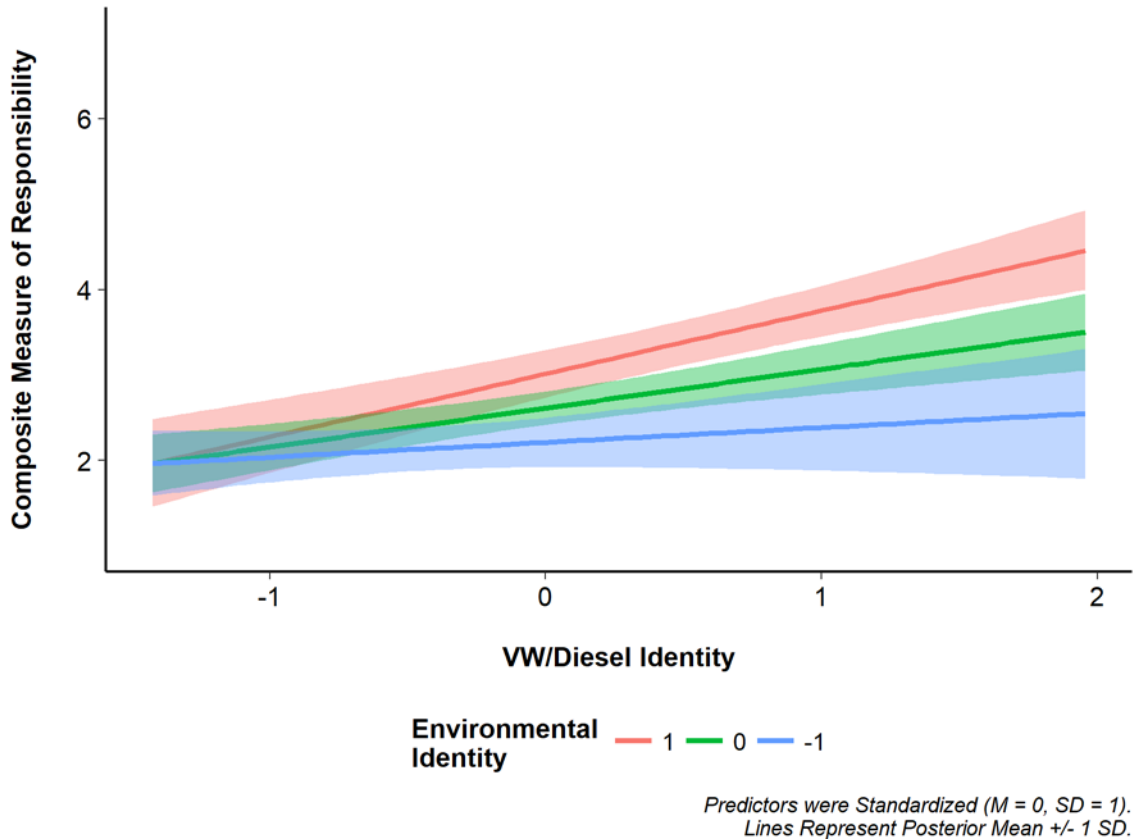


Figure 10. VW/diesel and environmental identity interaction: responsibility for composite. Results come from a Bayesian regression model. Predictors were standardized for the analysis. Blue, green, and red lines thus represent -1 SD, the mean, and +1 SD, respectively. Shaded intervals are 95% fitted regression intervals.

Fix Intentions and Speed to Fix Affected Vehicles

Intentions to fix one's vehicle was modelled using the same specifications as the analyses described above. As can be seen from the posterior distributions and interaction plot (see figures 12 and 13), there was little evidence to suggest a robust interaction effect on this measure, *Posterior Median* = .07, *95% HPDI* = -.12, .26, and the estimated Bayesian R-squared was roughly 4% (95% posterior interval = 1%, 9%). The posterior distribution for VW/Diesel identity was centered squarely at zero (*Posterior Median* <

.01, 95% HPDI = -.20, .21), whereas environmental identity had a positive effect similar to what was observed for other outcome measures, *Posterior Median* = .30, 95% HPDI = .09, .51.

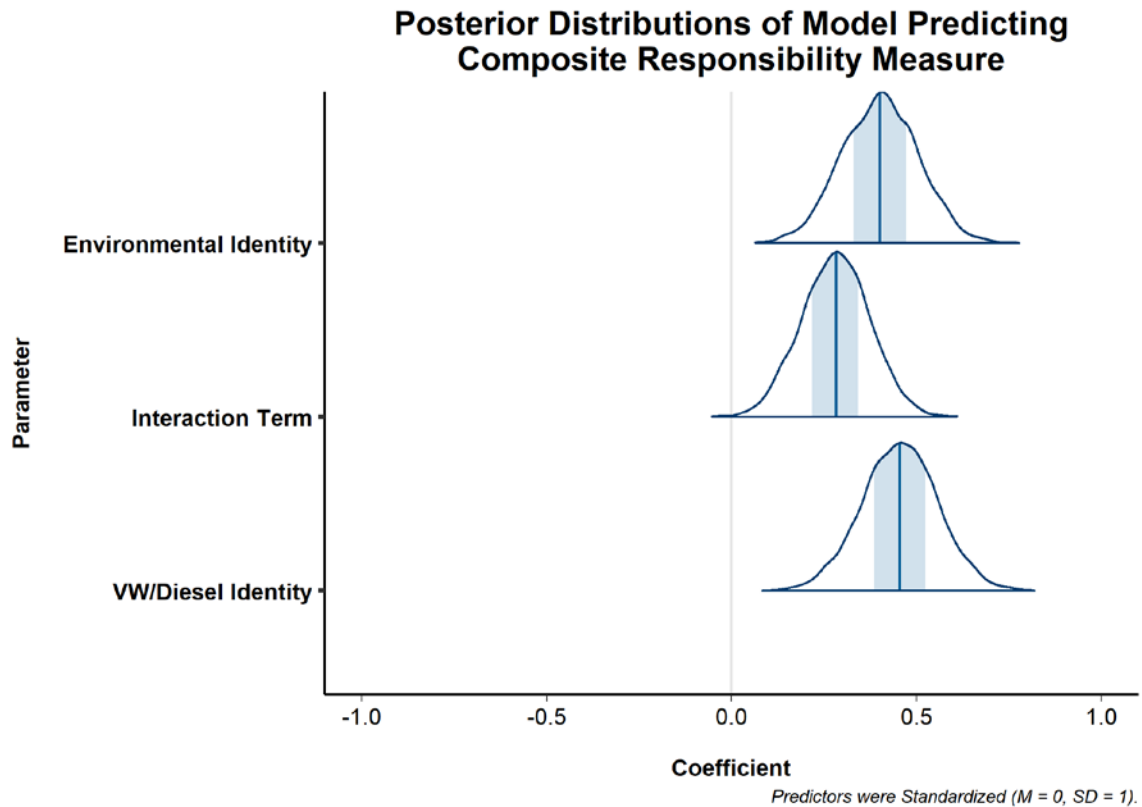


Figure 11. Posterior distributions of model predicting composite responsibility measure. Full posterior distributions from Bayesian linear regression model. Vertical blue lines represent posterior medians and shaded intervals represent 50% posterior intervals.

Finally, the measure of intended fix timing was analyzed using an ordinal logit regression model with flexible category thresholds. As this item was conceptualized as an ordinal measure with discrete outcomes categories, ordinal regression is an appropriate alternative to traditional linear regression. However, the Bayesian R-squared implementation is not computed for ordinal models, as the residuals are not defined in

these models. Figure 14 provides the graphical depictions of the posterior distributions. Prior specification and model details can be found in Appendix B.

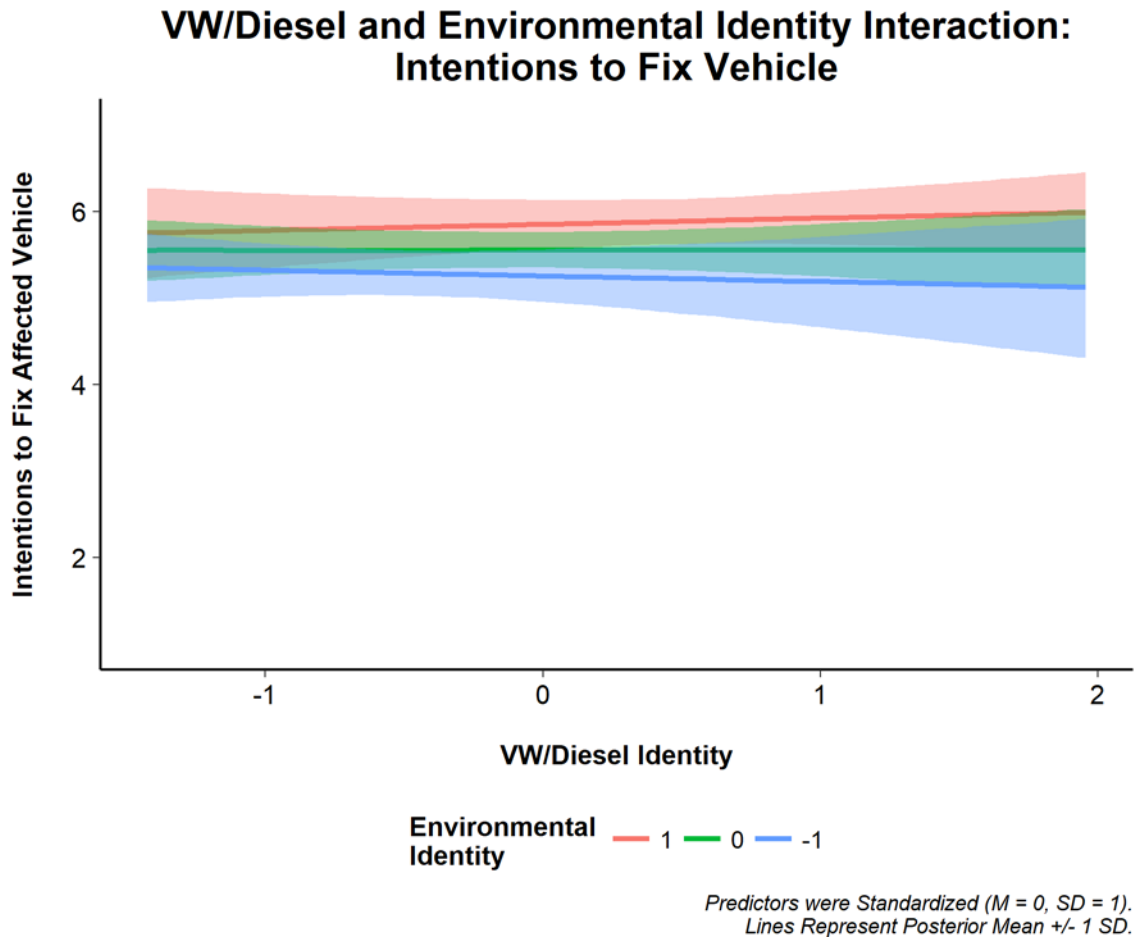


Figure 12. VW/diesel and environmental identity interaction: intentions to fix vehicle. Results come from a Bayesian regression model. Predictors were standardized for the analysis. Blue, green, and red lines thus represent -1 SD, the mean, and +1 SD, respectively. Shaded intervals are 95% fitted regression intervals.

The interaction was again positive, *Posterior Median* = .23, *95% HPDI* = .02, .44, *Odds Ratio* = 1.26, although as with prior analyses the uncertainty in the estimate was close to a half-scale point on the outcome scale. And, the odds ratio depicting the change in proportional odds was less than 2. The effect of VW/Diesel identity was primarily negative, although there was a small portion of the posterior probability at or above zero,

Posterior Median = -.19, 95% HPDI = -.43, .03, Odds Ratio = 0.83. In contrast, there was a positive effect of environmental identity on intended fix timing, Posterior Median = .49, 95% HPDI = .24, .72, Odds Ratio = 1.63. Comparing the interaction model to a model not including the interaction term yielded little support for changes in or added predictive capacity of including the interaction term (*LOO IC difference* = -3.02, *SE* = 4.52).

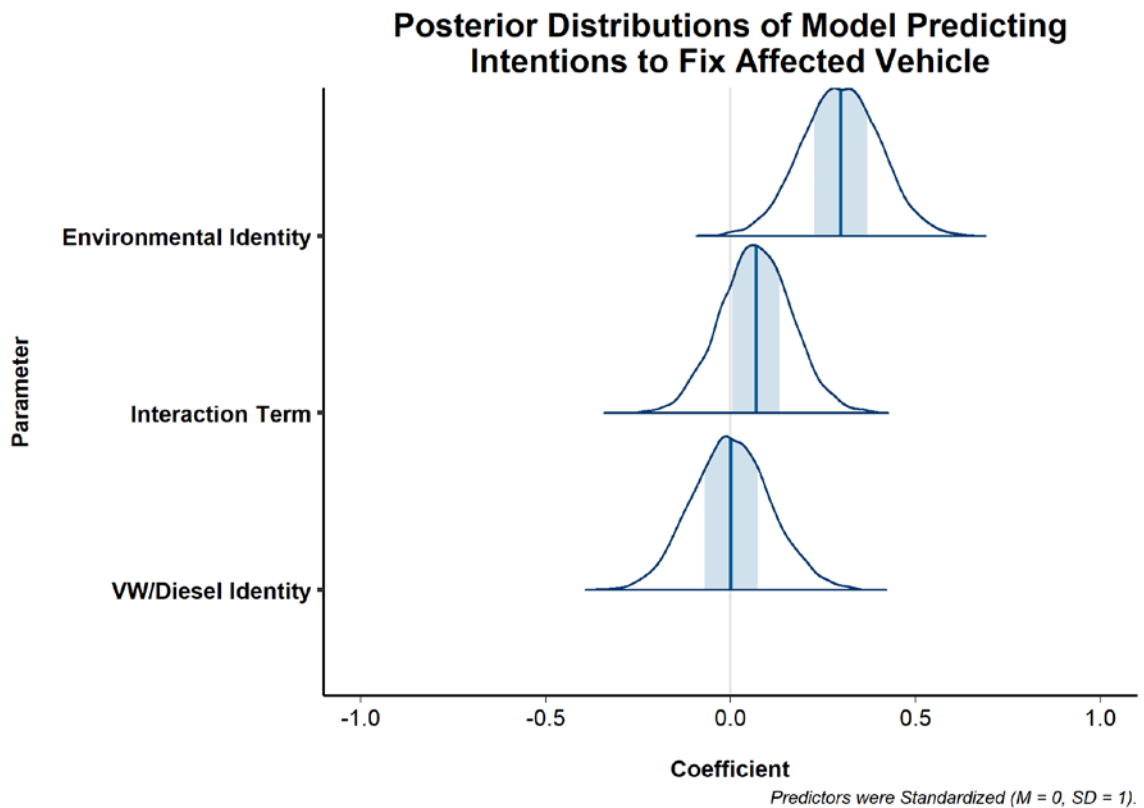


Figure 13. Posterior distributions of model predicting intentions to fix affected vehicle. Full posterior distributions from Bayesian linear regression model. Vertical blue lines represent posterior medians and shaded intervals represent 50% posterior intervals.

Discussion

We examined how contextually salient social identities influence ascriptions of personal responsibility for contributing and responding to a previously unanticipated collective action problem, i.e., excessive vehicle emissions, imposed by the actions of a

third party. Greater VW/Diesel ownership identification predicted greater ascriptions of personal responsibility for contributing and responding to the emissions problem particularly among owners who were also high in environmental identification. Greater environmental identification only very modestly buffered the negative effect of VW/Diesel ownership identification on the speed with which individuals intend to fix their vehicles once a fix is available. Consistent with our expectation that ascriptions of personal responsibility would be a key determinant of intentions to fix one's vehicle, among participants high in environmental identification, greater VW/Diesel identity resulted in greater ascriptions of personal responsibility for causing the scandal and subsequent ascriptions of responsibility for fixing affected vehicles.

Past research on social identity has largely focused on the direct, simple effects of particular identities on behavior. The present findings reveal how multiple social identities may interact to amplify or reduce the effects of particular identities on decision-making. These results are among the first that we are aware of to examine how such interactions affect responses to collective action problems and environmental wrongdoing. This may have implications for collective action and public goods dilemmas because such situations likely activate multiple identities, each of which may engender unique motives but which may also operate interactively to influence how people frame and respond to the problem. However, evaluation of the Bayesian posterior estimates, as well as out-of-sample predictive capacity using LOO IC suggested both considerable uncertainty in these estimates and a portion of un-modelled variance. Furthermore, the posterior probability of the interaction terms in the models of actual fix intentions and fix

timing had more of their posterior probability centered around zero than the other models, suggesting less support for direct effects of the interaction on these outcomes.

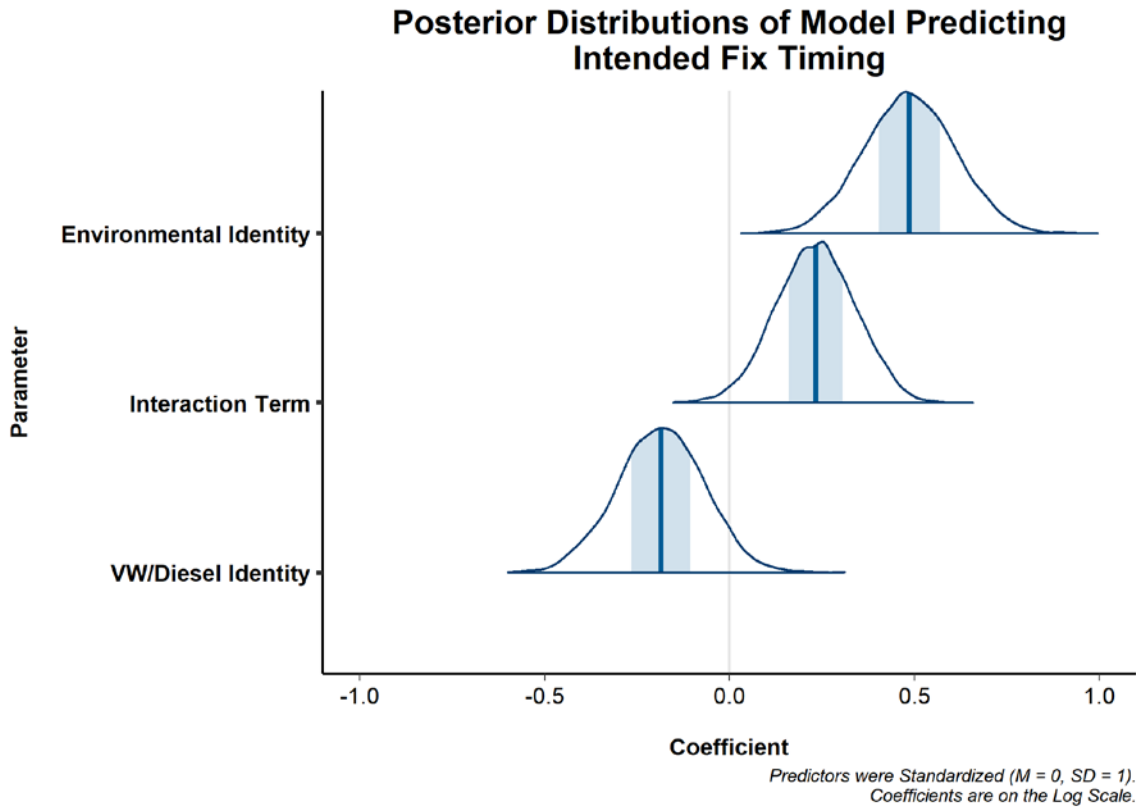


Figure 14. Posterior distributions of model predicting intended fix timing. Full posterior distributions from Bayesian ordinal logit regression model using flexible category thresholds. Coefficients are on the log scale. Vertical blue lines represent posterior medians and shaded intervals represent 50% posterior intervals.

It is important to note that the research described here was conducted prior to any details were public about the proposed (and now finalized) settlements between VW and U.S. regulators, and before the majority of vehicle owners had taken actions with their vehicles. Through the settlement agreement, the company is ascribed legal responsibility and is required to pay substantial monetary fines (Volkswagen Group of America, 2016). The initial settlement (October 2016) for 2.0-litre vehicles, includes a \$10 billion buyback program where eligible TDI owners are able to sell back their vehicles to VW at pre-scandal values depending on model, age, trim and region. The company also bears

responsibility for repairing vehicles of owners who instead opt for an approved fix. Each of the three generations of 2.0-litre vehicles require different, and potentially performance-undermining retrofits, while one generation has been approved for resale by U.S. regulators. A second settlement for 3.0-liter diesel models was reached in May 2017, differing substantially from the 2-liter agreement, provided VW cannot repair the 3.0-litre vehicles to be emissions compliant (Atiyeh, 2017).

A potentially problematic aspect of these agreements is that there is nothing at this point that requires compliance from owners; the company has until June 30, 2019 to buy back 85 percent of all vehicles, though it is not clear from the agreements whether owners will be obligated to obtain an available fix should they opt to not participate in the buyback. Given the varying emissions standards between states, the uncertainty regarding what the legal mandates will be, and the low likelihood of detecting unfixed vehicles, it is possible that some owners may leave their vehicles unfixed, even if a relatively “cost-free” solution is available. Thus, understanding what motivates individual-level action in response to this problem, especially when there is the potential for personal losses from cooperating, is critical.

A strength of the research reported here is that this was conducted in the immediate aftermath of a real-world social dilemma and carried out with stakeholders directly affected by the scandal. Thus, while correlational, we are hopeful that this research provides a temporal barometer on how multiple social identities influence how individuals form appraisals of responsibility, and ultimately, potentially make decisions about how to respond to such scandals. It is our opinion that future research on how social identities influence decision-making processes would greatly benefit by further

investigations that maximize ecological validity, take advantage of rapid-onset scandals and collective goods dilemmas such as this, and attempt to speak to real-time decision processes as best as possible.

Nevertheless, this research is not without its limitations. In particular, this research is correlational in nature, and thus strong inferences with regard to causality are not permitted. However, our models stemmed from extensive past research on social identity and judgments of responsibility, adopting a similar approach and methodology to other research in this domain. Future research would nevertheless substantially benefit from multi-method approaches, including more controlled experiments and qualitative research with affect owners. Furthermore, due to time, space, and budgetary constraints, the measures reported here were developed to be short, face-valid measures of our constructs. While demonstrating modestly acceptable psychometric properties for what we were able to accomplish, greater precision and granularity of measurement would be desirable in future investigations.

The findings reported here suggest one potentially powerful yet low-cost approach to promoting effective owner responses to the emissions problem: tailor outreach efforts to activate environmental concerns and the multiple social identities held by many VW owners. In some ways, the original branding of these vehicles as both environmentally friendly and performance oriented may be a blessing in disguise: having owners reflect on these characteristics of their original purchasing decisions may help promote effective environmentally- and public health-friendly responses to the emissions problem.

Bridge to Chapter 4

Chapter 3 discussed a novel investigation into the influence of multiple social identities activated in the context of an ongoing corporate scandal with environmental consequences. Perhaps one of the most interesting implications of this work is the finding that taking steps to emphasize or make salient a relevant social identity (e.g., environmental identity) may help motivate faster responses to scandals that strike at the heart of that identity. And, in terms of explaining motivations to change personal behavior to address the scandal, environmental identity produced more positive outcomes than VW/Diesel identity. There was only minimal support for the proposed interaction effects in these models. Evidence for an interactive effect of these identities was most pronounced in the context of judgments of personal responsibility, but were less consequential for actual response intentions. This is perhaps due in part to the number of decision factors that might influence fix responses which were not modelled directly in this study (e.g., potential fix causes, proximity to locations to get vehicles fixed, knowledge of what will and will not be covered financially by VW). While such interactions are by their nature interesting in thinking through theoretical questions, it remains unclear whether such ICT processes may lead to actual behavior change based on these data. Future research should take a more deliberate, careful approach in modelling the behavioral outcomes of such studies.

While this research did not directly examine ICT using more traditional measures and approaches, the findings presented carry interesting implications for this work moving forward. For example, these findings suggest that certain individuals are willing to ascribe themselves varying degrees of personal responsibility for a real-world scandal

they did not directly cause, even when this response may lead to personally costly outcomes. While such motivated identity processes are typically treated as a negative process in public engagement (and often to carry negative implications), it is also evident that certain identities, such as environmental identity, may lead some individuals to be more motivated to respond in positive ways. Given such a finding, it is important to reconsider the extent to which these findings are evidence for cognition that is specifically identity protective, as opposed to stemming from other possible motives. Given the measurements available and the correlational nature of these data, it is difficult to disentangle respondents' motivations in this regard. Yet, relative to those with higher environmental identity, those with greater VW/Diesel brand identity were less motivated to respond by fixing their vehicles. As these multiple identities may be contextually activated within the same individual at a given time, it is as of yet unclear how ICT processes are influenced by which (and how many) relevant identities are activated.

While much of the literature on ICT, and indeed on climate change attitudes more broadly, is carried out using text-heavy materials (e.g., randomly showing participants one versus another news article), little research has explored these phenomena in the context of responses to visual imagery. While an interesting methodological change in its own right, this also raises theoretical questions. For example, do individuals respond similarly to images of climate change as they do to text-based mediums? And, do different types of climate change imagery provoke stronger types of affective reactions and pro-climate change emotions, and does this vary depending on the worldview beliefs of respondents? Chapter 4 investigates these questions and others through a mixed-methods, cross-national investigation of responses to climate change imagery. In addition

to the descriptive results in the main body of Chapter 4, the addendum provides more comprehensive Bayesian hierarchical modelling to address the questions specifically related to cultural worldviews and responses to climate change imagery.

CHAPTER 4

RESPONSES TO CLIMATE CHANGE IMAGERY

Introduction

Over the past decade there has been a proliferation of academic research and practitioner literature that has sought to address the question of how to more effectively communicate climate change (e.g., CRED & ecoAmerica, 2014; Van der Linden et al., 2015b). However, although much is now understood about public engagement with climate change, the vast majority of climate communication studies have focused on verbal communication. Climate change is a particularly difficult issue to communicate, let alone visualize. The widespread perception of climate change as an abstract, distant, and uncertain phenomenon presents it as a uniquely complex problem for motivating individual and group-level engagement (Gifford, 2011; Markowitz and Shariff, 2012). But despite the fact that thousands of climate change images are shared by journalists, campaigners and educators around the world on a daily basis, little research has focused on how to more effectively communicate climate change in the visual medium.

The lack of past research on visual imagery and climate communication is both puzzling and problematic. A wide diversity of images are used to depict climate change—from pictures of smokestacks and traffic jams (highlighting causes of climate change) to iconic images of polar bears on isolated patches of ice (focusing attention on potential impacts) to photos of people installing photovoltaics on their roofs (showing possible solutions to the problem). Yet despite the crucial role of climate imagery in shaping how people conceptualize the issue of climate change (Leiserowitz, 2006), non-governmental organizations and climate change advocates often have only anecdotal

evidence to back up their selection of particular visuals over others; moreover, practitioners' intuitions about "effective" visual communication messages sometimes conflict with what researchers have found through controlled studies.

Research on Climate Change Imagery

The term 'visual communication' is an extremely broad one, with research on visuals and imagery having roots in a number of academic disciplines and fields (e.g., Messaris, 1997; King, 2014; Zillmann, 2002). As a consequence, an exploration of "climate visuals" might feasibly involve an analysis of disparate visual media, from maps and three-dimensional visualizations, to cartoons, infographics, graphs and even videos (O'Neill and Smith, 2014). Given the ubiquity of photographic images depicting climate change and the potential power of this type of visual to enhance engagement with climate change, our focus in the current paper was on photographic imagery. This decision does not imply that alternative visual media such as maps, cartoons, or infographics are less relevant for academic study, but it is notable that there are also very few systematic analyses of the effectiveness of climate change videos, cartoons, or infographics, despite their widespread use and assumed-efficacy in terms of public engagement (see O'Neill and Smith, 2014; Sheppard, 2012).

A limited body of research primarily using qualitative methodologies (e.g., Q-sort, focus groups) or content analysis has investigated how people think about and respond to photographic climate change imagery. Of the work that does exist, most grapples with the dual challenge of persuading the viewer that climate change is a significant issue while presenting it as a solvable one. There is also a related nascent literature using content analysis and related methods to examine how climate change is

framed and visualized in news media coverage (e.g., O’Neill, 2013; Rebich-Hespanha et al., 2015; Smith and Joffe, 2009). In a series of papers, O’Neill and colleagues (O’Neill, 2013; O’Neill, Boykoff, Niemeyer, and Day, 2013; O’Neill and Nicholson-Cole, 2009) found that dramatic and potentially fear-inducing images of climate impacts and extreme weather are good at capturing people’s attention (i.e., they have high ‘salience’) and make climate change seem more important, but they can also act to distance viewers (both psychologically and geographically), leaving them feeling overwhelmed rather than motivated to respond to the risks portrayed. Distressing photos may prompt a “helpless hopeless” feeling in the viewer (Banse, 2012), although this is partially contradicted by recent Australian research (Leviston et al., 2014). In their work, Leviston et al. (2014) found that dramatic images of climate change impacts (including natural disasters and melting ice) prompted strong negative feelings (alarm, anger, fear, upset or frustration) and increased arousal, but these feelings did not undermine their willingness to respond. Images of climate ‘solutions’ tend to make people feel more able to do something about climate change (they have high ‘efficacy’), but at the same time can reduce people’s sense that the issue is an important one (O’Neill and Nicholson-Cole, 2009; O’Neill et al., 2013). A recent study replicated these findings in a cross-national sample from Germany, Austria, and Switzerland (Metag et al., 2016).

A similar tension exists around using ‘localized’ versus ‘distant’ climate images. Perhaps the most iconic climate change image—the polar bear—has come to function as the primary visual cue associated with the issue (Doyle, 2007). However, images such as this have become problematic, as they appear to actively reinforce impressions of climate change as a distant issue (Manzo, 2010) rather than motivate increased interest, concern,

and intentions to act. Nicholson-Cole (2005) found that focus group participants often explain that they are more touched by national and local imagery because it is easier to relate to and consequently is more upsetting. However, in research by O'Neill and Hulme four years later, the same reasoning was used by participants to say why local icons are disengaging: "it will only affect locals and is not as much of a global issue" (O'Neill and Hulme, 2009). A recent review of the research suggests that reducing the perceived distance of climate change may actually have unanticipated effects on engagement (McDonald et al., 2015). Existing evidence regarding the impacts of highlighting local versus distant or global impacts of climate change on affect and issue engagement remains mixed (McDonald et al., 2015), and no research has carefully examined the importance of distance in the context of climate change imagery specifically.

Other aspects of the evidence base are more straightforward. People find it easier to engage with images if they include people (Banse, 2013; Nicholson-Cole, 2005; Braasch, 2013), and where direct eye-contact can be made with the subject of the image (Banse, 2013). While these conclusions are virtual 'truisms' among photographers, it is instructive to reflect on the images that participants in survey research spontaneously associate with the term 'climate change' (typically polar bears and 'smokestacks'), which do not necessarily conform to these principles (Leiserowitz, 2006; Smith and Leiserowitz, 2014). As even this brief review of the literature highlights, therefore, there is a need for research that provides advocates with an evidence-based assessment of climate imagery impacts on audiences.

The Present Research

One of the central goals of the present research was to explore non-experts' perceptions of and reactions to different forms of photographic climate change imagery in a manner that would enable us to extract applicable insights to use in developing a public database of climate change photographs (www.climatevisuals.org) for use by groups or individuals interested in climate change communication, such as climate change advocacy organizations, bloggers, or journalists. Therefore, the methodological and analytical approach of the research was primarily and purposefully exploratory in nature, with the imagery selected and questions examined being centrally guided by the goal of making practical and 'actionable' recommendations for climate change communication. To gain a robust assessment of perceptions and responses to climate change images, we utilized both qualitative (structured discussion groups) and quantitative (experimental survey) methods. In both cases, participants were presented with a variety of photographs depicting climate change causes, impacts and solutions, and we assessed their reactions to these images ranging from their comprehensibility and aesthetic appeal to the emotions and motivations they evoked. Based on the extant literature, we anticipated that four broad features of images would be particularly important in shaping responses.

First, images of climate change solutions were expected to generate the most positive affective reactions, whereas we expected images of causes and impacts to lead to more negative emotional responses (O'Neill et al., 2013). Second, images depicting ordinary people, particularly those either needing help (e.g., flood relief) or actively engaging in low-carbon behaviors (e.g., installing solar panels), were anticipated to be effective at "personalizing" climate change, increasing concern, and motivating a sense

of efficacy. Third, given recent evidence suggesting that depictions of climate change as localized can produce mixed reactions (e.g., reducing geographical distance vs. reducing temporal distance; McDonald et al., 2015; see also Rickard et al., 2016), we expected that there would be contrasting or even conflicting results with regard to images that depicted ‘distant’ versus ‘localized’ images. Finally, given the importance of high quality visuals for catching attention and promoting engagement (cf. O’Neill and Smith, 2014), aesthetically appealing images that are evaluated as authentic and/or entertaining were expected to increase the extent to which participants would engage with and attend to images favorably.

No research to date has utilized a cross-national, mixed methods approach to study how individuals react to climate imagery. By using diverse methods, the present research allowed us to identify and assess both similarities and differences in reactions to images as a function of how they were contextualized (i.e. in a participatory, dialogic context vs. individual images viewed as part of a controlled survey). As well as the many advantages it confers (in particular the potential to ‘triangulate’ between different data sources), mixed-methods research raises some additional questions and challenges that are not apparent in single-method designs, including the ordering of methodologies. In the current investigation, we deployed a ‘sequential exploratory’ design, using intentionally broad-brush and open-ended qualitative research to inform a narrower, more focused quantitative investigation (Creswell, 2013). This permitted us to use themes present in the existing literature to design the qualitative phase of the project, without unnecessarily restricting the scope of Study 1. Study 2 involved a more precise and systematic investigation of a smaller number of variables. Given the differences in these

two study designs, we anticipated both overlap and divergence in reactions to the images. Therefore, in addition to providing empirical insights into how the public reacts to climate change imagery, the design of our research also provided an opportunity to explore how methodological choices and differences may influence reactions to such imagery.

Study 1. Structured Discussion Workshops

Methods

Participants and procedure

Four structured discussion group workshops were held during June and July 2015 to examine individuals' responses to climate change images. The workshops took place in London and Berlin, with two workshops in each city. Individuals were recruited to participate in the workshops through online advertisements distributed through social media, online forums and email networks, as well as classified sites. Interested individuals completed an online prescreening survey in order to obtain basic demographic information (age, gender, ethnicity and occupation). This ensured a diverse range of participants, broadly reflecting the demographic stratification of the U.K. and Germany. All participants were financially compensated (£35 in the UK and 45 Euros in Germany); each session lasted approximately 120 minutes.

Both UK workshops took place in the same location on the same day. Six men and three women attended the afternoon workshop, while five men and four women attended the early-evening session. These participants all resided in London and came from diverse backgrounds in terms of occupation (e.g., civil servant, company director)

and age (three were 18–24, two aged 45–54 and one older than 75). Three participants were from an ethnic minority background. In the German workshops, 14 adults (age range 18–44) participated (the first session contained five women and three men; the second contained four women and two men). Participants in the German workshops were from a range of different countries including Spain and Canada as well as Germany (two identified being from an ethnic minority background). The majority of participants were university students or postgraduates in the German workshops.

Materials and design

The images (49 in total) selected for use were drawn from a ‘longlist’ created through a process of reviewing existing academic literature for key themes (e.g., the distinction between causes/ impacts/solutions emphasized in O’Neill, 2013), a series of semi-structured interviews with key stakeholders (academics, campaigners and journalists; see the Appendix to Corner et al., 2015 for further description of the stakeholder interviews), and an informal review of images and visual trends in high-profile climate change campaigns. The challenge was to select images from this longlist that would best provoke and stimulate conversation (rather than to systematically ‘match’ or ‘contrast’ images in a highly-controlled way). Nonetheless, we were able to select – through an iterative process of reflection and analysis among the research team – clusters of images (or ‘image sets’) that reflected the key themes identified from the existing literature and our stakeholder interviews (the full set of images utilized, and related images where copyright policies prevent reprinting, can be found in the online report at www.climatevisuals.org and the appendices to that report). These image sets included the central depiction of climate change causes, impacts, and solutions, as well as sets of

images depicting “clichéd” climate change imagery (e.g., polar bears), location differences (e.g., local vs. distant climate change impacts), the presence of people/animals, protest imagery, and images of politicians or celebrities.

The design of the discussion groups was adapted from the ‘narrative workshop’ methodology developed by Climate Outreach (Corner and Roberts, 2014), and reflects principles of participatory deliberative public engagement used to study public perceptions of a wide range of social and scientific/technological issues (e.g., Pidgeon et al., 2009, 2013). Participants were first asked to discuss their core values and sense of identity prior to introducing the topic of climate change into the conversation. Image sets were then presented to participants by the facilitator sequentially, typically two sets at a time (to encourage and promote comparison and contrast between the sets of images). For logistical reasons of space around the discussion table, image sets were removed once they had been discussed, but were sometimes re-introduced if participants requested them or referred to them. The first image set for each discussion group was always the ‘clichéd climate imagery’ category, but the order that subsequent sets were presented varied between groups according to the direction that the conversation took. It is important to note that individual images were not captioned, and image sets were not labelled. Thus, the central aim of presenting the image sets was not to elicit a judgment from every participant on every image, but to provide a structured (and theoretically informed) framework within which to facilitate the deliberations.

The facilitators used a variety of questions to prompt responses to the images (see Table 4). In each of the workshop, a standardized script was provided for the

facilitator, but as is typical in exploratory, qualitative work of this kind, conversations differed to some extent between each workshop.

Table 4. Categories and examples of questions discussed in the structured discussion groups.

<i>Category</i>	<i>Example Questions</i>
Understanding/salience	<p>“What is this trying to convey/what does it show?”</p> <p>“Is it difficult to understand?”</p>
Psychological distance/self-identification	<p>“Does the image ‘connect’ with you?”</p> <p>“Are the people in the image ‘like you’ or ‘other’?”</p>
Affect (emotion)	<p>“Does the image convey an emotion, and if it does, how does this make you feel?” “Fearful/fatalistic or hopeful/optimistic? Worried or reassured?”</p> <p>“Does the image depict something/someone ‘good/desirable/right’ or ‘bad/wrong/evil’?”</p>
‘Action’ (efficacy) and ‘personal engagement’	<p>“Does the image spark any desire to ‘respond’ to the situation depicted?”</p> <p>“What kind of response...something you could do yourself? Supporting a campaign? Lobbying politicians? Wanting to know more?”</p>
Politics and values	<p>“What (if any) political sentiments does the image convey? What values does it communicate?”</p> <p>“Do these match or conflict with your own?”</p>
Aesthetics and humor	<p>“Do you find the image visually attractive or not...is it the sort of image you would want to look at?”</p> <p>“Did the image surprise you or make you laugh? Is that a good or a bad thing?”</p>

Results

All discussion groups were audio recorded and detailed notes were taken from these audio recordings. Analyses proceeded through an iterative process of reading, thematic coding and reflection, with a particular focus on the variables described in Table 4. A variety of themes emerged from the four workshops. We focus here on three broad clusters of key findings: the importance of depicting credible and ‘authentic’ human subjects in the images; the critical reception given to ‘ clichéd’ climate images and depictions of protests and demonstrations; and, the complexities of ‘localized’ images in terms of participants’ reactions. Readers interested in further exploring the qualitative findings are referred to the project report (Corner et al., 2015).

The importance of credible and authentic human subjects

Results are consistent with past research indicating that imagery containing people tends to be more powerful, and that people respond more strongly to photos of one individual rather than many (Markowitz et al., 2013; Nicholson-Cole, 2005; Slovic, 2007). For example, one photograph showed a man in danger in a flood in Pakistan. One focus group member commented that, "[the photo].shows how it [climate change] affects the people rather than the community . . . you don't need a lot of people to convey a message, I think just the one person by himself it's really heart breaking to look at that."

Eye contact in photos also appeared to be important for promoting attentiveness, interest, and concern when viewing imagery of people (cf. Fox et al., 2007). In one image, a Nigerian man looks directly at the camera whilst gesturing to a fire behind him. Even though this image was not entirely understood by the participants in terms of

how it related to climate change, the distress in the man's face prompted the desire to seek out more information about what was happening. One participant commented that: "there's something in his face, like he's scared for his life, so whether it's war, fire, bomb, whatever that's reaction is hard to fake . . ." Where people were not present, some participants even requested their presence, with one group member remarking: 'I want scientists as well and guys in white coats, dead serious experts in their field staring you in the face, going get it together man, that's the sort of thing that motivates me'. This latter finding also fits with recent research in the public health domain suggesting that images of scientists can bolster the effectiveness of scientific consensus based messaging strategies (Dixon et al., 2015; see also Van der Linden et al., 2015a).

The generally strong reaction among participants to identifiable individuals, who seemed genuinely in distress, was in part driven by one of the most consistent findings to emerge from the discussion groups: participants were disinterested in and reacted with disdain toward photos that they perceived as 'staged', and reported greater interest and felt more persuaded by images that appeared to be 'authentic'. This manifested itself in a number of ways, and had an influence on images of causes, impacts and solutions alike; participants were generally cynical about the images they viewed and wary of being "taken in".

Several of the images depicting solutions to climate change were particularly prone to perceptions of inauthenticity. A photograph of children posing with and celebrating their school's solar panels was met with cynical reactions. Participants described this image as 'staged' and 'gimmicky'. Another image depicting a man installing draught excluders (draught stoppers) while being watched by a smiling family

was also strongly disliked and met with ridicule: “I think that family needs to get out a little more” [general laughter] “They're a little too excited about the draught excluding”. Images seen as staged and inauthentic also generated associations with advertising and marketing, which appeared to reduce their effectiveness for participants: “that's a problem for me, I don't want to feel like I'm being sold the idea of, if it has to be sold to me then I don't need it . . . ” However, photos that appeared unstaged and which displayed low-carbon lifestyles in a tangible way prompted positive, optimistic reactions. For example, an image of a man rolling out roof insulation was preferred because, ‘it looks like “real work” is going on’.

In contrast, participants’ responses to photos of politicians were, unsurprisingly, reflective of their political views. But the distaste for politicians as credible climate ‘messengers’ seemed to go beyond personal preferences and extended to a general cynicism about the political process as a whole, with one German group member commenting that all the images of politicians, “make me almost vomit.” Obviously staged photos of politicians—for example an image of David Cameron posing with a husky dog— nearly always prompted negative reactions, whereas more ‘day to day’ photos of politicians were sometimes met with less disdain. Some fairly mundane images of negotiators at a climate change summit were received more favorably than other photos of politicians, because they portrayed active engagement with climate change and appeared less staged.

Cynicism towards ‘climate clichés’

When asked (before being shown any photographs) at the beginning of the discussion groups what image first came to mind when they thought of climate change,

participants readily made a series of associations – polar bears, melting ice, a burning globe, fire, pollution, and coal power stations. However, when shown these ‘clichéd’ images, few appeared to be persuaded or more concerned about climate change when viewing them. Participants identified these images as having lost their impact precisely because of their familiarity and over-use: “. . . the polar bear and the burning earth makes me angry for some reason. Not because I’m like, oh no that’s a pressing issue, but like ‘oh this is so annoying’.” A widely circulated image of a burning earth held in a human hand prompted a number of mixed reactions. Some liked it because, ‘it kind of says the world is in our hands a responsibility to take care of . . . just like we take care of our children,’ but others referred to it as “a bit stupid”, “a bit naff” and “[it] just pisses me off”. One group member commented that it felt to him like “propaganda” forcing him to react in a certain way when he wasn’t sure he wanted to.

A minority of participants was still moved by some of these clichéd images, particularly those depicting polar bears. Some participants reported that they might be motivated to respond pro-socially after seeing the polar bear imagery, but this was largely in reference to helping the polar bear specifically: “I feel really sorry for the polar bears, I might donate for the polar bear thingy, but not for global warming”. Similarly, images of land drying out, deforestation, and droughts that are also familiar clichés were not readily associated with climate change: “. . . if someone was to pass me this image [of a man in a dried out landscape] it would be like, poverty, third world countries. This is just what I’ve been raised to think. This wouldn’t affect me as far as climate change.” These results pose a difficulty for climate change communicators: the imagery most readily associated with climate change may not be the most effective at

promoting concern about climate change or intentions to take personal action. Overuse of certain types of images results in a reduction in their effectiveness, and may even come to be seen as inauthentic and this seemed to extend in the minds of most discussion group participants to images that depicted climate protests and demonstrations.

While participants expressed interest in and sympathy for social justice issues and some concern about climate change, most were not sympathetic to ‘typical environmentalists’ or images of environmental protest. When asked to say how they pictured environmental campaigners, one London group member described, ". . . someone who chains themselves to a fracking banner . . . someone that marches and don't really want to communicate the full facts." Another categorized marchers as, “either hipsters trying to be cool or . . . lunatic extremists." Consistent with these negative impressions, images of environmental protestors often prompted accusations of hypocrisy. In Germany, one participant objected to an image of a child at a climate change protest. The child, who was holding a banner in the shape of a foam finger, was described as: ". . . a classic example of jumping on the bandwagon. She wants you to take the threat seriously, but these balloons, and this foam finger, are the worst for the environment. It's so outrageous, a lot of the time these protestors that are protesting climate change are doing things like this." An image of a protester with his face painted blue was perhaps the most negatively received of all the photographs we tested. He was accused of being a ‘frat guy’ or alternatively someone who ". . . probably used the same face paint to paint himself at Glastonbury this weekend, and rubbed out climate and put Kanye West." Overall, participants did not like the generic protest images

either. One picture prompted the comment, “For me, it feels like I’ve seen that image a 1000 times for pretty much every cause there is in the world”. Specific campaign related jargon in images, such as ‘divest’ or ‘climate justice’, meant little to the group members and mostly prompted confusion.

The complexities of ‘localizing’ climate images

The results of our discussion groups support the idea that reducing the psychological distance of climate change as a strategy for engagement and the effectiveness of displaying local climate change impacts are not as straightforward as previously thought. While localizing climate change may possess some advantages, what counts as a ‘local’ impact and whether this motivates or undermines concern about the wider climate issue was mixed. For example, photographs of recent flooding in the UK and Germany— events that have already been linked to the warming climate—were met with a mix of positive and negative reactions. Several participants said the images made climate change feel more immediate, and worrying: " I think [image of people protesting about flooding on a Pacific island] is good, but personally for me [image of a flood in a UK town] has got more of an effect, because it’s local, because you can actually see that something’s happened”. However, not all participants exhibited this type of response.

One key factor that emerged in responses to localized imagery was participants’ consideration of how the effects of climate change would impact wealthier countries relative to those less well off. One participant objected to the concept that local, familiar imagery should be used to produce reactions in Westerners, arguing “for me the whole point of climate change is it's about knowing what's going on outside your bubble . . . to

me Western people saying they feel more sorry for western people because they get flooded . . . to me that's really selfish”.

Participants’ responses suggested that they believed Western countries would be relatively resilient to climate change impacts, and were thus less concerned about the negative impacts of climate change when depicted in these local contexts. Flooding in Germany or the UK was perceived by some as less of a serious issue than effects in other countries:

“A flood in this country doesn't have the same emotional effect as a flood in other countries, it's going about, you're not massively inconvenienced in that picture”. [looking at an image of a UK town, flooded to knee/waist level]. “And that I know that guy's fine if his house got flooded, he'll be fine, he'll get money from insurance or whatever because that's the society that we're living.”

In comparison, some participants had strong reactions to images of people experiencing climate change impacts in distant places: ‘ . . . with [image of a Nigerian man looking directly at the camera whilst gesturing to a fire behind him] . . . he seems like in real emotional pain and it kind of affects me. Not like before when you have people yaaay solar panels . . . an honest reaction to the situation, losing everything he used to have.’

Study 1 Discussion

The results of the discussion groups yielded a number of novel insights about reactions to visual imagery related to climate change and relate to the four broad categories of images that we expected to play a central role in participants’ evaluations. First, the perceived authenticity and credibility of human subjects in the images

evaluated played a consistent role in shaping participants' judgments, with 'real people' preferred to 'staged' images of politicians, or even environmental protestors. Images where the subjects were 'celebrating' rather than simply engaging with low-carbon technologies were typically viewed as contrived, rather than compelling or motivating. Taken together, these findings support and extend the findings of previous studies showing that solutions-focused imagery is likely to evoke more positive reactions (O'Neill and Nicholson-Cole, 2009; O'Neill et al., 2013), and that ordinary people in images can provide a 'personalizing' influence (Banse, 2013; Nicholson-Cole, 2005; Braasch, 2013). However, they also suggest some clear but challenging conclusions for climate campaigners, as the depiction of 'celebratory' groups around particular climate solutions and picture of demonstrators on protest marches are common.

Second, our findings also fit with the growing understanding of the complexity of reducing the 'psychological distance' of climate change as a strategy for increasing engagement and action on climate change (McDonald et al., 2015). Images depicting local climate change impacts, while effective for some, also had a number of unanticipated consequences. Primary among these was the fact that participants believed that impacts in other less developed nations were going to be worse and that the UK and Germany would be resilient against climate change impacts. Therefore, depicting local impacts appeared to reduce concern and to some extent trivialize the issue. For some participants, depicting local impacts was even seen as offensive, with the belief that concern about climate change should not rest purely on self-interest, but rather on concern about global impacts.

Despite the rich findings derived from this participative exploration of public opinion, qualitative methods alone are not able to furnish climate change communicators with systematic data on public responses to climate change imagery. Study 2 was therefore designed to provide a complimentary methodological approach to understanding public responses to climate imagery, focusing on a smaller number of images, but drawing on a much larger (and representative) sample.

Study 2. Online Survey Experiment

In order to build on and test the generalizability of findings from the discussion groups, we developed an online survey with embedded experiment to administer cross-nationally. A smaller number of images from Study 1 were selected for use in Study 2 on the basis of three criteria: first, to comply with the tripartite cause/ impact/solution distinction; second, to reflect a degree of diversity within each of these categories (e.g. climate impact images depicted a range of impacts); and third, where specific images in Study 1 had attracted particular attention (e.g., an image of children ‘celebrating’ around newly installed solar panels). Our outcome variables included many of the dimensions that emerged during the discussion groups (e.g., understanding of image meaning, emotional reactions) but were also designed to assess aspects we considered particularly important to quantify (e.g., willingness to share the images, motivations to change behavior after seeing the image). We also sought to gain a more nuanced perspective on how these different image types are interpreted by individuals with different identities. Therefore, we also explored cross-national differences in responses to imagery, as well as the role of climate change skepticism in determining how participants reacted to differing types of climate change imagery. Given the growing

role of social media and importance of social sharing and “viral” media, we were also interested in assessing how individuals thought others would react to these images. As this was not a direct focus of the findings presented here, the descriptive results of these analyses can be found in Appendix C.

Methods

Participants

A market research firm, Research Now, was contracted to conduct a three-country, online (internet) survey with embedded experiment in the US, UK and Germany. Research Now provided non-probability, nationally representative quota samples for each country. These samples are matched to country-level census data on geographic region, gender and age, and education level was also tracked in the U.S. Difficulty in obtaining a sufficient number of older adults in all countries resulted in samples that slightly underrepresent adults over the age of 65 ($M = 44.46$, $SD = 16.60$, $Median = 44$, $Min = 18$, $Max = 88$). In total, 3014 participants (U.S., $n = 1001$; U.K., $n = 1007$; Germany, $n = 1006$) participated in the study. Gender quotas were met closely (51.4% female).

Measures and procedure

Research Now invited individuals to participate in a 15–20 min survey in exchange for financial compensation. The survey was conducted in the primary language of the country in which participants lived (English for US and UK, German for Germany). The research team constructed the original survey materials in English, which were then translated into German by a native speaker. A second native German

speaker later reviewed the translated version of the survey. Where appropriate, changes to improve readability and comprehension were made.

After consenting to participate in the study, participants reported on their degree of climate change skepticism using two items (e.g., “I am uncertain about whether climate change is happening or not”; 1 = strongly disagree, 7 = strongly agree; $M = 3.71$, $SD = 1.663$; $r = 0.552$). Skepticism did not differ between experimental conditions, $F(2, 3011) = 2.061$, $p = 0.127$, $R^2 = 0.001$. However, the three countries slightly differed on their level of skepticism, $F(2, 3011) = 9.231$, $p < 0.001$, $R^2 = 0.006$, with the U.S. sample ($M = 3.82$, $SD = 1.768$) and U.K. sample ($M = 3.78$, $SD = 1.632$) reporting greater slightly greater skepticism than the German sample ($M = 3.53$, $SD = 1.570$; differences between U.S. and U.K. are not statistically significant, but both significantly differ from Germany at $p < 0.001$).

Participants were then randomly assigned to see images that portrayed either climate change causes, impacts, or solutions, which served as the three conditions for the experimental component of the study (approximately 333 participants in each country saw causes, impacts, or solutions). In total, each participant saw a series of six images from one category, which were fully randomized within condition (the set of images used in the experiment, as well as descriptive statistics for each individual image, can be found in the online report at www.climatevisuals.org/research/).

After each image was displayed on the screen, participants were asked to respond to a set of six items. As there are no psychometrically validated measures of reactivity to climate change imagery, the scale items were created by the researchers to address some of the key themes and focal points of the findings from Study 1. Table 5

displays these items and the construct they were intended to measure. After completing all measures for all six images shown, participants were thanked for their participation.

Results

Table 6 displays the correlations between each outcome variable in this study. Our primary analyses examined whether there were differences between our experimental conditions (causes vs. impacts vs. solutions) on our outcome variables. Therefore, we computed average scores for participants' responses (i.e., understanding, affect, etc.) collapsed across the six images that they saw during the study. The majority of these were very highly correlated with one another. However, emotional responses to images were only weakly correlated with the other outcomes.

Table 5. Constructs, items, and scales used in the online survey experiment.

Construct	Item	Scale
Understanding of image	To what extent do you feel as though you have an understanding of what this image is trying to convey?"	1 = <i>not at all</i> , 5 = <i>completely</i>
Affective response	On a scale of -5 to +5, where -5 equals "really negative" and +5 equals "really positive," how does this image make you feel?	-5 = <i>really negative</i> , +5 = <i>really positive</i>
Information seeking motivations	How motivated do you feel to seek out more information about what this image depicts?	1= <i>not at all motivated</i> , 4 = <i>very motivated</i>
Willingness to share the image	Compared to most other images about climate change that you've seen, how much more or less willing would you be to share this image with friends on social media?	1 = <i>much less willing</i> , 5 = <i>much more willing</i>

Motivation to change personal behavior	Does the image make you want to change your own behavior to reduce your impact on the environment?	1 = <i>not at all</i> 5 = <i>very much</i>
Motivation to support climate change policy	“Does the image make you more or less supportive of government policies to tackle climate change?”	1 = <i>much less supportive</i> 7 = <i>much more supportive</i>

Emotional response to images

There was a large and significant effect of condition on participants’ affective reactions to the images in each category, $F(2, 3011) = 747.174$, $p < 0.001$, $R^2 = 0.332$. Images of climate change solutions generated a modestly positive emotional reaction ($M = 1.21$, $SD = 1.653$), whereas images of climate change impacts ($M = 1.14$, $SD = 1.97$) and causes ($M = 1.68$, $SD = 1.695$) both generated negative emotional reactions. Tukey’s post-hoc analyses indicate that all three conditions significantly differed from one another on affective reactions (Mean differences ranged from 0.54 to 2.88, p ’s < 0.001).

Table 6. Bivariate correlations between study measures assessing responses to imagery.

	(1)	(2)	(3)	(4)	(5)	(6)
Understanding (1)	1					
Emotional response (2)	.067	1				
Seek out information (3)	.634	.090	1			
Share image with others (4)	.580	.109	.818	1		
Change personal behavior (5)	.601	.057**	.857	.834	1	

Support government climate policy (6)	.554	.037*	.747	.809	.828	1
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Note. * $p < .05$, ** $p < .01$, all other coefficients are significant at $p < .001$

Motivation to change personal behavior and support government policy

There was also a significant effect of image condition on expressed motivations to change personal behavior after viewing the images, $F(2, 3011) = 37.128$, $p < 0.001$, $R^2 = 0.024$. Climate change impacts generated the greatest desire to change personal behavior ($M = 3.36$, $SD = 1.023$), which was significantly greater than motivations generated by causes ($M = 3.17$, $SD = 0.973$; Mean difference = 0.189, $p < 0.001$) and solutions ($M = 2.98$, $SD = 0.954$; Mean difference = 0.379, $p < 0.001$). The effect of image condition on support for climate change policy at the governmental level was also small but significant and followed the same pattern as the results for personal behavior, $F(2, 3011) = 44.998$, $p < 0.001$, $R^2 = 0.029$. Images of impacts generated greater support ($M = 4.84$, $SD = 1.20$) for climate change policy than pictures of causes ($M = 4.65$, $SD = 1.083$; Mean difference = 0.193, $p < 0.001$) and solutions ($M = 4.36$, $SD = 1.141$; Mean difference = 0.481, $p < 0.001$).

Motivations to share images with others

Image category also produced a significant effect on participants' willingness to share the images with others, $F(2, 3011) = 32.591$, $p < 0.001$, $R^2 = 0.021$. Images of impacts generated the greatest motivation to share the images with others ($M = 3.40$, $SD = 0.899$). Solutions images were the least likely to engender motivations to share ($M = 3.09$, $SD = 0.851$), while causes fell in between the impacts and solutions categories (M

= 3.22, $SD = 0.819$). Post-hoc analyses revealed that all conditions differed significantly, if minimally, from one another (Mean differences > 0.18 , p 's < 0.005).

Understanding of images and motivations to seek out more information.

Understanding of the images was also significantly affected by 2 image condition, $F(2, 3011) = 22.821$, $p < 0.001$, $R^2 = 0.015$. Images of climate change impacts were slightly better understood by participants ($M = 3.80$, $SD = 0.813$) than causes ($M = 3.66$, $SD = 0.798$, Mean difference = 0.141, $p < 0.001$) or solutions ($M = 3.55$, $SD = 0.815$; Mean difference = 0.243, $p < 0.001$). Consistent with these findings, there was also a small but significant effect of condition on motivations to seek out more information, $F(2, 3011) = 27.146$, $p < 0.001$, $R^2 = 0.018$. Impacts images generated greater information seeking ($M = 2.67$, $SD = 0.803$) than causes ($M = 2.53$, $SD = 0.766$; Mean difference = 0.139, $p < 0.001$) or solutions ($M = 2.42$, $SD = 0.761$; Mean difference = 0.255, $p < 0.001$).

Country level differences

Table 7 displays tests of significance and mean differences between each country on the outcome measures, collapsed across image type. The German sample tended to report the highest reactivity to imagery used in the study (e.g., greater affective reactivity, greater willingness to change personal behavior, etc.), while participants in the United Kingdom tended to report the lowest responses. The country-level effect on image responses was particularly pronounced for reported understanding of images, willingness to seek out more information, and motivation to change personal environmental behavior. The German sample significantly differed from both (Mean

differences > 0.35 , p 's < 0.005), while the U.S. and U.K. samples did not significantly differ on affective reactivity in these two conditions (Mean differences < 0.15 , p 's > 0.7). In contrast, in the solutions condition, while all samples reported greater positive affect, the U.S. sample ($M = 1.41$, $SD = 1.670$) and German sample ($M = 1.25$, $SD = 1.599$) reported comparable levels of positive affect (Mean difference = 0.16, $p = 0.442$). The U.K. sample ($M = 0.981$, $SD = 1.665$) reported less positive affect in than the U.S. sample (Mean difference = 0.43, $p = 0.002$) and marginally less than the German sample (Mean difference = 0.27, $p = 0.075$). There were no other significant or trending interactions between image type and country of origin.

Interaction between image type and climate change skepticism

There were also significant interactions between climate change skepticism and image type condition on five of the six items assessing participants' image responses. Table 8 displays the interactions for each measure (including the non-significant interaction for the understanding measure), each of which follows a very similar pattern. While in the causes and impacts conditions, greater skepticism predicts less pro-environmental responses (e.g., flatter emotional response, less willingness to change personal behavior), this effect is reduced in the solutions condition. This interaction appears to be driven by reduced motivations to act by non-skeptics after seeing solutions images, rather than a positive shift by skeptical participants. Similar, though weaker, interactions emerged for several measures when examining political ideology as a moderator rather than climate change skepticism (see Appendix C).

Table 7. Country-level differences on image responses collapsed across image-type.

Item	<i>F</i>	<i>R</i> ²	Country	<i>Mean</i>	<i>SD</i>
Understanding	86.217***	.054	U.K.	3.43	.805
			U.S.	3.68	.804
			Germany	3.89	.768
Affective response	9.498***	.006	U.K.	-.434 ^a	2.051
			U.S.	-.392 ^a	2.232
			Germany	-.776	2.217
Seek out more information	72.025***	.045	U.K.	2.32	.776
			U.S.	2.58	.788
			Germany	2.72	.731
Share image with others	14.133***	.009	U.K.	3.12	.819
			U.S.	3.31 ^b	.889
			Germany	3.28 ^b	.878
Change personal behavior	40.403***	.026	U.K.	2.95	1.005
			U.S.	3.22	1.037
			Germany	3.33	.906
Support government policy	15.313***	.01	U.K.	4.47	1.085
			U.S.	4.63	1.271
			Germany	4.75	1.101

Note. Post-hoc analyses to examine between-country differences were performed using Tukey's adjustment. Matching superscripts denote post-hoc tests that did not attain significance. All other post-hoc comparisons are significant at $p \leq .05$

Discussion

The results of the experimental survey yielded a number of interesting findings, some consistent and some inconsistent with the results of the qualitative research (see General discussion below). Consistent with the qualitative results, images of politicians and protesters were rated as particularly ineffective in the quantitative study. Images of climate change impacts were the most effective at increasing self-reported motivations to change behavior and support government policy. While climate change impacts also produced negative emotional reactions, given these other findings, it seems that this negative affect may have been important for increasing intentions to act. In contrast, images of climate change solutions, while producing substantially more positive affect, also tended to score the lowest on motivations to change behavior, support government policy, or seek out more information about the image. Indeed, solutions images decreased non-skeptics' issue engagement on nearly all response items such that there were no differences between skeptics and non-skeptics in that condition. Thus, it is not clear from this evidence that the use of solutions imagery on its own—while less polarizing—will be conducive to greater environmental action overall. This finding does in some ways differ from O'Neill et al. (2013), who found that images of solutions produced greater feelings of self-efficacy in a Q-sort task. One possibility for this difference in results could be due to variations in the types of 'solutions' imagery used. For example, the images depicting solutions to climate change in the research presented here tended to focus on depicting concrete actions being taken by individuals, which may have communicated to individuals that they no longer needed to take personal action because others were doing so. Future research should examine the influence of

different types of ‘solutions’ imagery on behavior change, motivation, and efficacy in more detail to better understand these differences.

Limitations of these findings include the use of single-item measures to assess each construct, as well as the fact that our items assessed self-reported intentions rather than measuring actual concrete behaviors. Future quantitative research should use expanded scale measures and assess actual behavior in order to more comprehensively understand the influence of different types of climate change imagery. Furthermore, the items assessed in this study, which were designed to gain a broad assessment of individuals’ perceptions, differed from some of the past research on imagery (e.g., O’Neill et al., 2013). Therefore future research would also benefit by using multiple measurement types from past research to better understand the diverse effects of imagery on public perceptions.

Table 8. Interactions between climate change skepticism and imagery condition.

	Interaction (<i>F</i>)	Condition	<i>b</i>	<i>SE</i>	95% Confidence Intervals	
					Lower	Upper
Understanding	1.662	Causes	-.04*	.02	-.068	-.007
		Impacts	-.04*	.01	-.070	-.012
		Solutions	-.01	.02	-.035	.025
Affective response	118.399***	Causes	.41***	.03	.348	.473
		Impacts	.53***	.03	.469	.588
		Solution	.11***	.03	-.176	-.051
		Causes	-.05**	.02	-.078	-.019

Seek out more information	3.739*	Impacts	-.06***	.01	-.087	-.031
		Solutions	-.01	.01	-.034	.024
		Causes	-.04*	.02	-.075	-.010
Share image with others	3.045*	Impacts	-.07***	.02	-.102	-.040
		Solutions	-.01	.02	-.047	-.017
		Causes	-.08***	.02	-.119	-.045
Change personal behavior	5.306**	Impacts	-.10***	.02	-.133	-.062
		Solutions	.02	.02	-.054	.020
		Causes	-.14***	.02	-.187	-.102
Support government policy	5.736**	Impacts	-.18***	.02	-.218	-.137
		Solutions	-.08***	.02	-.120	-.036

Note. *** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .10$

General Discussion

The current research presents some of the first evidence gathered regarding the impact of climate change imagery on individuals' affective, attitudinal and behavioral responses to the issue. Using a unique (in this domain) combination of qualitative and quantitative methods, we uncovered a number of practically relevant and theoretically interesting findings that can inform and improve climate change communication in a

cross-national context. Importantly, we found points of both convergence and divergence between the results of the two studies, highlighting the critical importance of studying the impact of visual imagery using a variety of methods. For an expanded discussion of the research findings, see Corner et al., 2015 and the accompanying Appendix to that report.

Images depicting climate change impacts, such as those displaying individuals with authentic, identifiable emotional expressions evoked issue concern and emotional reactions from participants in the discussion groups and, overall, images of impacts were the most motivating for individuals (e.g., intentions to change personal behavior) in the quantitative survey. Findings regarding images of climate change solutions were also similar across the two studies. In the survey, images of solutions evoked positive affect, but were among the least motivating for participants, while in the discussion groups, although images of individuals genuinely engaging with climate solutions were well regarded, a number of solution-based images (e.g., protestors advocating for solutions to climate change) were met with cynicism.

The present work also challenges, or at least raises questions about, current orthodoxy regarding the communication of climate change impacts and causes versus solutions. Many climate communications guides (e.g., CRED & ecoAmerica, 2014) and research findings (e.g., Campbell and Kay, 2014) suggest that highlighting possible solutions to climate change is critical for engaging many audiences. Although doing so may be necessary in many cases, the present findings suggest images of such solutions (e.g., installing solar photovoltaics) may not be sufficient for motivating action, in part because audiences do not always connect these images to climate change. On the other

hand, images depicting climate impacts were readily connected to the issue by our participants and were also more motivating of action. Participants were also motivated to share these images with others and believed that they would be effective visuals for prompting others to act as well, although results from the qualitative work also indicate that these images can be overwhelming for viewers, possibly reducing engagement for some individuals (see also Lertzman, 2015). Together these results suggest that, just as with verbal climate communications (e.g., CRED & ecoAmerica, 2014), coupling images of climate impacts with concrete behavioral actions for people to take (i.e., solutions) may be particularly important for maintaining engagement.

Our results also raise questions about the relative efficacy of localizing the issue of climate change for audiences. In our discussion groups, many participants exhibited greater empathetic reactions to depictions of distant climate change impacts, particularly in developing countries. In contrast, some participants saw local climate change impacts as either trivializing the issue or else as offensive by focusing on one's own country rather than others. These results align with recent work suggesting that at least some groups (e.g., Democrats) react more positively to stories about climate impacts affecting people living far off geographically or temporally (Hart and Nisbet, 2012). However, this was also one area where the two studies disagree, as localized images fared better than more distant images in the survey experiment. One possible explanation that can accommodate both sets of findings (and corresponds to current theorizing on psychological distance) is that localized images are effective to the extent that they are perceived as serious (rather than trivializing the wider issue of climate change by suggesting that limited local disruption is equivalent to major climate

impacts elsewhere). Future research is needed to more comprehensively examine how different climate change images impact individuals' perceptions of the psychological distance of climate change.

Finally, the results of both studies also suggest that clichéd images of climate change produce mixed responses among the public. Images that our survey participants could quickly and easily understand such as 'smokestacks', deforestation, and polar bears on melting ice – were positively received and associated with the greatest support for climate change policy and action. In the qualitative work, however, while these 'classic' climate images were easily recognizable by participants, they also produced a muted emotional response and often prompted cynicism. Together, these results highlight the challenging balance communicators must strike between using easily-recognizable but over-saturated climate images and less familiar but potentially more engaging visuals. Our work suggests that contextualizing less familiar but potentially powerful images by connecting them with more readily recognizable aspects of climate change may be one effective pathway forward.

Future Directions

The present findings raise a number of important questions to be resolved by future research. Perhaps most critically, additional research is needed to examine whether different types of solutions-based imagery resonate more or less strongly with particular audiences, as recent work suggests that various solutions (e.g., more regulation versus more reliance on nuclear energy) appeal to different audiences in quite divergent ways (e.g., Kahan et al., 2011). More generally, additional research is needed to identify ways in which the positive affect associated with many climate

solutions can be leveraged into greater issue engagement. In addition, future research should continue to unpack the complex dynamics involved in using imagery that depicts climate change impacts and how this interacts with key issues such as psychological distance, reactance and apathy (see McDonald et al., 2015; O'Neill et al., 2013). Another fruitful future research direction would be to examine how photographic climate change imagery may differentially influence individuals' responses depending on different accompanying text-based frames of climate change. For example, Hart and Feldman (2016) recently found that images of solar panels were more likely to increase perceived efficacy to act on climate change when text accompanying the image discussed actions that can be taken to address climate change.

It is also worth re-emphasizing that the research presented here focused on photographic climate change imagery, rather than visuals about climate change more broadly. However, it seems likely that a number of the principle themes uncovered in these analyses may reasonably extend to other forms of visuals. The value of authenticity is likely to be important regardless of the visual medium, and indeed may emerge as even more important in other mediums aside from photographs (e.g., documentary films, animations). There may be other instances where divergence in responses occurs across types of visuals. For example, producing effective illustrations, infographics or animations may follow different criteria for effectiveness than photographs or films altogether (e.g., is presenting people in a cartoon depicting climate change similar to presenting real people in photographs?). These are important empirical questions beyond the scope of the present investigation; future research is

needed to uncover the relative importance of different principles examined here in the context of other visual mediums.

Finally, points of both convergence and divergence between the findings of our qualitative and quantitative work point to the importance of mixed-methods studies in this domain. One important advantage of qualitative over quantitative methods in the context of studying climate imagery is the ability they provide to more fully contextualize images for study participants; the lack of context in the quantitative work may help explain some of the findings regarding both iconic and solutions-oriented imagery. On the other hand, quantitative approaches can support generalizability. Although the design and findings of these studies do not permit definitive explanations of the points of divergence between the quantitative and qualitative findings, several possibilities exist. First, the discussion group design may have permitted participants to be more elaborative both in their cognitive processing of the images themselves as well as in their reported reactions to the imagery. In contrast, the closed-ended, narrowly specific questions that participants answered in the quantitative study may not have allowed for the same degree of elaboration by participants. In future mixed-methods approaches, allowing for open-ended responses by participants in the quantitative portion, as well as assessing depth of information processing, may help shed light on the origin of these discrepancies. Second, whereas in the quantitative survey participants viewed the images by themselves one at a time, participants in the discussion groups viewed the images in rotating sets (and saw all of the images of the causes, impacts, and solutions) in a group setting. These clear contextual differences may have allowed for different elaborations and interpretations of the images, such as

participants cognitively comparing and contrasting the image sets differently while responding in the two studies. Future mixed-methods research might consider standardizing the cross-method design and deliberately asking participants to make or not make comparisons across images sets in order to help explore the effects these processes may have on responses. Future research should continue to use a mixed-methods approach as well as attempt to capture the unique advantages afforded by various methodologies in order to better understand how individuals interpret and react to what will often be strongly-framed, context-rich climate imagery.

Addendum: Bayesian Modeling of Cultural Worldviews

Overview

The results provided in Chapter 4 highlight some inferential, though primarily descriptive, findings on how individuals perceive and respond to climate change imagery, and how this is influenced by the type of imagery, country, and climate change skepticism. While beneficial in a general sense, the aforementioned analyses suffer from several methodological limitations. Inferences from the statistical models relied primarily on descriptive comparison, and *p*-values were reported as an inferential measure in spite of their lack of utility in the case of the large participant sample recruited. Furthermore, these preliminary analyses were done in a piecemeal fashion using fixed-effects regression/ANOVA, rather than through a more unified hierarchical regression framework.

While participants responded to the dependent measures after each image viewed, in the initial analyses I averaged across responses to different images within condition

(i.e., averaged affective responses across all of the images participants viewed). However, this process of averaging can mask important variability captured from such within-subject measurements, and can lead to more biased estimates (McElreath, 2016). Therefore, in the hierarchical regression models presented which analyze outcomes related to the imagery, I allowed the intercept of the model to vary across each image participants saw. Furthermore, while effects across each country appeared modest, allowing the model intercepts to vary across each country rather than entering country as a fixed-effect covariate is considered a better approach to modelling such variability (Gelman et al., 2013).

Further, these analyses did not directly address the role of cultural worldviews in motivating respondents' climate change attitudes or their responses to the images that they viewed. As noted in the main body text, other measures were included in the full survey experiment that were not able to be reported in the main text due to space limitations of the original publisher. Inclusion of these measures allows for a more theoretically-informed investigation. In particular, Kahan et al.'s (2011) 12-item cultural worldview measure was included, which measures worldviews along the dimensions of hierarchical-egalitarian and individualist-communitarian. Theoretically, these worldview measures are thought to be antecedents to climate change attitudes, and associated with political ideology to varying degrees; Kahan et al. (2011) explored the role of cultural worldviews by entering these measures and their interaction as predictors of climate change attitudes. In general, higher hierarchical and higher individualist attitudes tend to be associated with greater negative climate change attitudes, whereas the reverse is true for egalitarian and communitarian attitudes.

Therefore, instead of taking the approaches described in the main text of Chapter 4 (e.g., fitting an interaction between climate change skepticism and experimental condition), I fit a series of more theoretically-driven and empirically robust models. In addition to providing a follow-up to Kahan et al. (2011) using a large, multi-national sample of respondents, these data also offer the ability to directly assess the factor structure of the 12-item measurement and examine any cross-national differences in the measurement structure. The analyses described here extend Kahan et al. (2011) and the prior work discussed in Chapters 2 and 4 by examining the role of cultural worldviews, political ideology, and climate change skepticism in influencing responses to visual imagery used to depict climate change.

The relationships between cultural worldviews, political ideology, and climate change skepticism were explored by fitting a model to predict skepticism from the other measures of interest, alongside key demographic predictors. This model was then extended to also examine how these factors influence perceived threats from climate change. Finally, participants' responses to the climate change imagery were modelled using a more parsimonious, theoretically informed modelling approach (e.g., incorporating cultural worldviews and key demographics, using dimension reduction to create composites), while also modelling the data in a more appropriate, hierarchical manner.

Measures

Cultural worldviews

To measure cultural worldviews, Kahan et al.'s (2011) 12-item self-report measure was used. This measure includes items designed to assess the hierarchical-egalitarian (HE) and individualist-communitarian (IC) dimensions of cultural worldviews (see Table 9). Based on the procedure of Kahan et al. (2011), all items were scored on six-point Likert-type scales (strongly disagree to strongly agree) with no neutral midpoint. Six items measured HE total, with the three egalitarian items reverse coded for analysis. Of the six items measuring IC, the three measuring communitarian attitudes were also reverse coded. The HE items were averaged together into a single composite, as were the IC items, with higher scores reflecting greater hierarchical and individualistic worldviews, respectively.

Table 9. Cultural worldview constructs and scale items.

Variable	Item	Worldview
IINTRSTS	The government interferes far too much in our everyday lives.	Individualism
CHARM	Sometimes government needs to make laws that keep people from hurting themselves.	Communitarian
IPROTECT	It's not the government's business to try to protect people from themselves.	Individualism
IPRIVACY	The government should stop telling people how to live their lives.	Individualism
CPROTECT	The government should do more to advance society's goals, even if it means limited the freedom and choices of individuals.	Communitarian
CLIMCHOI	Government should put limits on the choices individuals can make so they don't get in the way of what's good for society.	Communitarian
HEQUAL	We have gone too far in pushing equal rights in this country.	Hierarchical
EWEALTH	Our society would be better off if the distribution of wealth was more equal.	Egalitarian

ERADEQ	We need to dramatically reduce inequalities between the rich and the poor, whites and people of color, and men and women.	Egalitarian
EDISCRIM	Discrimination against minorities is still a very serious problem in our society.	Egalitarian
HREVDIS2	It seems like blacks, women, homosexuals and other groups don't want equal rights, they want special rights just for them.	Hierarchical
HFEMININ	Society as a whole has become too soft and feminine.	Hierarchical

Note. Egalitarian and Communitarian items were reverse scored for analysis.

Following Kahan et al.'s statistical modelling approach (2011), the items were averaged along the HE and IC dimensions. A Cronbach's alpha was computed for each six item composite as a rough index of reliability. The HE composite ($M = 3.01$, $SD = .984$, $Median = 3.17$) had adequate reliability, $.76$, 95% CI = $.74, .77$, while the IC composite ($M = 3.75$, $SD = .781$, $Median = 3.67$) had lower reliability, $.63$, 95% CI = $.61, .65$. Examination of the item-total correlations for the IC composite suggest that removing the IPRIVACY item would increase the alpha to $.67$. However, given that each sub-measure only consists of three items and this reliability increase is only incremental, the full measure was used for analysis. These measures had lower reliability than was found in Kahan et al. (2011; HE = $.87$, IC = $.81$). There was negative skew ($.49$, $SE = .01$) in the distribution of IC, while the skewness of HE was less prevalent ($.07$, $SE = .02$).

Climate change skepticism

The two items measuring climate change skepticism were scored on 7-point Likert-type scales, with higher scores indicating greater skepticism. These items are the same as those described in Chapter 4, but are provided here again for clarity and with extra psychometric detail. These items had a moderate correlation, $r = .55$, 95% CI = $.526, .576$, sharing approximately 30% of their variance. The items were averaged into a

composite score of skepticism, $M = 3.71$, $SD = 1.66$, $Median = 4$, which possessed very little skew ($.05$, $SE = .03$). However, the skepticism measure had noticeable clumping at the lowest scale point ($n = 304$) and at the midpoint ($n = 540$).

Perceived threat of climate change impacts

Near the end of the survey, participants were asked to respond to six items measuring the extent to which they were concerned about a variety of potential threats of climate change. These included sea level rise, migration, and drought, among other things, and were scored on 7-point scales (higher scores indicating greater concern). These measures had strong inter-item correlations, and were thus averaged into a general measure of perceived threat, $.90$, $95\% \text{ CI} = .89, .91$. Participants were, on average, moderately concerned about these threats ($M = 4.64$, $SD = 1.38$, $Median = 4.67$), with only very modest skew observed in the measure ($-.30$, $SE = .03$).

Pro-climate change responses, affective reactions, and understanding of imagery

For modeling, a subset of items were selected from the post-image response items described in Chapter 4. This item reduction was based on both conceptual and statistical grounds. Motivations to change personal behavior and to support public climate change policy had a strong positive correlation sharing close to 70% of their variance, potentially indicative of a more general pro-climate change motivation, $r = .83$, $95\% \text{ CI} = .816, .839$, $R^2 = .685$. As these two items likely have similar psychological antecedents and were strongly correlated, they were averaged together into a composite measure. The single-item affective response measure was analyzed as its own outcome, as was self-reported understanding of the images (see Tables 5 and 6 in Chapter 4 for more information on these measures). These two items were selected for analysis given their connection to

literatures on comprehension of climate change (Kahan et al., 2012) and on the role of affect in climate change decision making (Chapman, Lickel & Markowitz, 2017). Thus, three separate outcomes were modelled in response to the images participants viewed. Affect was reversed coded for this analysis to ease interpretation, such that higher scores reflect more negative affective reactions. Higher scores on the understanding item reflected greater self-reported understanding of the images.

Results

Factor analysis of worldviews

While for the statistical modeling I focus on Kahan et al.'s (2011) two-composite format, I also performed confirmatory factor analyses to examine the factor structure of the full scale. Three structures were compared: the proposed two-factor solution (HE & IC as two factors), an alternative four factor solution treating each sub-measure individually, and a single-factor solution loading all items on one factor. In addition to fitting and comparing these models, I also tested whether this factor structure was similar or different across the three countries from which data were collected.

Confirmatory factor analyses were performed using the lavaan package for R (Rosseel, 2012), and the tests of measurement invariance were performed in an automated fashion using the semTools package (semTools Contributors, 2016). All variables were standardized to fit the models ($M = 0$, $SD = 1$), and the structures were estimated using robust maximum likelihood estimation, Huber-White (sandwich) standard errors, and the Yuen-Bentler adjusted test statistic, as implemented in lavaan.

The two-factor solution was not a good fit to the data, $\chi_2(53) = 4108.01$, scaling correction factor = 1.357, robust $CFI = .528$, $SRMR = .139$. The factor loadings (see

Table 10) demonstrate that the hierarchical and egalitarian items had only modest factor loadings with one another, and the same is true for the individualism and communitarian items. The four factor solution had a substantially better fit to the data, although in absolute terms was only modestly well-fit, $\chi_2(48) = 653.56$, scaling correction factor = 1.328, robust $CFI = .931$, $SRMR = .054$. While most loadings were much more sensible, CHARM had a only a modest loading on the communitarian factor. Finally, the one factor model was tested. This model was not a good fit to the data, $\chi_2(54) = 5385.53$, scaling correction factor = 1.363, robust $CFI = .376$, $SRMR = .159$.

Table 10. Confirmatory factor analysis results: loadings of the two-factor solution.

Construct	Variable	Loading Estimate	Robust SE
Hierarchical- Egalitarian (HE)	HEQUAL	1.121	0.028
	HREVDIS2	1.288	0.027
	HFEMININ	1.158	0.026
	EWEALTH	0.366	0.044
	ERADEQ	0.473	0.043
	EWEALTH	0.474	0.039
Individualist- Communitarian (IC)	IINTRSTS	0.960	0.024
	IPROTECT	0.708	0.028
	IPRIVACY	1.051	0.024
	CHARM	0.166	0.033
	CPROTECT	0.209	0.040
	CLIMATECHOI	0.229	0.040

Note. Loading estimates reflect standardized regression coefficients. Robust SE refers to sandwich standard errors.

As only the four factor solution was an adequate fit to the data, I utilized this model to perform the tests of measurement invariance. Following the procedure of the semTools package, five models were tested and iteratively compared, beginning with the strictest model, the configural model. In the configural invariance model all aspects of the model are constrained to be equal across each country in the sample. Compared to the other models (e.g., varying loadings, varying intercepts, etc.), this model had the lowest

chi-squared estimate, $\chi_2(144) = 1062.1$, compared with next best fitting model with varying loadings, $\chi_2(160) = 1289.4$, $\chi_2_{\text{difference}}(16) = 81.37$, $p < .001$. These results are suggestive, though not conclusive, of the structure of these attitudes being roughly equal across the nations tested. Nevertheless, these findings suggest that future work using the cultural worldviews measures may need to further improve upon their properties.

Bivariate associations among worldviews, skepticism, and political leaning

HE and IC had a small positive correlation, $r = .15$, 95% CI = .114, .184, sharing just over 2% of their variance. HE had a much more robust positive association with right-leaning political attitudes, $r = .47$, 95% CI = .441, .497, sharing approximately 22% of their variance. The estimate of association between IC and right-leaning political attitudes was positive, but very small in magnitude, $r = .05$, 95% CI = .018, .089, $R^2 = .003$. HE and climate change skepticism shared roughly 20% of their variance, and were positively associated, $r = .45$, 95% CI = .417, .474. Skepticism was also positively associated with IC, although this relationship was much less pronounced, $r = .11$, 95% CI = .077, .147, $R^2 = .013$. The findings regarding climate change attitudes, ideology, and their association with HE and IC converge with those of past research on the subject.

Modeling strategy

The primary goal of these analyses was to build statistical models predicting climate change skepticism, perceived threats from climate change, and responses to the climate change imagery respondents viewed. Bayesian hierarchical models were estimated for each analysis. HE, IC, and their interaction were fit as the focal predictors (fixed effects) in each model described. Additionally, each model included gender (0 = Female, 1 = Male), age, and left-right political attitudes as covariates, given their

typically small, but potentially informative, effects on climate change attitudes (e.g., Hornsey et al. 2016). For the models of pro-climate change actions that were in reference to participants' responses to climate change imagery, experimental condition was entered as a predictor for these models, as well as the dispositional measure of climate change skepticism. As participants provided ratings for each image in different conditions, the intercept of the model was allowed to vary by scores for each image. For all models, the intercept was also allowed to vary across each country represented.

As noted, a Bayesian estimation approach was implemented to generate models and interpret their degree of uncertainty. In places where there was the potential for including or not including certain model terms (e.g., interaction terms), model comparison and weighting was performed to evaluate which models had the best estimated out-of-sample predictive performance. My approach to this comparison and evaluation stems from recommendations of Gelman et al. (2013) and McElreath (2016). I utilized approximate leave-one-out cross-validation to estimate out-of-sample predictive performance and generate model weights (Vehtari et al. 2017).

All non-categorical predictors were standardized for the analyses ($M = 0$, $SD = 1$). Given that the pro-climate change motivation items are scored on two different scales, this outcome measure was also standardized in order to form an aggregated composite. I focus substantive model interpretation on the full posterior distributions of the models, and provide figures depicting the full posterior distributions of the fixed and random effects, as well as the estimated interaction effects.

Predicting skepticism

Climate change skepticism was modelled as the product of the worldview measures and relevant demographic predictors. While I did not anticipate experimental condition to meaningfully influence skepticism, I also sought to examine whether accounting for condition impacted model performance to explore any unanticipated effects or systematic failures of assignment to conditions. Thus, models were fit that both included and did not include image condition. When compared using LOO IC, the models were virtually indistinguishable (*LOO IC difference* = -0.60, *SE* = 4.56). The model including condition received ~56% of the LOO model weight. While the influence of including this variable was expected to be minimal in terms of prediction as a result, it was entered nevertheless to better account for the structure of the data and original design. Collinearity diagnostics were well within acceptable ranges for this model and all others reported (variance inflation factors < 2).

Figure 15 displays the full posterior distributions of key model parameters in the skepticism model, and figure 16 provides a decomposition of the fitted interaction intervals for the HE*IC interaction. Overall, this model of skepticism explained approximately 25% (95% posterior interval = 23%, 28%) of the variance. HE had the largest influence on skepticism, with a 1 SD increase in HE associated with a .59 unit increase in skepticism.

Posterior Distributions of Climate Change Skepticism Model

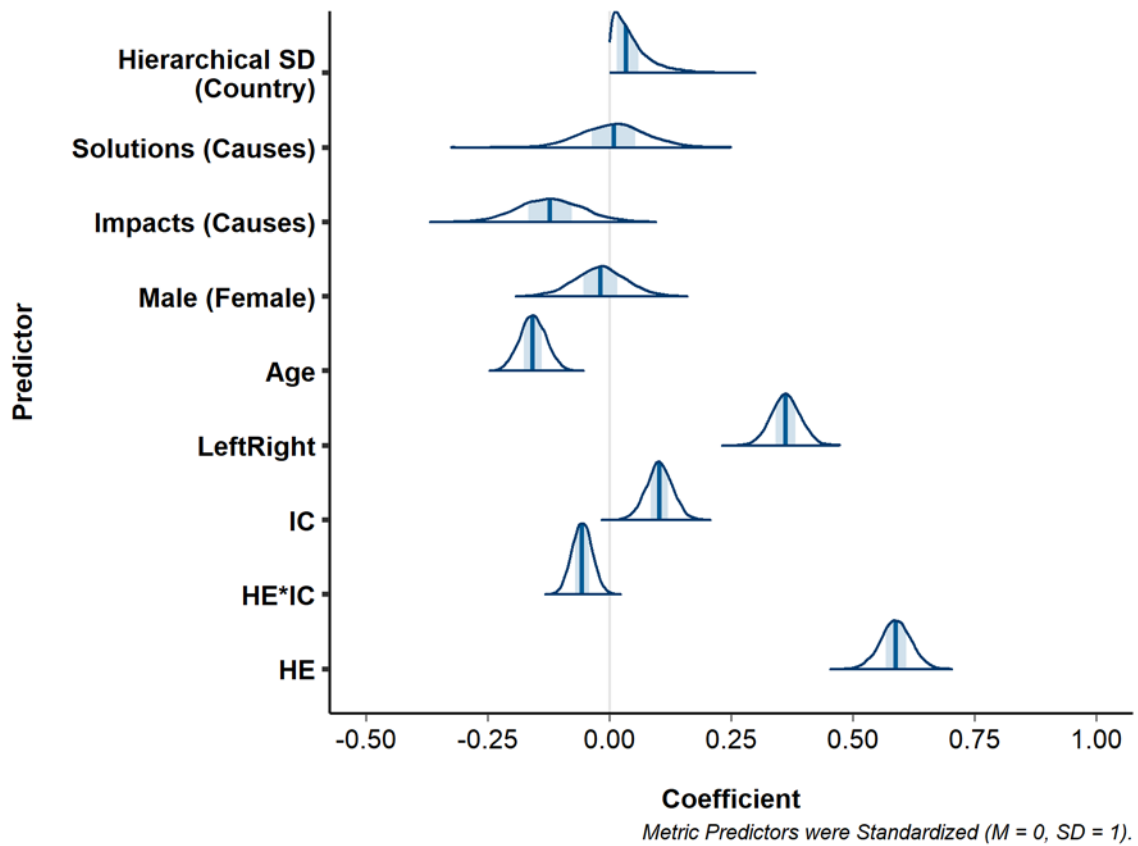


Figure 15. Posterior distributions of climate change skepticism model. Full posterior distributions from Bayesian hierarchical regression model. Vertical blue lines represent posterior medians and shaded intervals represent 50% posterior intervals.

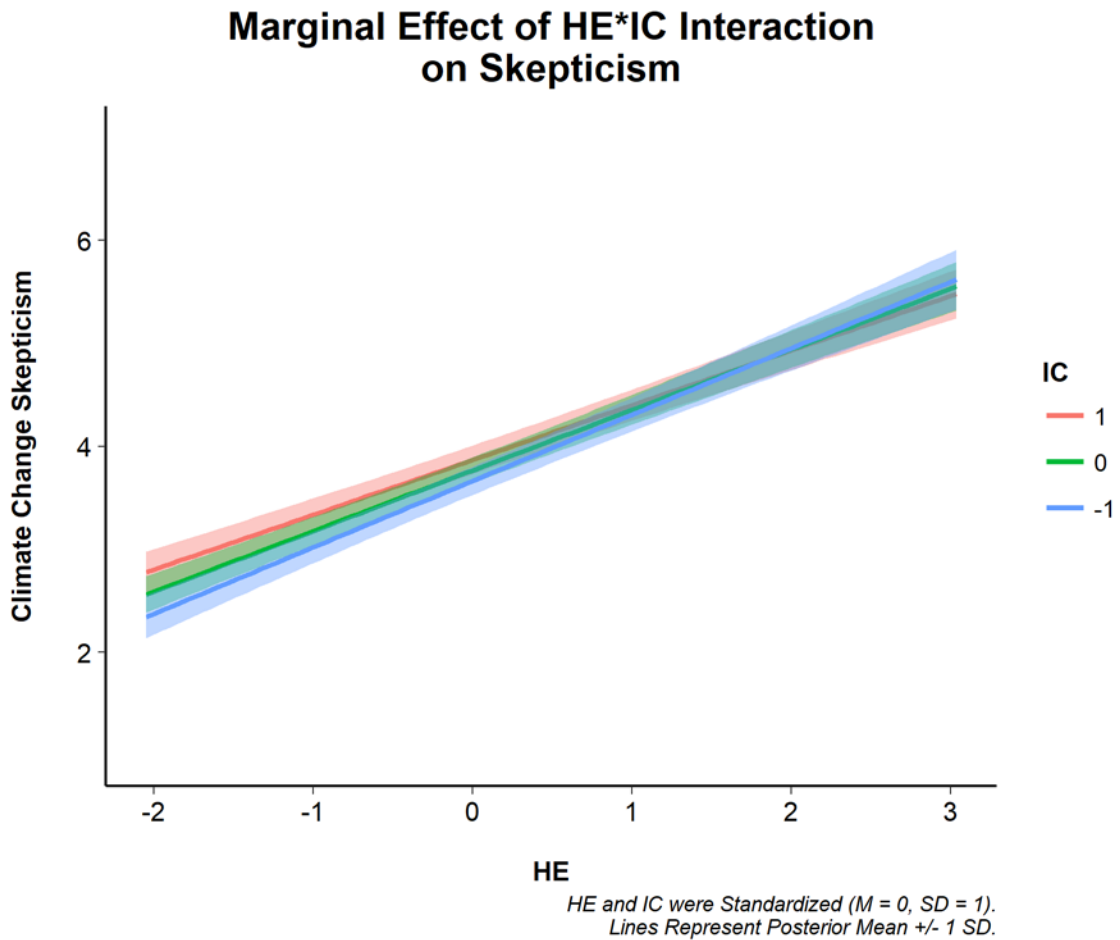


Figure 16. Marginal effect of HE x IC interaction on skepticism. Results come from a Bayesian hierarchical regression model. Predictors were standardized for the analysis. Blue, green, and red lines thus represent -1 SD, the mean, and +1 SD, respectively. Shaded intervals are 95% fitted regression intervals.

Right-leaning political views were the second strongest positive predictor of skepticism. Age had a negative influence on skepticism such that an increase of 1 SD in age lead to a roughly .16 unit decrease in skepticism, when adjusting for the effect of the other model predictors. IC also led to increases in skepticism, although the majority of the posterior distribution fell between 0 and .20, suggesting a relatively small effect. The interaction between HE and IC produced a negative effect on skepticism scores.

However, this effect was smaller than the positive main effects of HE or IC, and should

be interpreted with caution and a recognition of the size of the estimate. Evaluation of the fitted regression intervals for the interaction in figure 16 help portray the nature of this effect. At lower levels of HE, higher levels of IC were associated with slightly lower degrees of skepticism. However, when plotted on full outcome scale, this effect was very small relative to the main effects in the model.

Perceived threat of climate change impacts

To predict perceived threats of climate change, I fit a model with the same set of predictors as for skepticism. As these threat items were measured after participants saw a subset of climate change images, experimental condition was also entered as a predictor to incorporate any influences of this design. Furthermore, given the clear conceptual link between skepticism of climate change and perceived threats from climate change, skepticism was also included in this model as a predictor.

Candidate models were again fit using Bayesian hierarchical regression, allowing the model intercept to vary across each country. This was done to better account for variability in perceived threat across the sampled countries, each of which may be prone to these impacts to varying degrees. All non-categorical predictors were standardized ($M = 0$, $SD = 1$). This model accounted for roughly 17% (95% posterior interval = 15%, 19%), of the variance. Figure 17 provides a plot of the full posterior distributions for the key model parameters. The single strongest predictor of threat perceptions was HE, with a one standard deviation increase in hierarchical attitudes associated with a roughly .25 unit decrease in perceived climate change threat.

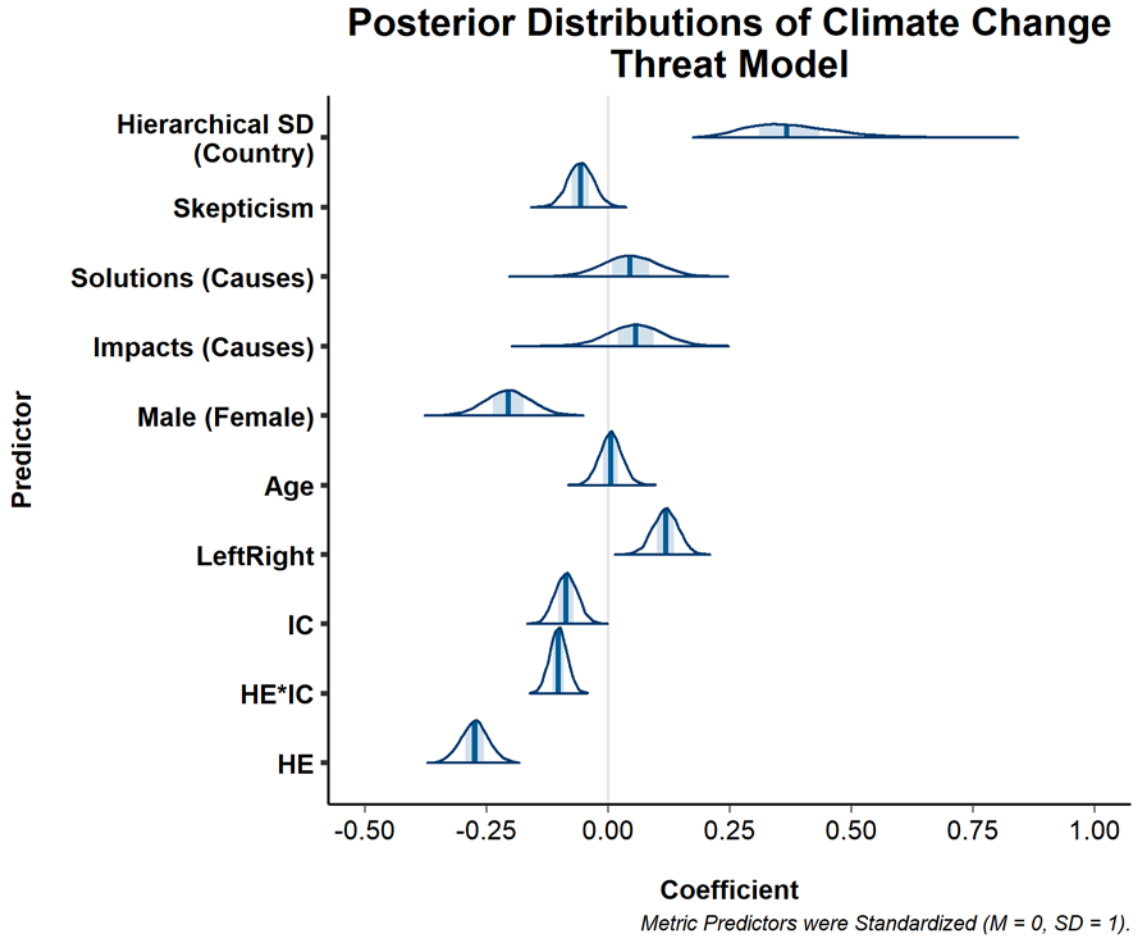


Figure 17. Posterior distributions of climate change threat model. Full posterior distributions from Bayesian hierarchical regression model. Vertical blue lines represent posterior medians and shaded intervals represent 50% posterior intervals.

There was only a small amount of variability across each country in terms of threat perceptions, as evidenced by the estimated hierarchical standard deviation parameter being centered close to zero. Though, the higher degree of uncertainty in this parameter is likely due to the limited information available (i.e., variation across 3 countries with similar political structures; see figure 18). In particular, participants in the United States and Germany reported higher risk perceptions than those in the UK by close to 1 unit.

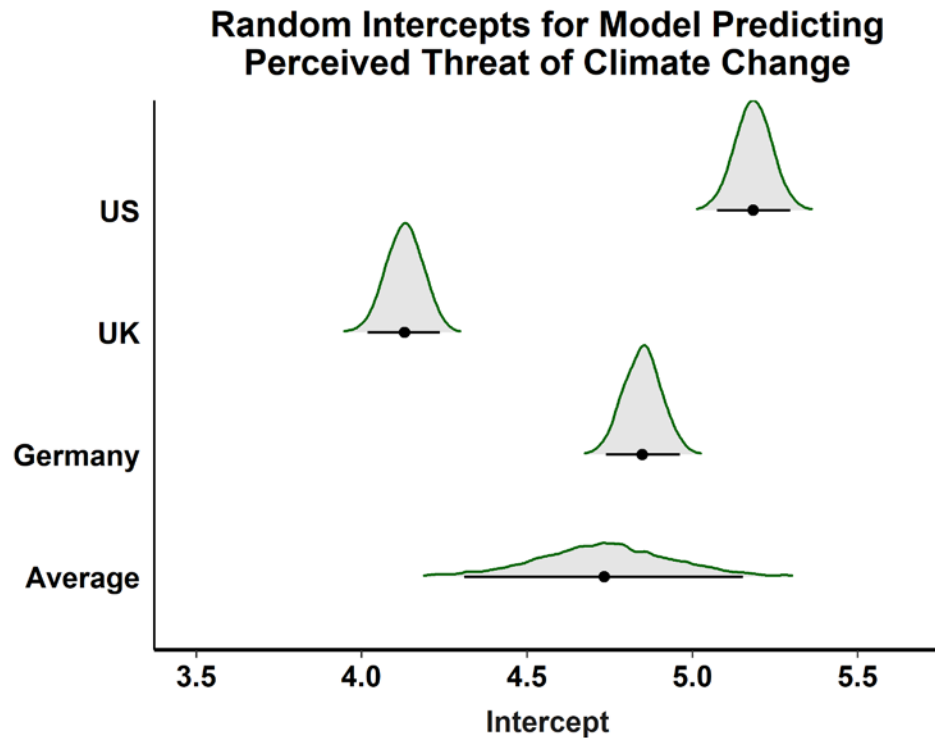


Figure 18. Random intercepts for model predicting perceived threat of climate change: countries. Plot depicts the full posterior distributions of the random effects.

IC, as well as the interaction between HE and IC had small estimated effects, nearly half the size of the effect of HE. In spite of their estimates being small, the full posterior distributions of both fell entirely below zero. Figure 19 provides a decomposition of the interaction and 95% fitted regression intervals. As HE and IC both increased, threat perception levels decreased most strongly. In contrast, as IC levels increased, the negative effect of HE on threat perceptions was largely attenuated. However, it is worth emphasizing again that these estimates are small in magnitude, and the fitted regression intervals substantially overlap. This suggests that while this interaction may be observed in larger samples and contribute to our understanding of threat perceptions at a theoretical level, this effect is likely to be small and may be difficult to estimate precisely in smaller sample sizes.

In comparison to females, males exhibited a considerable decrease in threat perceptions, although the uncertainty in this estimate is larger than for measures of HE and IC. Interestingly, in this full model, greater right-leaning political ideology was associated with greater, rather than less threat perceptions. However, it is important to note that in addition to being a relatively small effect, this effect emerges while adjusting for important variables, such as HE, IC, and skepticism, all of which are correlated with right-leaning ideologies. Indeed, the bivariate correlation between right-leaning ideology and threat perceptions was negative, $r = -.05$, 95% CI = $-.081, -.01$, sharing less than 1% of their variance.

Responses to climate change imagery

To estimate pro-climate change motivations, a Bayesian hierarchical regression model was estimated with random intercepts estimated across each image participants viewed and across each country in the sample. Prior specifications can be found in Appendix B. Figures 20 through 23 display the posterior distributions of key model parameters, interaction effects, and visualization of the random intercepts.

Marginal Effect of HE*IC Interaction on Threat Perceptions

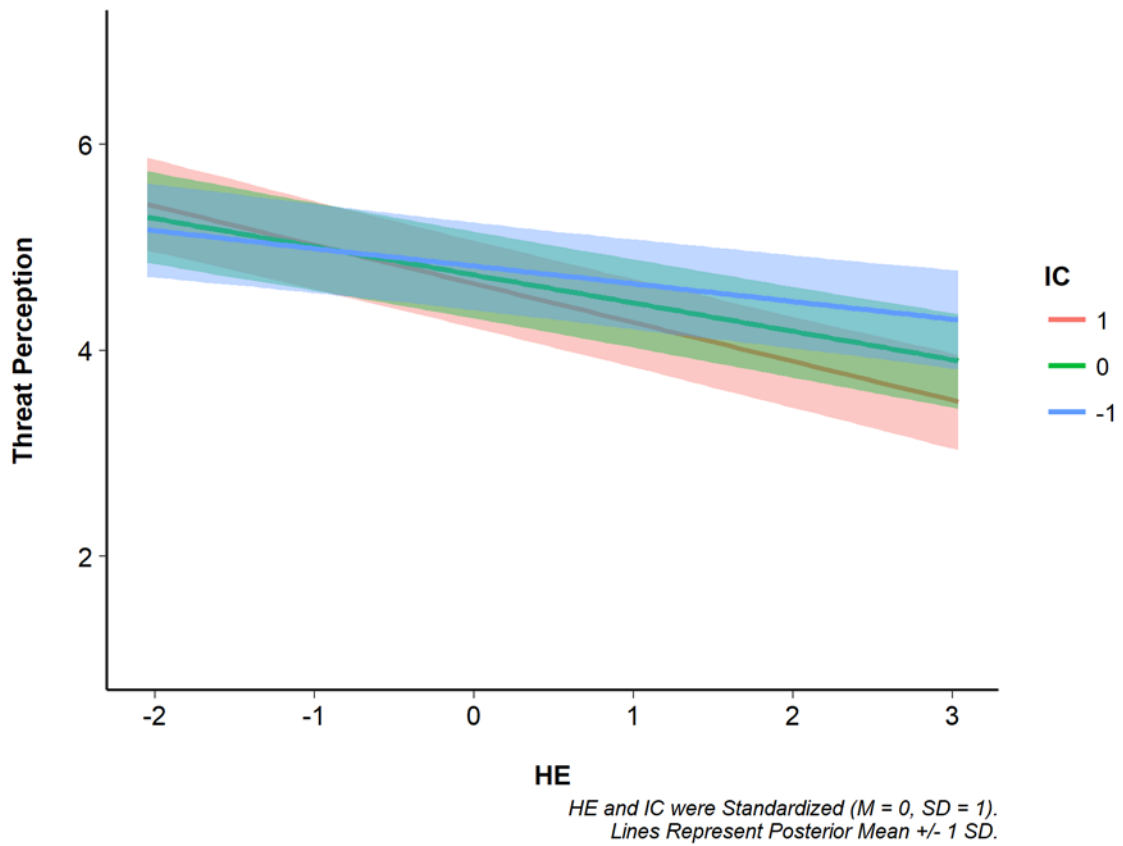
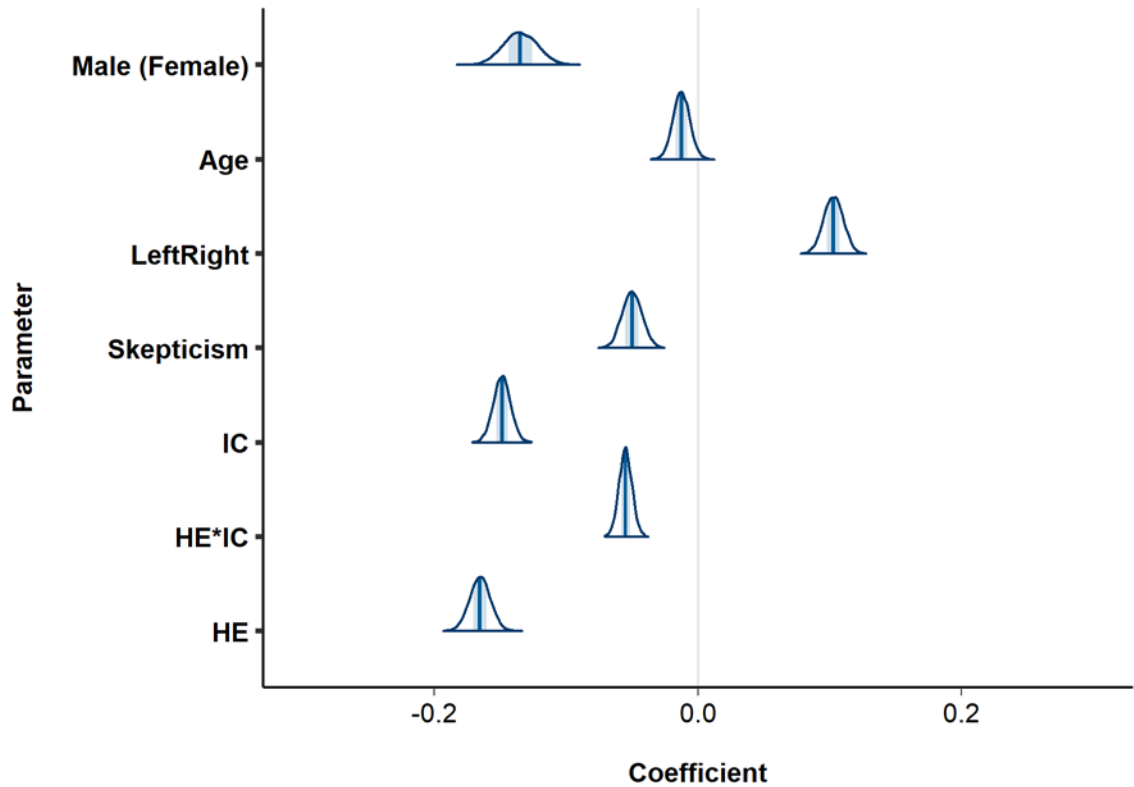


Figure 19. Marginal effect of HE x IC interaction on threat perceptions. Results come from a Bayesian hierarchical regression model. Predictors were standardized for the analysis. Blue, green, and red lines thus represent -1 SD, the mean, and +1 SD, respectively. Shaded intervals are 95% fitted regression intervals.

Posterior Distributions of Post-Image Pro-Climate Change Motivations



Metric Predictors and Outcome were Standardized ($M = 0$, $SD = 1$). For Visual Clarity, random Effects and Effects of Condition are Omitted.

Figure 20. Posterior distributions of post-image pro-climate change motivations. Full posterior distributions from Bayesian hierarchical regression model. Vertical blue lines represent posterior medians and shaded intervals represent 50% posterior intervals.

In this case, both metric predictors and the outcome were standardized ($M = 0$, $SD = 1$), and therefore results should be interpreted in terms of standard deviation changes in both predictor and outcome. Similar to perceived climate change threats, HE again had the strongest influence on responses to the climate change imagery, with a 1 SD increase associated with a close to .2 SD decrease in pro-climate change motivations. The effect of IC was similarly negative and close to the same magnitude. The entire posterior distribution of the interaction effect was narrow and below zero, although the magnitude of the effect was less than .15 of an SD . Thus, as with prior findings, the interaction

effects are theoretically interesting but small in overall size. Males exhibited more negative responses than females, with an effect that rivals the size of a 1 *SD* change in cultural worldviews. Figure 21 provides a decomposition of the interaction effect between HE and IC. As with prior models, this effect was small in magnitude and likely possesses only limited importance for predictive performance.

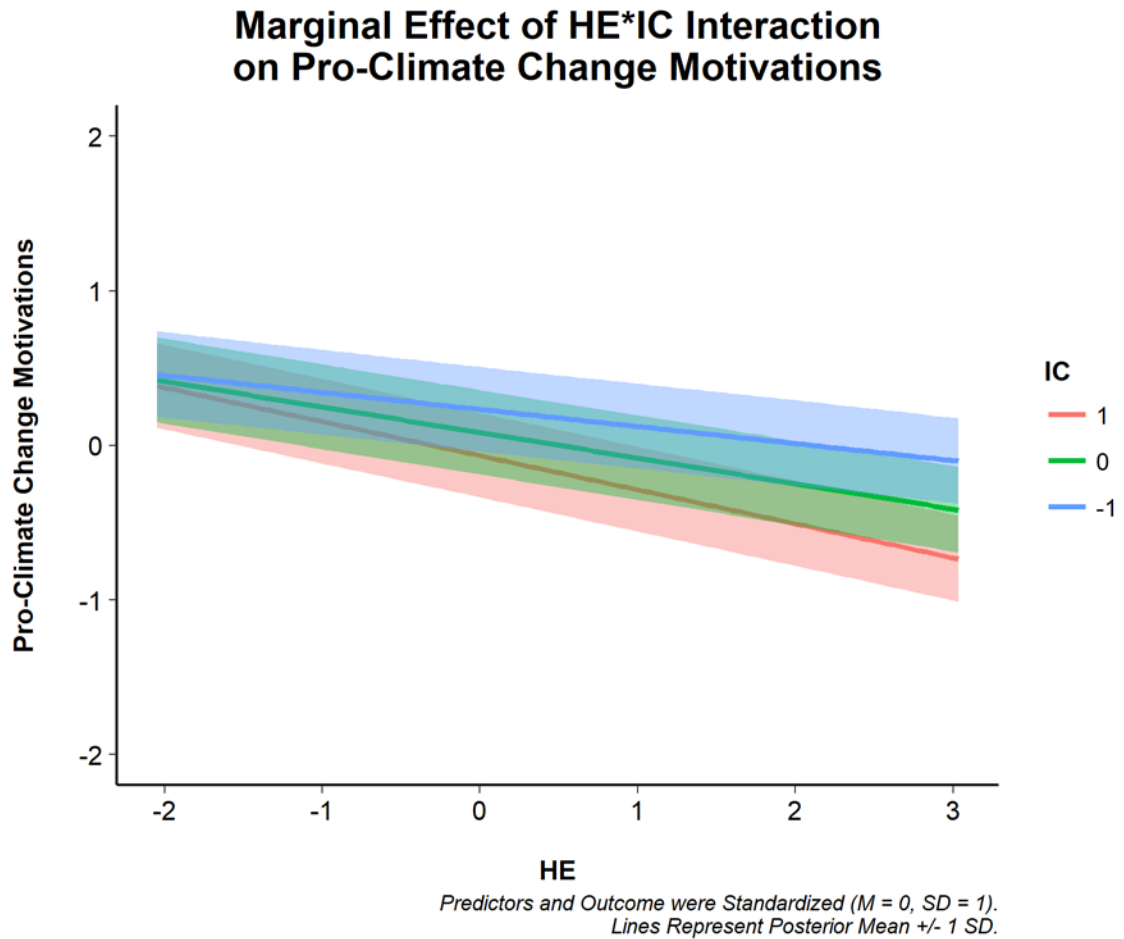


Figure 21. Marginal effect of HE x IC interaction on pro-climate change motivations. Results come from a Bayesian hierarchical regression model. Predictors were standardized for the analysis. Blue, green, and red lines thus represent -1 SD, the mean, and +1 SD, respectively. Shaded intervals are 95% fitted regression intervals.

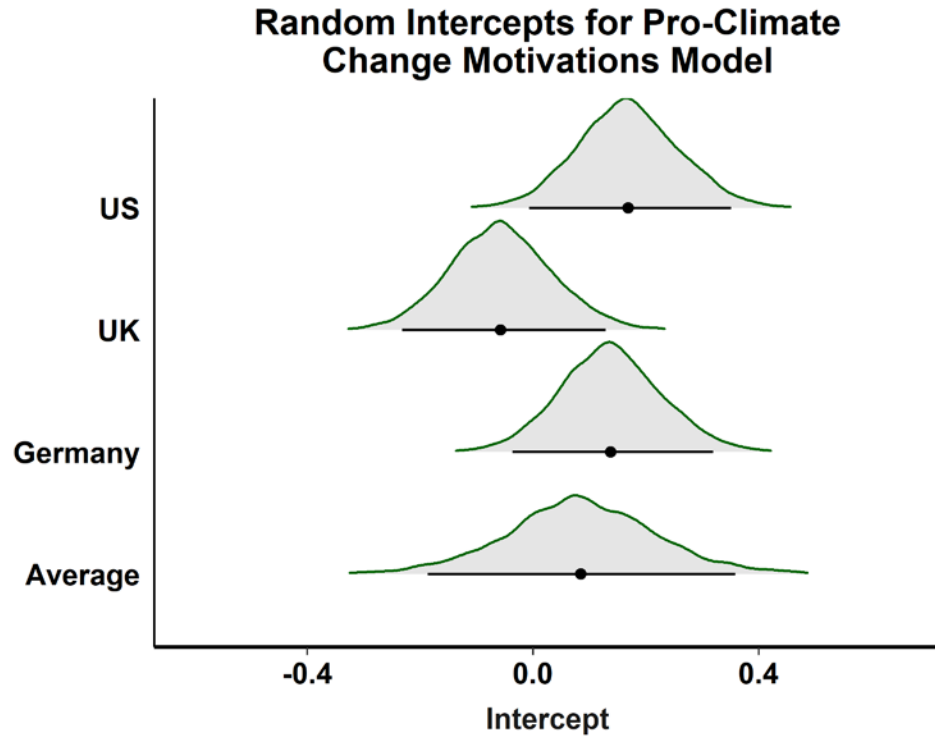


Figure 22. Random intercepts for pro-climate change motivations model: countries. Plot depicts the full posterior distributions of the random effects.

Figure 22 displays the posterior distributions of the random intercepts across each country. These effects were small in magnitude on the standardized scale, with US and German participants reporting greater pro-climate change motivations than the UK respondents. Figure 23 provides a decomposition of the random intercepts estimated across each image. There was modest but consistent variability across each of the images presented. The image in the solutions condition depicting kids learning about solar panels was more positively received on average than the other images presented. Images of a man eating meat, and national politicians, were less motivating for participants.

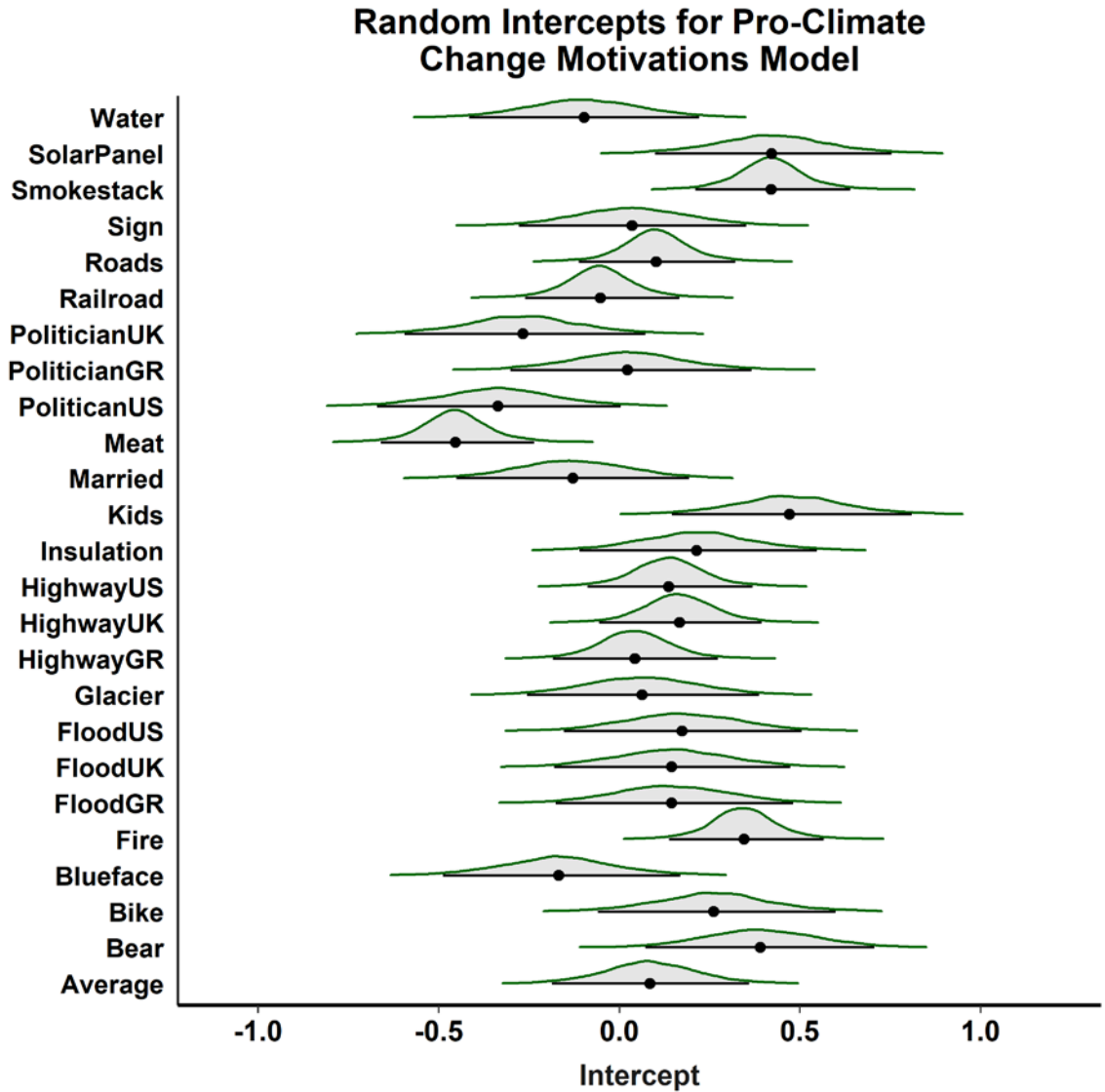


Figure 23. Random intercepts for pro-climate change model: images. Plot depicts the full posterior distributions of the random effects across each image.

Similar to the climate change motivations model, to estimate the effects of these predictors on self-reported understanding of the climate change imagery random intercepts were estimated across country and across each image viewed. Ordinal regression was performed on this outcome, using a cumulative logit model. Priors and model details are provided in Appendix B.

Posterior Distributions of Understanding of Climate Change Imagery

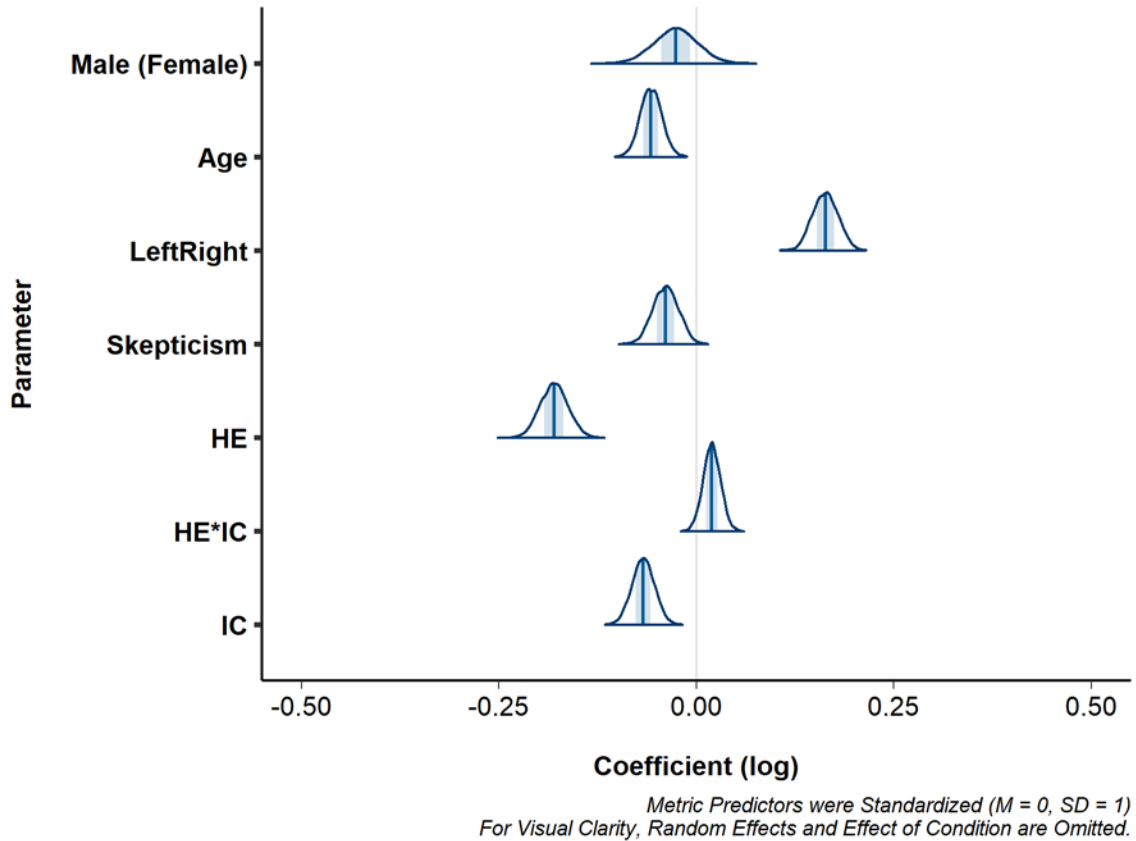


Figure 24. Posterior distributions of understanding of climate change imagery. Full posterior distributions from Bayesian ordinal hierarchical regression model. Vertical blue lines represent posterior medians and shaded intervals represent 50% posterior intervals. Coefficients are on the log scale. For visual clarity of the full posterior distributions, the hierarchical standard deviations and effect of condition are omitted.

HE had the most robust negative influence in the model, although this effect was not particularly large in magnitude, *Posterior Median* = -.18, *95% HPDI* = -.21, -.15, *Odds Ratio (OR)* = 0.835 (see figure 24). The estimates of the effect of experimental condition was highly variable, with little evidence to suggest a meaningful positive or negative effect. Due to their large variability in comparison to the other predictors, these effects are omitted from figure 24 depiction for visual clarity of the posterior distributions. IC also negatively influenced self-reported understanding, although the

effect was roughly half the size of the effect of HE, *Posterior Median* = -.07, *95% HPDI* = -.10, -.04, *OR* = -.932. There was little evidence to suggest a meaningful interaction between HE and IC in this model. The posterior probability of the interaction term was constrained almost entirely to values around zero, *Posterior Median* = .02, *95% HPID* = -.002, .04. Skepticism and age had slightly larger estimates than the HE*IC interaction, both producing negative associations with understanding. The effect of gender was negative, although the majority of the posterior probability was centered around zero, *Posterior Median* = -.03, *95% HPDI* = -.08, .03. Figure 25 depicts all of the random intercept estimates on the log scale, including both the intercept estimates across country and across images. As with the other measures, there was notable variability across these estimates. Germany reported the greatest understanding of the images, followed by the US and the UK. Images of the politicians, meat consumption, as well as other images of climate change impacts, had more negative influences on understanding. The most understood images included the imagery of a polar bear (impacts), smokestacks (causes), and solar panels (solutions).

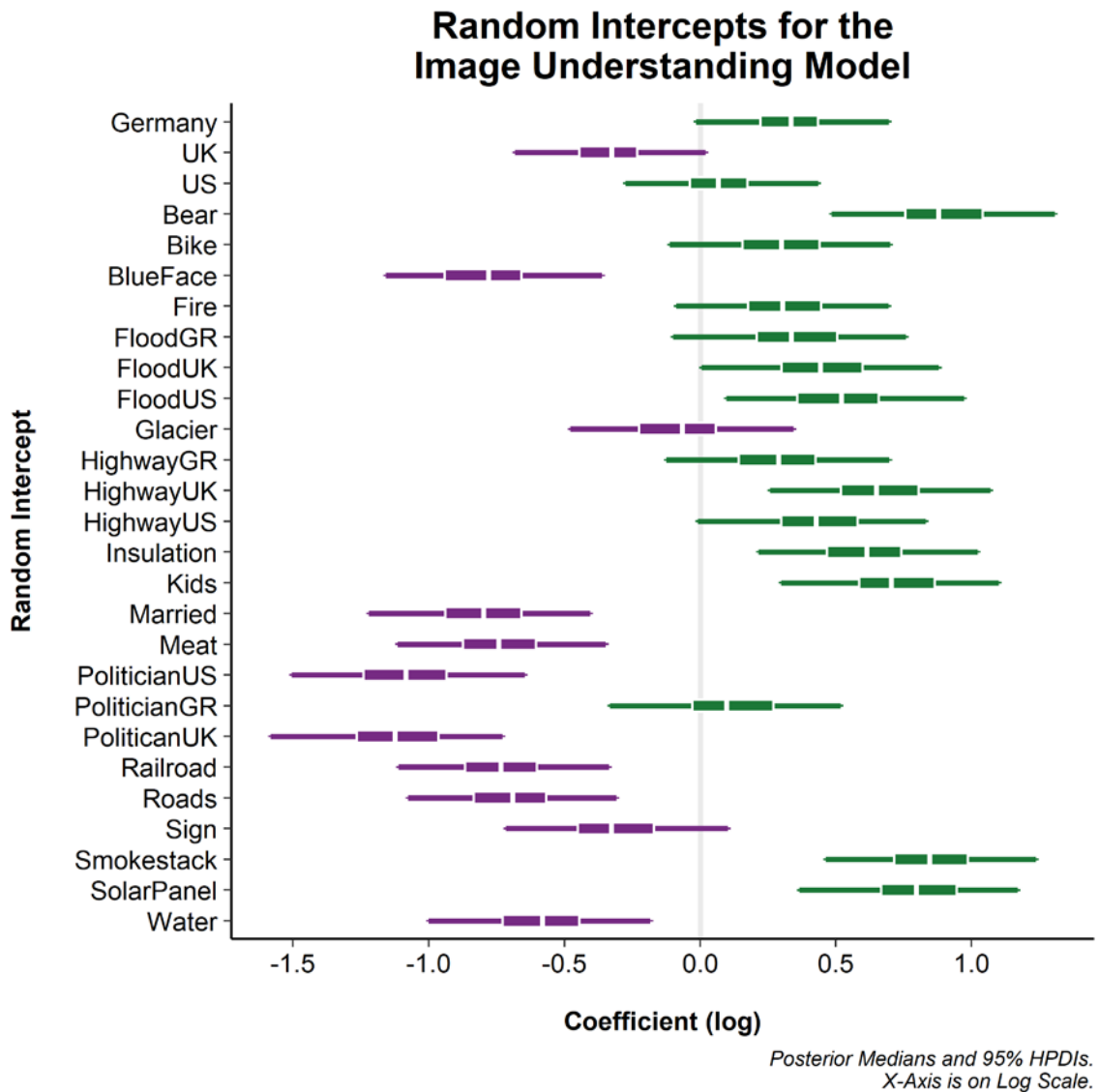


Figure 25. Random intercepts for the image understanding model.

The same model configuration was used to estimate affective reactions. In the case of affective reactions, IC had a stronger effect on negative affect than HE, with a 1 *SD* increase leading to a roughly .25 unit increase in negative affect. The posterior distribution of the interaction effect between HE and IC was similar in size, though measured more precisely, than the effect of HE. Evaluation of figure 27 provides a depiction of the estimated interaction effect.

Posterior Distributions of Negative Affect in Response to Climate Change Imagery

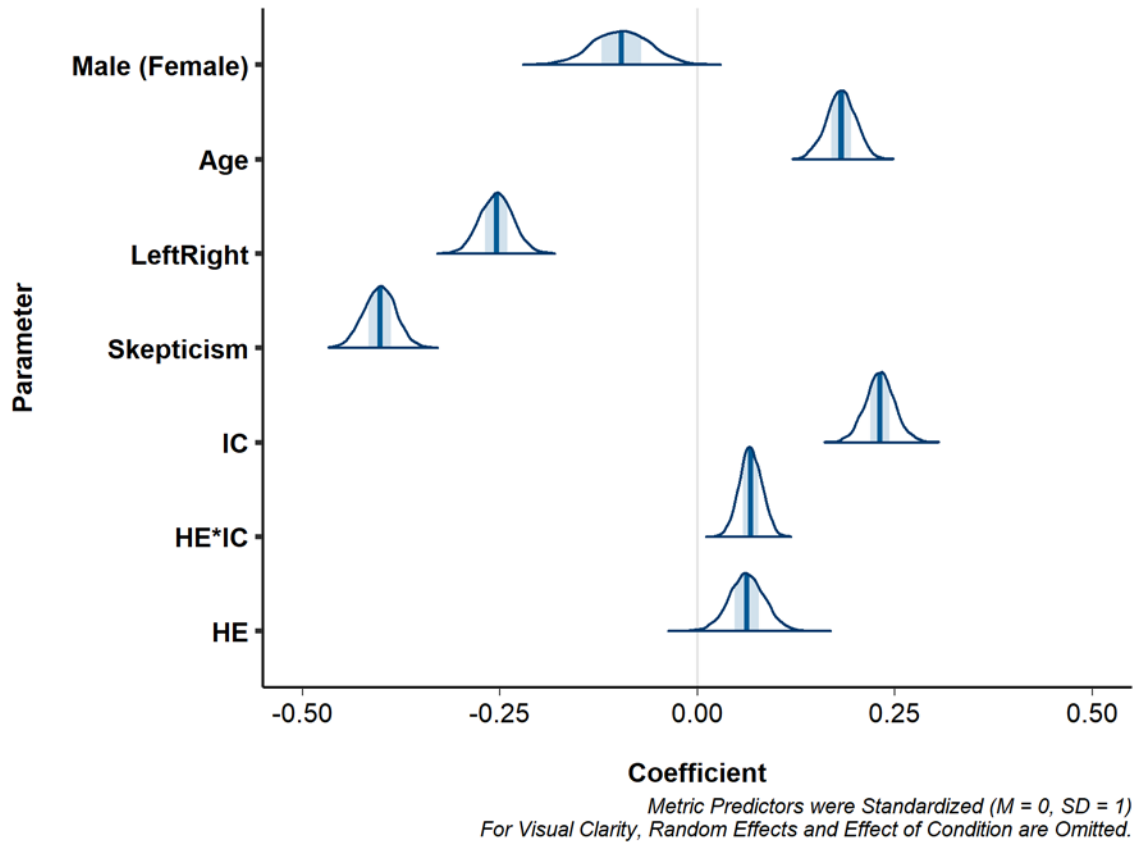


Figure 26. Posterior distributions of negative affect in response to climate change imagery. Full posterior distributions from Bayesian ordinal hierarchical regression model. Vertical blue lines represent posterior medians and shaded intervals represent 50% posterior intervals. For visual clarity of the full posterior distributions, the hierarchical standard deviations and effect of condition are omitted.

There was substantial overlap in the interval estimates, although the general pattern is that increasing HE lead to slightly greater negative affective reactions specifically when individuals were higher in IC. Compared with prior models, climate change skepticism and political leaning both emerged are more pronounced predictors than the cultural worldviews of affective reactions. These effects were in the opposite direction of the worldviews. A 1 *SD* increase in skepticism was associated with a

decrease in negative affect equivalent to somewhere between -.3 and -.5 scale point difference. The pattern of effects of political leaning was very similar, though the effect was centered around a decrease of .25 units on the outcome scale. The majority of the posterior distribution for the estimated gender effect fell below zero, with males reporting less negative affect relative to females. Finally, a 1 *SD* increase in age was associated with greater negative affective reactions with an effect magnitude rivaling that of IC.

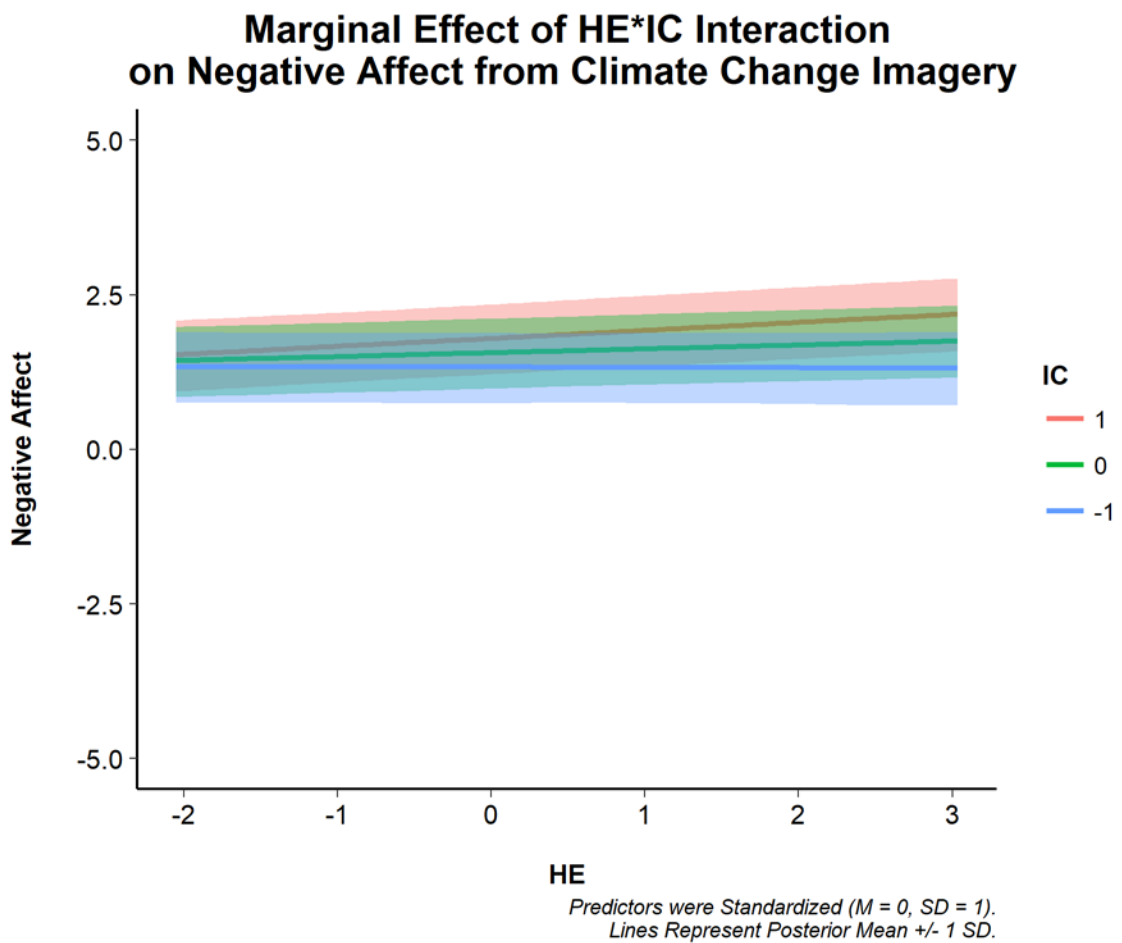


Figure 27. Marginal effect of HE x IC interaction on negative affect from climate change imagery. Results come from a Bayesian hierarchical regression model. Predictors were standardized for the analysis. Blue, green, and red lines thus represent -1 SD, the mean, and +1 SD, respectively. Shaded intervals are 95% fitted regression intervals.

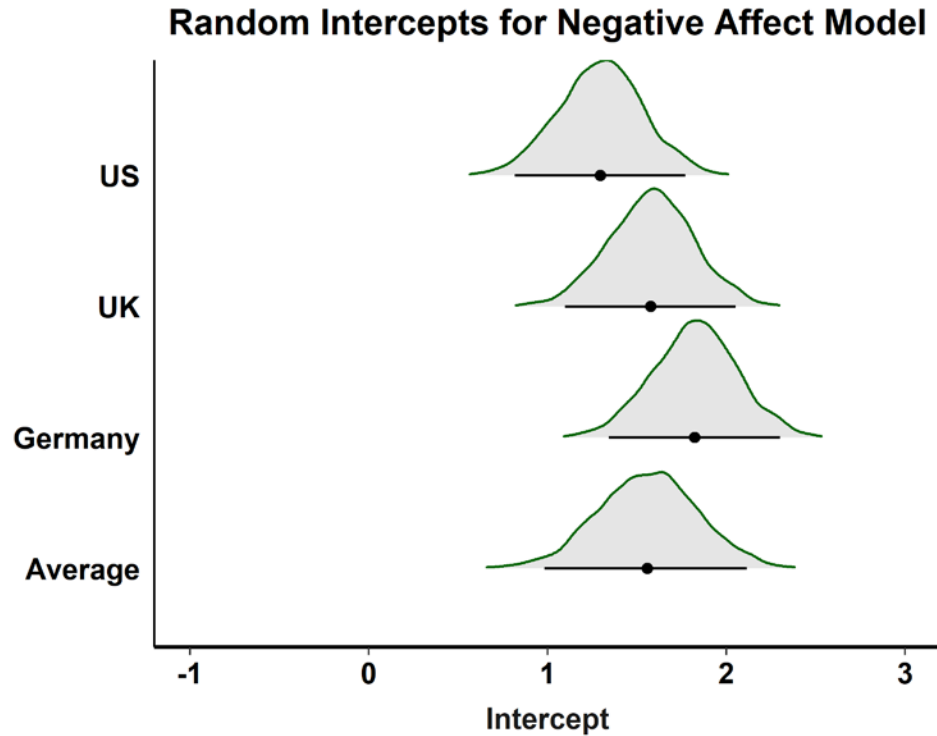


Figure 28. Random intercepts for negative affect model: countries. Plot depicts the full posterior distributions of the random effects.

Figures 28 and 29 depict the posterior distribution estimates of the random intercepts in the affect model. On average, each nation in the sample reported negative affect reactions to the imagery. The variability between country was smaller in this case than prior random intercept models. Germany and the UK both reported greater negative affect than US participants, although as depicted in figure 28, there was substantial interval overlap. Figure 29 demonstrates greater variation in climate change imagery in terms of affective reactions. Images of politicians, protestors ('Blueface'), and meat consumption produced less negative reactions than other images. Images producing more negative affect included the images of smokestacks, solar panels, and children learning about solar panels.

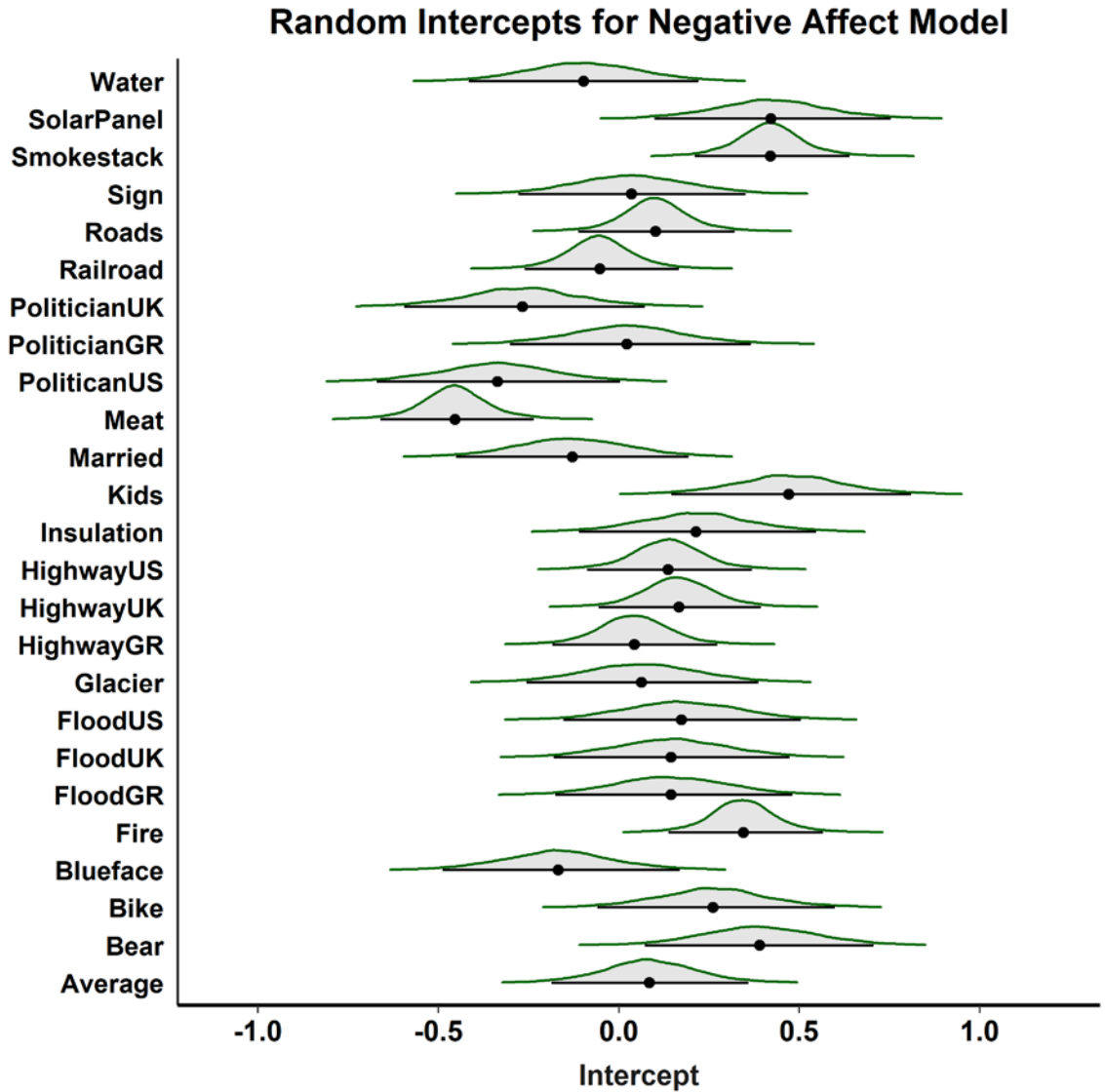


Figure 29. Random intercepts for negative affect model: images. Plot depicts the full posterior distributions of the random effects across each image.

Discussion

The results of the Bayesian hierarchical regression models yield interesting insights to accompany the main body text of Chapter 4. In particular, these follow-up analyses took a more integrative, holistic approach to modelling climate change skepticism and responses to the climate change imagery. After building these

theoretically informed models, there was little evidence to suggest a robust difference in general responses to different types of climate change imagery (i.e., no robust experimental treatment effects). However, a number of other important findings were uncovered. In support of Kahan et al. (2011; 2017), HE had a strong influence on climate change skepticism, with those higher in hierarchical values reporting greater levels of skepticism, as well as lower perceived threats from climate change, and lower pro-climate change motivations. The effect of IC was typically in the same direction and followed a similar pattern as HE, although smaller in magnitude. Interestingly, this pattern diverged in the context of negative affective reactions. Specifically, IC was associated with greater negative affective reactions, following the opposite pattern of HE and of IC on other items.

The evidence for interaction effects emerged across the measures of responses to climate change imagery, although again these effects were small in magnitude. In general, each interaction effect followed a similar pattern for the post-image items, with combinations of high HE and high IC leading to more negative outcomes for climate change engagement. As there is considerable uncertainty in the fitted regression intervals for these models, interpretation of specific interaction patterns should be done with caution.

Across the majority of models, the worldview measures, especially HE, appeared to generate a more robust influence than political ideology and climate change skepticism. This may be in part because these worldviews are thought to form a foundation of ideological perspectives and views on climate change, and thus may be more proximal to the outcomes of interest than these other measures. Interestingly, this

pattern changed in the context of affective reactions, with both skepticism and political leaning having stronger effects on affective reactions than the worldview measures. At this point, I do not have any theoretical explanation as to why these measures would operate differently for affect in comparison with other post-image responses. Future work should further unpack this phenomenon to make sense of which measures are more versus less related to different types of worldview and identity measures.

The findings in this study also suggest that future scale construction work is needed to better measure each of these constructs. The 2-item measure of climate change skepticism had a lower inter-item correlation than I had anticipated, leading to greater uncertainty in this measure. The fact that the four-factor structure of the cultural worldview measures was a substantially better fit to the data is encouraging, as this structure in fact more accurately captures the design of the scale. However, this structure is slightly at odds with the analytic approach of creating two separate composite measures by reverse coding portions of the items of interest. Furthermore, several models were estimated using underlying Gaussian assumptions in places where ordinal regression may have been used as an alternative. This approach was retained for comparability with past research findings, as well as the large sample size rendering Gaussian assumptions more plausible. While we retained this approach to remain consistent with past literature, future work should more comprehensively consider ways to improve both the validity and reliability of the measures, while also identifying which future models would be more appropriately assessed using ordinal regression instead of the approach presented here. The Bayesian inferential approach was useful in uncovering

an making sense of these estimates, and also offers a useful starting point for developing more informed prior distributions for future studies.

CHAPTER 5

GENERAL DISCUSSION

Summary of Key Findings

The work presented throughout this manuscript examined several different sets of empirical findings nested under the larger umbrella of identity-protective cognition. The research involved both qualitative and quantitative investigations, and included correlational and experimental designs. Statistical inference was performed using both frequentist and Bayesian statistical methods, offering an insight into the relative contributions of each. In Chapter 2, I presented work examining how identity-protective process, particularly those related to climate change skepticism, influence how the public perceives and responds to natural disasters that have become associated with climate change. Linking a disaster with climate change (relative to a ‘natural’ cause) led those with greater climate change skepticism to engage in justifications to withhold aid from disaster victims, while also suppressing donation intentions.

Chapter 3 looked at the role of contextually-activated social identities in responding to personally-relevant environmental problems. In the context of the Volkswagen diesel emissions scandal, this work highlights that different identities can sometimes have competing and sometimes cooperative effects on influencing pro-environmental responses. While these contextually activated identities influenced judgments of personal responsibility and intentions to fix affected vehicles (especially among high environmental identifiers), evidence for their interactive effects were limited at best. There was little evidence to suggest a strong interaction between identities in motivating actual intentions to fix affected vehicles.

Finally, Chapter 4 altered the traditional research paradigm in this domain by evaluating public responses to different types of visual imagery used to depict climate change. This chapter provided both qualitative and quantitative insights to describe these responses and how they vary across ideological perspectives. Additional Bayesian statistical modelling identified the ways in which cultural worldviews impact climate change skepticism, perceived threats from climate change, and responses to climate change imagery. In particular, being higher in hierarchical and individualistic worldviews predicted greater skepticism, fewer pro-climate change motivations, and less perceived threat from climate change impacts. On the other hand, higher individualism was associated with more negative affective reactions to climate change imagery than hierarchicalism. In most cases, the effects of these worldviews were larger than those for political ideology or climate change skepticism.

Overarching Implications for Theory and Practice

The findings of the aforementioned research have several implications for the role of ICT in responding to environmental problems. However, given the focus on attitudinal-based assessments in this research, direct implications for applied practice should be made with considerable caution. Chapter 2 highlights the potential for motivated reasoning processes activated in defense of one's identity to extend beyond the proximal belief (i.e., climate change beliefs) and on to other distal outcomes. Caution from media outlets and communicators about 'overselling' the connection between climate change and other outcomes is warranted, as this may be polarizing for certain audiences that may otherwise respond more positively. This work compliments Kahan et al. (2017) in particular, and suggests that this second-order approach may be a promising

area for future theoretical and applied work. The extent to which such motivated processes emerge on other politicized issues aside from climate change, however, remains to be clearly demonstrated.

Chapter 3 directly examined how multiple social identities may simultaneously and interactively influence how individuals make judgments about personal responsibility for environmental problems. This work presented an initial investigation into the processes involved, and future work should take steps to provide fruitful follow ups. In particular, while there was suggestion of a potential interaction effect whereby judgments of responsibility were greatest when individuals were high in both VW/diesel and environmental identities, evidence for effects on behavioral intentions was low. And, model comparisons for predictive performance suggested little added value by including the interaction term on these measures. Therefore, I am cautious to offer any broader insights for applied practice in this case until central theoretical and empirical questions are addressed.

Taken together however, the findings of chapters 2 and 3 yield an important question for future research: Do identity-protective processes primarily influence attitudinal responses, or do they also influence behavior directly? And, if so, how and when does this occur, and what are the best steps for modelling this process? In the findings of both Chapter 2 and Chapter 3, ICT effects examined through the interaction models yielded stronger evidence for their effects on attitudes (e.g., donation justifications, perceived responsibility) than on behavioral intentions. This is a point that has not been clearly discussed in the context of ICT, or in the context of motivated reasoning and climate change/environmental psychology more broadly.

Chapter 4 extends theory and research on ICT into the domain of visual imagery, while also looking at the processes surrounding ICT in a multi-national context. To my knowledge this was the first examination of this kind. In the context of climate change imagery, the findings from Chapter 4 suggest that similar ideological and worldview motives shape responses to images as observed in more text-heavy mediums. Therefore, the use of visual imagery may unfortunately not be a panacea for applied practice in terms of directly overcoming these motives. However, as the original design of this study was not tailored to yield experimental insights into the role of different worldviews in driving responses to imagery, implications for theory aside from understanding bivariate construct associations may be limited. Also, while the research did identify similar psychometric properties across each of the three countries examined, this might be expected given the similar philosophical histories of the countries examined. At a macro-theoretical level, the ICT suffers from an Anglo-centric focus; future work might extend conceptualizations of worldviews and identities to be more transnational in its approach and application.

Finally, one theoretical issue that was glossed over in the main body of research was a consideration of the extent to which the psychological processes discussed are indeed evidence for an identity *protective* motive, as opposed to another explanation. Using attitudes to *express* one's identity even at personal cost (e.g., the link between environmental identity and perceived responsibility discussed in Chapter 3) may also be applicable to some of the findings presented. This is also a point which the literature has not clearly addressed: What, if anything, distinguishes different identity-related motives

from one another, and how do we best measure this process? Future work involving both observational, experimental, and qualitative research is needed to unpack this question.

Limitations and Other Considerations

The three projects described in this document suffer from several overarching limitations that warrant consideration. First, this work would have benefitted by a more careful development of scale measures for each construct. For instance, political ideology was measured slightly differently in each study, as were environmental attitudes and climate change skepticism. Further, in certain studies only single-item measures were used of constructs. While some of these decisions were justified by the limited past research on certain of the issues discussed and survey limitations, this criticism is not one that should be ignored or taken lightly. Bayesian statistician and political scientist Andrew Gelman once said the following regarding measurement error and inference in such designs:

“...when effect size [sic] is tiny and measurement error is huge, you’re essentially trying to use a bathroom scale to weigh a feather—and the feather is resting loosely in the pouch of a kangaroo that is vigorously jumping up and down.”

(Gelman, 2015)

This metaphor runs the risk of being too applicable in a number of the findings reported here, particularly those in Chapter 2 and 3. While this indictment regarding measurement error and effect sizes plagues much of the published literature in this domain (see below) and I took steps to address this as best as possible, it is important moving forward to address this issue. For example, in spite of the benefits of focusing on a Bayesian statistical estimation approach, low reliability of measures directly influences the degree

of model uncertainty and the precision of the inferences that can be made. Statistical methods cannot salvage imprecise measurement and design.

This work is also limited by its emphasis on self-report attitudinal measures in the absence of measures of proximal behavioral outcomes. This limitation is one that plagues much of the research in this domain. While these attitudinal measures are of interest for theoretical aims, they may do little to speak to the real-world outcomes of interest to practitioners. Future work should seek to go beyond this measurement filter, and do more to examine a full range of outcomes. Finally, this work does not directly contribute to our understanding of whether the ICT account of polarization is more or less credible than other accounts, such as the role of large misinformation campaigns or political elite cues.

Concluding Thoughts: Towards a Robust Science of Science Communication

Amidst a pervasively polarized climate for the communication of science and environmental risks, it is vital that social scientists offer the best evidence possible to practitioners. This requires a comprehensive, careful investigation of science communication, and how both knowledge and ideology influence the decision making process. To date, unfortunately, meaningful discussions among scholars on this issue have been mostly supplanted by competing debates over what ‘works’ versus what ‘doesn’t work’ in the context of communication, without providing basic clarity regarding what it means for one these approaches to ‘work’. New papers are published with increasing frequency proclaiming that communicating scientific consensus to the public is a powerful tool to increase engagement (e.g., van der Linden et al., 2015), that scientific consensus is not worth the attention it is given as a rhetorical device (e.g., Pearce et al., 2017), and that the evidence for the role of consensus in motivating

engagement is flawed (e.g., Kahan, 2017). On the other hand, ICT has recently faced criticism from those who perceive it as implying that knowledge, or awareness of the judgment of scientific experts, are not important for motivating public engagement (van der Linden, 2015). Yet, within the current paradigms of research, it is hard to imagine such debates being resolved without substantial changes to current practices. While it is common to resolve such conversations by abstractly recommending the need for more research, I instead offer several methodological and theoretical considerations to hopefully advance a more robust science of science communication.

The connection between attitudes and behavior in science communication research is perhaps the most central problem. Put shortly, few hypotheses in science communication research make clear specifications regarding what techniques/characteristics lead to changes in behavioral versus attitudinal outcomes of interest. These distinctions are rarely given the close consideration they deserve, perhaps due to the immense difficulty in studying behavioral processes at scale. This lack of clarity and standardization regarding what the most important outcomes are in science communication research makes it difficult to make meaningful comparisons among studies or techniques. Furthermore, a robust science of science communication demands greater measurement precision. Loken and Gelman (2017), for example, highlight the fundamental problems in inferring evidence from studies with small sample sizes given high degrees of measurement error that are common in the social sciences. Yet, in most research in the science communication field, little discussion is offered about the role of measurement issues, nor is consideration frequently given to their impact on inferences.

The over-emphasis on null hypothesis significance testing as the chief criteria for evaluating the ‘success’ of an experiment also tends to lead to a binary-decision making process rather than a more nuanced understanding of how to glean practical evidence from statistical findings. Abandoning statistical significance and NHST in favor of a combination of approaches full would be helpful in this regard (Loken & Gelman, 2017; McShane et al., 2018). However, no statistical tool is foolproof. Therefore, a more comprehensive workflow of qualitative and quantitative inquiry to address specific problems in science communication would be beneficial.

Making meaningful advances to improve our responses to climate change and other environmental problems necessitates a healthy social science capable of speaking to questions of interest for maximizing our understanding of effective public engagement. A robust science of science communication, one which is open, reproducible, and theoretically driven, is of the utmost importance.

APPENDIX A

PUBLICATION INFORMATION

Chapter 2 Reference

Chapman, D. A., & Lickel, B. (2016). Climate change and disasters: how framing affects justifications for giving or withholding aid to disaster victims. *Social Psychological and Personality Science*, 7(1), 13-20.

The main text, figures and tables of Chapter 2 are reproduced exactly as they appeared in the print version of the published article. However, following publication, several slight rounding errors were identified by the authors. At the suggestion of the editor, this was disclosed at on the PubPeer link for this article (<https://blog.pubpeer.com/publications/811A98DA7D327F9592B0803763FA04#2>). The rounding errors have been corrected in the current reproduced version.

Chapter 4 Reference

Chapman, D. A., Corner, A., Webster, R., & Markowitz, E. M. (2016). Climate visuals: a mixed methods investigation of public perceptions of climate images in three countries. *Global Environmental Change*, 41, 172-182.

The main text, figures and tables of Chapter 2 are reproduced exactly as they appeared in the print version of the published article.

APPENDIX B

BAYESIAN MODELS AND PRIOR SPECIFICATIONS

All Bayesian statistical models were estimated using the ‘brms’ package for R (Burkner, 2017). Brms is an R package which harnesses Stan (Carpenter et al. 2017) on the backend to perform full Bayesian inference using Hamiltonian Monte Carlo (HMC, No-U-Turn Sampler [NUTS]). Below, I provide a description of the models tested, divided by chapter. While some differences exist across models, the general principles to modelling (e.g., philosophical approach on prior specification) were quite similar across each.

Each model was estimated using three Markov chains with 4,000 sampling iterations per chain, 2,000 of which were designated as warmup. Thus, posterior inference was based on an effective sample size up to 6,000 samples. However, as is common, the number of effective samples varies from parameter to parameter during estimation. One of the chief benefits of HMC with a NUTS sampler is that, in addition to not needing to use conjugate priors, it also samples the parameter space much more efficiently than alternatives; whereas other samplers (e.g., JAGS) typically require long burn-in periods and larger numbers of iterations to sample distributions, HMC can construct posterior distributions efficiently with far fewer iterations (note, warm-up iterations are not the same as burn-in samples, which are discarded in JAGS).

Initial model checks for divergent transitions in the Markov chains or other problems were performed on simplified versions of the models (e.g., a model with just 2 chains of 2,000 samples) to diagnose sampling problems prior to full model estimation

(to save computation time). In the case of the hierarchical models, these initial checks helped identify the need to place more regularizing priors on the hierarchical standard deviations (see below), which is quite common in cases with limited information (e.g., comparing only three countries). These checks also helped calibrate aspects of the chains to make them more efficient (e.g., increasing the delta from the default of .80 to .95). Details on why/how increasing the delta of the algorithm improves estimation is beyond the scope of this document. It will suffice to say that increasing the delta increases the granularity of the sampling process, but is computationally expensive. A default of .8 is used in Stan, but it is recommended to increase this when divergent transitions emerge.

For every model evaluated, a variety of checks were performed. Trace plots were evaluated to ensure that the chains mixed adequately, and Rhat was computed for each model. Rhat is a Bayesian diagnostic which approximates the degree to which the chains mix together appropriately; Rhat values above 1.00 warrant investigation and caution in interpretation (Gelman et al. 2013). In no case did these models have Rhat values that exceeded 1, nor were there divergent transitions found in the chains. Posterior predictive checks were evaluated to loosely diagnose whether the model specifications could accurately reconstruct the distribution of the outcome measures (Gelman et al. 2013). Plots of these checks can be provided upon request, along with full model code, data, scripts, and study materials. In each case, these checks were adequate to suggest that these models could recreate the outcome distributions with a reasonable degree of accuracy. While in no way definitive, these checks suggest that there are not glaring problems with the Markov chains or posterior distributions which warrant attention,

beyond the specific sampling assumptions (e.g., treating binned survey responses as generating from an underlying normal distribution as opposed to another)..

Below I provide a simplified notation of the model specification using loose mathematical notation (adapted from the approach of McElreath, 2016). To avoid redundancy, as many of the models were estimated using a highly similar philosophy to prior specification, I instead provide details on the modelling strategy overall, and denote specific changes to these as well as their justification. For example, the following displays model code for a simplified Bayesian linear regression model with 2 predictors:

$$\begin{aligned} Y &\sim \text{normal}(\mu_i, \sigma) \\ \mu_i &= \alpha + \beta_1 * \text{predictor} + \beta_2 * \text{predictor} \\ \alpha &\sim \text{normal}(0,3) \\ \beta_1 &\sim \text{normal}(0,1) \\ \beta_2 &\sim \text{normal}(0,1) \\ \sigma &\sim \text{half cauchy}(0,1) \end{aligned}$$

Where Y is the outcome, which is modelled as being normally distributed with a mean (μ_i) and residual error, sigma (σ). The ‘ \sim ’ symbol should be read as ‘is distributed as’. Then, the mean of the model is set as being equal to our model formula, containing the model intercept (α), and a regression coefficient for each predictor (β_1, β_2). The priors on the intercept and predictors are specified in the final few lines of code above. Specifically $\alpha \sim \text{normal}(0,3)$ can be read as ‘the model intercept is normal distributed with a mean of 0 and a standard deviation of 3.’ The same approach is followed to read the priors for the model predictors. Finally, the last line of the formula can be read as: ‘the residual standard deviation of the model is distributed as a half Cauchy distribution

with a location of 0 and scale of 1'. In the case of such residual standard deviation priors, the parameters are always a 'half' Cauchy distribution (i.e., half Cauchy rather than Cauchy). This is because the standard deviation estimated always has a lower bound of zero. The same is true of priors placed on hierarchical standard deviation parameters.

Throughout all models, I adopt recommendations of Gelman et al. (2013) and the Stan Development Team (2018), using weakly informative prior distributions that promote regularization on the model parameters. All metric predictors for each model are standardized ($M = 0, SD = 1$). Outcome measures are kept on their original scale unless otherwise noted. Below, I provide a brief description of the models tested, divided by chapter.

Chapter 2

Each Bayesian model in chapter 2 was fit using weakly informative priors scaled to the response distribution and a Gaussian response distribution. In this case, normal distribution priors for model intercepts were adjusted for each model to be centered near the median of the response distribution with a slightly wider standard deviation than the scaled distribution (e.g., $\text{normal}(5,2)$). Regression parameters were given a normal distribution prior ($\text{normal}(0,1)$). Residual error of the model (σ) was given a half Cauchy prior (location = 0, scale = 2). Each model converged with no direct changes being made to the sampling algorithm.

Chapter 3:

For the models of judgments of responsibility, the same strategy was applied as chapter 2, with the exception of also estimating an ordinal regression model. Judgments

of responsibility and intentions to fix affected vehicles were estimated using a Gaussian response distribution, regularizing priors on the regression coefficients ($\text{normal}(0,1)$) and a half Cauchy prior on sigma (0, 2). Given the skew in these items, the model intercepts were estimated using a weakly informative t-distribution prior centered near the median of the response distribution (e.g., $\text{student_t}(3,3,2)$) which possesses wider tails than the normal distribution. This distribution is also used in several other models further below. The model of fix timing was estimated using a cumulative response distribution, logit link function, and flexible category thresholds, which implements ordinal regression. In these models, there is no sigma to be estimated. Mildly regularizing priors were again fit on the regression coefficients ($\text{normal}(0,1)$) and the intercept ($\text{student_t}(3,0,1)$). All models converged and no changes were made to the estimation algorithms.

Chapter 4

The model of climate change skepticism was estimated using a hierarchical linear regression model using a Gaussian response distribution. As there was a mixture of categorical and metric predictors, a slightly wider normal distribution prior ($\text{normal}(0,2)$) was placed on all regression coefficients. The intercept was centered near the median of the response distribution ($\text{normal}(4,1)$), and sigma was given a half Cauchy prior (0, 1). As this model also has random intercepts estimates, the model also requires placing a prior on the hierarchical standard deviation estimate (i.e., the variability in the random effects estimate). The model was initially fit with a half-normal prior (0,.5), although several divergent transitions occurred. A more informative prior was then placed on this parameter ($\text{half-normal}(0,.1)$). In addition, the delta for the estimation algorithm was

increased from .8 (the default) to .99. This specification lead to convergence with no divergent transitions.

The climate change threat model was identical in its specification approach as the skepticism model. Regularizing priors were placed again on the regression coefficients (normal(0,2)), the intercept (normal(5,1)), and sigma (half Cauchy(0, 1)). Given greater variability in the random intercept, a half normal prior (0,.2) with slightly wider scale was placed on this parameter. Given the expectation of some diverging transitions, the delta of the model was increased to .99 prior to initial estimation. The model summary indicated no issues of diverging transitions for this model.

In the pro-climate change motivation model and those that follow below, random intercepts were estimated both for country and for the images participants rated. Both predictors and outcomes were standardized in the motivation model, requiring slightly more narrow priors on coefficients given that effects are now on the standardized scale. Regularizing priors were placed on the regression coefficients (normal(0,.5), intercept (student_t(3,0,.5)), and sigma (half Cauchy (0, 1))). The priors on the hierarchical standard deviations for both images and countries were half-normal priors with a narrow deviation (normal(0,.2)). After warnings of several divergent transitions, the delta was increased to .90, at which point the divergences disappeared.

The model for affect was very similar. However, as the outcome is not standardized in this case, priors on the coefficients and intercept were spread out slightly to allow more variability (normal(0,1) and student_t(3,0,2) respectively). The other priors were the same as the previous model.

The hierarchical model of image understanding was estimated using a cumulative response family and logit link function. As such, the parameters are estimated on the log scale. Prior specifications were identical to the affect model, with the exception that the prior on sigma was removed.

APPENDIX C

SUPPLEMENTARY ANALYSES ACCOMPANYING CHAPTER 4

Below is a direct reproduction of the supplementary online material published in Chapman et al. (2016) and discussed in Chapter 4.

Beliefs about Others' Reactions to the Images

In addition to the main dependent measures covered, we also assessed participants' beliefs about how they thought others would react to the images they saw. We performed identical analyses as those described in the full text, which are described below. We asked four items that gauged how participants thought others would react to the images. These assessed whether the image would influence *perceived urgency* ("Would this image make someone feel like climate change is a more urgent problem or less urgent problem?" 1 = *not at all urgent*, 5 = *very urgent*), affect *support for climate change prevention and adaptation policies* ("After seeing this image, how supportive do you think someone would be of government policies focused primarily on *preventing* climate change?"; "After seeing this image, how supportive do you think someone would be of policies focused primarily on *preparing or adapting* to future climate change impacts?"; 1 = *not at all supportive*, 5 = *very supportive*) and whether the image would be *shared by others* ("How willing do you think others would be to share this image on social media or talk about it with their family and friends?" 1 = *not at all willing*, 5 = *very willing*). Table C1 below displays the correlations between these measures and the other dependent measures.

Table C1. Bivariate correlations between all image-related dependent measures.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Understanding (1)	1									
Emotional response (2)	.067	1								
Seek out information (3)	.634	.090	1							
Share image with others (4)	.580	.109	.818	1						
Change personal behavior (5)	.601	.057**	.857	.834	1					
Support government climate policy (6)	.554	.037*	.747	.809	.828	1				
Will increase urgency (7)	.613	.053**	.771	.773	.815	.780	1			
Will increase mitigation support (8)	.533	.095	.702	.72	.755	.720	.847	1		
Will increase adaptation support (9)	.566	.089	.741	.741	.787	.764	.889	.859	1	
Others will share image (10)	.551	.089	.761	.775	.766	.685	.841	.806	.829	1

Note. * $p < .05$, ** $p < .01$, all other coefficients are significant at $p < .001$

Table C2 displays the results of analyses examining the effects of image condition on participants' beliefs about how others would react to the images they saw. Across all four items, images depicting climate change impacts were rated as most likely to increase urgency, support for prevention and adaptation policies, and be shared by others.

Table C3 displays country-level differences in beliefs about others reactions to the images. Consistent with the outcome measures described in the main text, Germans exhibited the highest level of beliefs that others would be motivated by these images, while those in the U.K. exhibited the lowest levels of belief that the images would motivate others or increase support for climate change policy. There were no significant interactions between country and image type on these measures.

Table C2. Effects of image type on perceptions of others' reactions to the images.

Item	<i>F</i>	<i>R</i> ²	Condition	<i>M</i>	<i>SD</i>
Will increase Others' Urgency	68.963***	.044	Causes	3.26	.815
			Impacts	3.49	.887
			Solutions	3.27	.893
Will increase support for Prevention Policy	51.353***	.033	Causes	3.13	.901
			Impacts	3.36	.973
			Solutions	2.94	.938
Will increase support for adaptation policy	44.948***	.029	Causes	3.16	.882
			Impacts	3.39	.961
			Solutions	2.99	.934
Others will be motivated to share the images	49.103***	.032	Causes	2.54	.734
			Impacts	2.74	.773
			Solutions	2.40	.761

Note. Post-hoc analyses were performed separately for each item to compare the mean differences between conditions using Tukey's adjustment for multiple comparisons. For each, all mean differences are significant at $p < .001$.

Table C3. Country-level differences in beliefs about others' responses to the images.

Item	<i>F</i>	<i>R</i> ²	Country	<i>Mean</i>	<i>SD</i>
Will increase Others' Urgency	35.725***	.023	U.K.	3.09	.867
			U.S.	3.29	.921

			Germany	3.42	.834
			U.K.	3.03	.906
Will increase support for Prevention Policy	10.756***	.007	U.S.	3.16 ^c	.976
			Germany	3.23 ^c	.968
			U.K.	3.03	.917
Will increase support for adaptation policy	28.477***	.019	U.S.	3.17	.980
			Germany	3.34	.895
			U.K.	2.41	.753
Others will be motivated to share the images	33.556***	.022	U.S.	2.59	.795
			Germany	2.68	.730

Note. Post-hoc analyses to examine between-country differences were performed using Tukey's adjustment. Matching superscripts denote post-hoc tests that did not attain significance. All other post-hoc comparisons are significant at $p \leq .05$

We also examined whether there were interactions between image type and climate change skepticism on beliefs about others' reactions to the images. Table C4 displays the results of these analyses. Primarily, the significant interaction patterns for these measures suggest that skepticism predicts lower beliefs that images of impacts will affect others' policy support and sense of urgency, but does not predict beliefs about others' responses to the causes or solutions images. For beliefs about which images others would be motivated to share, skepticism marginally predicts greater beliefs that others will share solutions images, whereas the pattern is in the opposite direction (though nonsignificant) for causes and impacts images.

Table C4. Interactions between climate change skepticism and imagery condition on beliefs about others' responses to the images.

Variable	Interaction (<i>F</i>)	Condition	<i>b</i>	<i>SE</i>	95% Confidence Intervals	
Will increase Others' Urgency	6.803**	Causes	-.01	.02	-.043	.023
		Impacts	-.06***	.02	-.088	-.026
		Solutions	.03 [†]	.02	-.005	.060
Will increase support for Prevention Policy	4.093*	Causes	.004	.02	-.032	.039
		Impacts	-.04*	.02	-.077	-.009
		Solutions	.03	.02	-.008	.063
Will increase support for adaptation policy	3.397*	Causes	.003	.02	-.032	.038
		Impacts	-.04*	.02	-.073	-.006
		Solutions	.02	.02	-.012	.058
Others will be motivated to share the images	3.275*	Causes	.02	.01	-.013	.044
		Impacts	-.02	.01	-.049	.006
		Solutions	.03 [†]	.01	-.001	.056

Note. *** $p < .001$, ** $p < .01$, * $p < .05$, [†] $p < .10$

Analyses Involving Political Ideology

The political ideology of participants was measured using a single item index of the extent to which they reported being on the left or right of the political spectrum (0= *left*, 10= *right*; $M = 5.05$, $SD = 2.155$). Ideological beliefs did not significantly differ

between experimental conditions, $F(2, 3011) = 1.733, p = .177, R^2 = .001$). However, there were small cross-national differences on this measure, $F(2, 3011) = 15.797, p < .001, R^2 = .01$, with the United States ($M = 5.26, SD = 2.294$) and United Kingdom ($M = 5.15, SD = 2.073$) being slightly more to the political right than the German sample ($M = 4.75, SD = 2.059$; differences between U.S. and U.K. are not statistically significant, but both significantly differed from Germany at $p < .001$).

Similar to our analyses for climate change skepticism, we examined whether participants' responses to the different image types (collapsed across country of origin) were moderated by the political ideology of the respondents. There was a significant interaction between image condition and ideology on affective reactivity to the images, $F(2, 3008) = 38.865, p < .001$. In both the causes imagery and impacts imagery conditions, individuals on the political right reported less negative affective (i.e., more positive) responses to the imagery than those on the political left (slope for ideology in causes condition: $b = .24, SE = .03, p < .001, 95\% \text{ CI's} = .162, .291$; slope for ideology in the impacts condition: $b = .28, SE = .03, p < .001, 95\% \text{ CI's} = .238, .338$). In contrast, in the solutions imagery condition, political ideology no longer significantly predicted affective reactivity ($b = -.003, SE = .02, p = .912, 95\% \text{ CI's} = -.052, .046$), suggesting that those on the political left and right reported similar levels of affect after viewing these images.

There was also a significant interaction between imagery type and ideology on beliefs about the effect of images on other peoples' support for climate change adaptation policies, $F(2, 3008) = 3.082, p = .046$. In the causes imagery condition, greater conservatism (i.e., on the political right) predicted greater beliefs that these images would

increase others' support for climate change adaptation ($b = .04$, $SE = .01$, $p = .004$, 95% CI's = .013, .066). In the climate change solutions condition, this same pattern emerged, although the slope was only marginally significant ($b = .02$, $SE = .01$, $p = .076$, 95% CI's = -.003, .050). In the climate change impacts condition however, ideology did not significantly predict participants' responses to this item ($b = -.01$, $SE = .01$, $p = .570$, 95% CI's = -.035, .019).

There was also a marginally significant interaction between ideology and imagery condition on participants' reported beliefs about how the images would affect others' support for climate change mitigation policies, $F(2, 3008) = 2.533$, $p = .08$. This interaction follows nearly the same general pattern as the findings for the climate change adaptation policy interaction. In both the climate change causes and climate change solutions conditions, the greater a participant was on the political right of the spectrum, the more likely they were to think that these images would increase other people's support for climate change mitigation policies (slope for ideology in causes condition: $b = .04$, $SE = .01$, $p = .005$; 95% CI's: .012, .066; slope for ideology in the solutions condition: $b = .03$, $SE = .01$, $p = .011$; 95% CI's: .008, .061). In the climate change impacts condition, ideological beliefs did not significantly predict participants' beliefs about how this image would affect others ($b = -.001$, $SE = .01$, $p = .931$; 95% CI's: -.028, .026). No other significant interaction effects emerged for political ideology.

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