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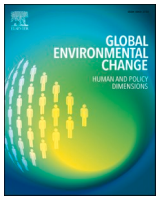

Disaster experience mitigates the partisan divide on climate change: Evidence from Texas☆

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ABSTRACT

Despite the abundance of real world events and scientific information linking the worsening extreme weather to climate change, public attitudes toward climate issues in the United States remain highly divided along partisan lines. We compare the effect of different stimuli linking extreme weather events to climate change – personal experiences and scientific information – in reducing the partisan gap. A two-wave survey corresponding to multiple extreme weather events in Texas, including a natural experiment with power outage data from the 2021 North American Winter Storms, shows that personal experiences with extreme weather reduce the partisan divide in climate beliefs and polices. Scientific information attributing extreme weather events to climate change, however, had no effect in closing the partisan gap. These findings suggest that extreme climate events and disaster experiences force vividly tangible information about the proximity and severity of climate change on exposed individuals, prompting belief-updating and preference-shifting toward pro-climate policies.

1. Introduction

Climate change-induced extreme weather events, such as wildfires in the western United States and hurricanes along the Gulf Coast and Eastern Seaboard, occur with increasing frequency, visibility, and consequence (Davenport et al., 2021; Parks and Abatzoglou, 2020). Experience with these extreme climate events and disasters present vividly tangible stimuli about the proximity, severity, and costliness of climate change. Scientific information attributing extreme weather and its consequences to anthropogenic climate change has also become more abundant through both academic research (Trenberth et al., 2015) and public science channels (IPCC, 2022). Yet, individual beliefs and policy preferences about climate change in the U.S. remain deeply polarized along partisan lines (Leiserowitz et al., 2023; Dunlap et al., 2016). This is in spite of the fact that climate-skeptic individuals, who tend to be Republican, are increasingly exposed to ever-growing amounts of experiential and informational stimuli about climate change. This cause of partisan division is of particular importance because it is associated with gridlock on climate policy-making (Hazlett and Mildenberger, 2020).

Can extreme weather experiences and scientific information attributing extreme weather to climate change reduce this partisan gap? Both these *experiential stimuli* (personal experiences with extreme weather) and *informational stimuli* (scientific information attributing these events to climate change) are seen to be key drivers of individuals associating climate change with negative outcomes (Thaker and Cook, 2021; Wong-Parodi and Garfin, 2022). However, despite numerous studies investigating how these two stimuli shape climate attitudes, conclusive findings about either factor have yet to be established. Empirical evidence about the experiential stimuli (Howe, 2021; Sisco, 2021; Reser and Bradley, 2020; Howe et al., 2019) and the informational stimuli (Rode et al., 2021) are mixed between exhibiting positive or null effects. Moreover, scientific information even led to backfire effects among specific politically-relevant subgroups (i.e., Republicans (Zhou, 2016; Hart and Nisbet, 2012) and climate skeptics (Dixon et al., 2019; Chapman and Lickel, 2016)). Recent studies have begun to examine how

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the relationship between personal experiences and pro-climate attitudes differs across political groups (Constantino et al., 2022; Hazlett and Mildenberger, 2020; Zanocco et al., 2019; Ogunbode et al., 2020). Notably, Constantino et al. (2022) and Zanocco et al. (2019) find evidence that negative personal experience with extreme weather decreased the partisan gap on climate attitudes, as Republicans tended to shift closer to Democrats' positions. Conversely, Hazlett and Mildenberger (2020) show that Republican-dominated areas in California were unresponsive to wildfire exposure when voting on climate-policy ballots, which effectively increases the partisan gap.

Critically, existing research does not directly compare the impacts of extreme weather experiences and scientific information, two different types of stimuli prompting individuals to link climate change to negative outcomes, on the same individuals. The lack of within-sample comparisons leaves notable gaps in our understanding of climate attitudes. First, given sample heterogeneity across studies, it is difficult to contextualize findings about different stimuli (i.e., experiential and informational) against one another. Second, personal experiences with extreme weather and scientific information on attribution is likely to conditionally impact or moderate climate attitudes (Lacroix et al., 2020), which cannot be examined unless we explicitly model the interaction effect on a sample of individuals.

In this paper, we fill these gaps by simultaneously examining the effects of personal experiences and scientific information in influencing the climate attitudes of partisan individuals. We achieve this through several research designs that we conducted as part of two-wave survey (2020 and 2021) fielded in Texas, U.S., a state that has experienced both major hurricanes and extreme winter storms in recent years. Our surveys draw directly on personal experiences, a preregistered experiment,[1] and a natural experiment, each measuring exposure of our survey respondents to the link between climate change and extreme weather. We explored both personal experiences about hardship directly experienced from climate disasters and scientific information explicitly highlighting the link. We started with the general expectation that both experiential and informational stimuli will effect pro-climate attitudinal change, then examined how the heterogeneous effects for both stimuli across partisan groups can lead to a reduction in the partisan gap on a set of climate attitudes ranging from belief in anthropogenic climate change to support for various pro-climate policies.

As previewed in the introduction of our research design above, results come from three sets of analyses – survey, quasi-experimental, and experimental – that systematically explore how Democrats' and Republicans' beliefs about climate change and support for pro-climate policies vary by their personal experiences and exposure to scientific information. We find that Republicans update their beliefs about anthropogenic climate change and climate policy when they personally experience extreme weather events while Democrats generally update their beliefs very little because their existing beliefs are already strongly pro-climate. The observed mechanism that experiences drive pro-climate attitudes, however, also holds for Democrats for outcomes not subject to a ceiling effect (i.e., their willingness to share pro-climate messages on social media). In terms of scientific information, experimentally provided scientific attribution linking climate change and extreme weather events had no measurable impact on climate change attitudes for both partisan groups, even when moderated by existing personal experiences.

Beyond being the first study, to our knowledge, that simultaneously examines the effects of different types of stimuli across a fixed set of individuals from distinct partisan groups, our study makes a number of additional contributions. First, we explicitly study the potential for an interactive effect between the two kinds of stimuli, for which we found none. Second, focusing on Texas afforded a number of benefits, most notably being able to study individuals' experiences with both expected (i.e., hurricanes) and unexpected (i.e., winter storms) extreme weather events. Here, our findings are highly robust across both contexts. Third, because of the timing of our surveys and the collection of real-world data, we were able to measure personal experience in different ways. Specifically, we measure both perceived personal experience and objective geographic exposure (i.e., being in an afflicted location at the time of an extreme weather event). Perceived personal experience captures important psychological realities (Reser and Bradley, 2020), but it is hard to identify the causal effect of perception. On the other hand, while geographic exposure – as an externally validated measure of the state of the world – facilitates identified causal estimates, they do not perfectly map onto experience as a construct (Reser and Bradley, 2020) and are prone to measurement imprecision (Akerlof et al., 2013). Given the shortcomings of any singular measurement approach, we opted to examine both. The results we present about the effects of personal experience are weakly robust to both measurement approaches.

The remainder of our paper proceeds as follows. In the second section, we provide an overview of our methodological approach, specifically how we measured pro-climate attitudes, details about our case study, and how we implemented our surveys. In the third section, we present our findings about the *experiential stimuli*, measured both as perceived personal experience and as geographic exposure. In the fourth section, we present our findings about the *informational stimuli*, which was embedded in a scientific information experiment. On the whole, our results show that, although climate attitudes are widely viewed as inflexible, especially for Republicans, individuals do update their attitudes when experiencing extreme weather events. Between the two oft-examined types of stimuli prompting individuals to link climate change to negative outcomes, we show that personal experiences are more effective than information on scientific attribution in effecting pro-climate attitudes.

2. Methods

In this study, we conducted three set of analyses using data from a two-wave survey among Texas residents ($n_{wave1} = 1375, n_{wave2} = 305$). In this methods section, we outline methodological considerations common to all our analyses. Specifically, we discuss how we measured different facets of pro-climate attitudes, the merits and particulars of using Texas as a case study from which to draw our samples, and how we implemented our survey. Due to the variety of analyses we conducted across each of our studies, we leave the detailed discussion of each study, including how we measure different stimuli and how we made inference design choices, in each study's respective section.

2.1. Pro-climate attitudes

To assess how widely applicable our comparison of the experiential and informational stimuli is, we examined a variety of pro-climate attitudes, which are summarized in Table 1. First, we included a set of general questions capturing respondents' belief in anthropogenic climate change. Second, we asked respondents about their policy preferences, both in terms of support for different approaches to climate mitigation, and in terms of support for disaster resilience. Beyond these main climate attitudes, we also included two measures of social media activism to capture pro-climate tendencies that have a low baseline of support across both partisan groups. Finally, we included a number of additional measures that we summarize in Supplementary Information S2.[2]

[1] Our preregistration materials are deposited at OSF (https://doi.org/10.17605/OSF.IO/SMQCH). They are also included in Supplementary Information S6.

[2] Our questionnaire is included in Supplementary Information S5.

Table 1
Measures of pro-climate attitudes. *Additive scale measures (see Supplementary Information S5).

Concepts	Survey Measures	Wave
Belief in Anthropogenic Climate Change	Pro-climate Belief*	Both
Support for Climate Change Mitigation	Federal Carbon Emissions Tax	Both
	Climate Change Mitigation Spending	Both
Support for Disaster Resilience Policy	Disaster Relief Spending	Both
	Infrastructure Improvement (Flood Barrier)*	1
	Infrastructure Improvement (Power Grid)*	2
Social Media Activism	Social Media Like	1
	Social Media Retweet	1

2.2. Texas as a case study

Texas is an ideal political and environmental context to study change to partisan beliefs about climate change. Politically, though solidly 'Red' at the state level, Texas exhibits substantial political and demographic diversity in its major metropolitan areas. Climate change impacts also vary considerably by region in Texas. While Houston is at constant risk of hurricane exposure, the other metro areas are far enough from the coast that they are not directly threatened. In addition to the threat of hurricanes, Texas now faces more winter storm variation because of changes to the polar vortex. Subzero temperatures, once rare along the Gulf Coast region, are becoming more prevalent.

Further, as we show with Google Trends data in Fig. 1, Texas residents have been highly aware of extreme weather events and their consequences, which adds further value to Texas as a case for our examination of how perceived experiences matter to pro-climate attitudes. These trends explicitly capture the relative search interest on given topics within Texas. Our approach is consistent with prior studies that used Google Trends to measure drought awareness in California (Kam et al., 2019) and global interests in human rights (Dancy and Fariss, 2023). Major extreme whether events in Texas, such as Hurricane Harvey and the 2021 winter storms, have triggered peaks in disaster awareness. Comparing the relative degree of search interest for specific climate event terms to another popular search term (i.e., 'astros' for Houston Astros, a highly competitive Major League baseball team, which won Baseball's Major League World Series in November 2017 and played in the World Series in 2019), we see the peaks of awareness in Hurricane Harvey, captured by 'hurricane', can be found in August–October 2017, and the peaks of awareness for the winter storms, captured with searches for 'power' for power outages, are found in February 2021.

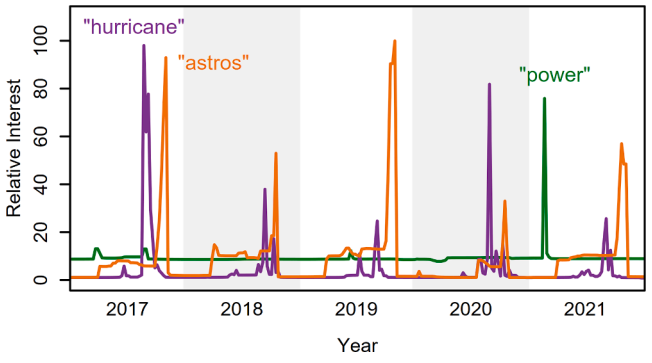

Fig. 1. Comparison of relative web search interest from Texas (de-noised Google Trends) for terms associated with Hurricane Harvey, the 2021 North American winter storms, and the Houston Astros.

2.3. Survey administration

We conducted a two-wave survey of Texas residents with a stated partisan affiliation. The first wave took place three years after Hurricane Harvey. It was conducted between October 18, 2020 and November 5, 2020, through three survey platforms, Lucid, Prolific, and CloudResearch.[3] Using prescreening data from each platform, we recruited Democrats and Republicans who resided in Texas. We originally planned to recruit all participants using Lucid, but recruitment was slow due to the constrained nature of our target population. To avoid a large shift in the information environment due to election results reporting on November 6, we expanded our recruitment to Prolific and CloudResearch. For these subsequent samples, we implemented additional quality checks.

The second wave took place a few months after North American winter storms Uri and Viola in 2021. It was conducted between July 7, 2021 and October 14, 2021. For this sample, we recruited respondents from the first wave from Prolific and CloudResearch, but not Lucid because it does not support recruitment of past participants.

In both Waves 1 and 2, at the beginning of the study, participants were given a consent form that described the study instrument (i.e., answering questions on demographics and disaster experiences, reading a news article about disasters), ensured that their responses will be kept anonymous, and that the study involved minimal risks. After the study, participants were debriefed with the purpose of the study (i.e., better understand how citizens are affected by disasters and evaluate political issues), and were provided with the contact information of the study team. The Wave 1 survey took approximately 12 min to complete and the Wave 2 survey took approximately 8 min to complete.

In the first wave, a total of 1375 eligible respondents (779 Democrats and 596 Republicans) were included in the analysis. In the second wave, the sample consisted of 305 respondents (194 Democrats and 111 Republicans) who participated in the first wave. The 305 Wave 2 respondents equate to a 53.4% retention of the subset of Wave 1 respondents we recruited for our Wave 2 survey. A full breakdown of the participant pool by survey platform and partisanship is in Table 2.[4]

Table 2
Survey recruitment details by wave. n_D and n_R respectively indicate sample size of Democrats and Republicans.

Field dates	Platform	n_D	n_R	Remuneration
Wave 1				
Oct. 18 – Oct. 23, 2020	Prolific	96	72	$2
Oct. 24 – Nov. 5, 2020	Lucid	424	380	up to $4
Oct. 29 – Nov. 5, 2020	Prolific	172	81	$2
Oct. 30 – Nov. 5, 2020	CloudResearch	87	63	$2
Wave 2				
Jul. 7 – Aug. 30, 2021	Prolific	116	62	$2
Aug. 31 – Oct. 14, 2021	Prolific	42	25	$4
Sep. 24 – Oct. 14, 2021	CloudResearch	36	24	$2

[3] Prior to the launch, we conducted a pilot on Lucid with 132 respondents (74 Democrats and 59 Republicans) who are not included in the final data set due to mismatches with our sampling criteria and other data quality concerns (i.e., speeders or spammers). Based on the pilot, we implemented more quality controls for the full launch.

[4] A breakdown of the distribution of basic sociodemographic variables for our Wave 1 and Wave 2 surveys is in Supplementary Information S1.

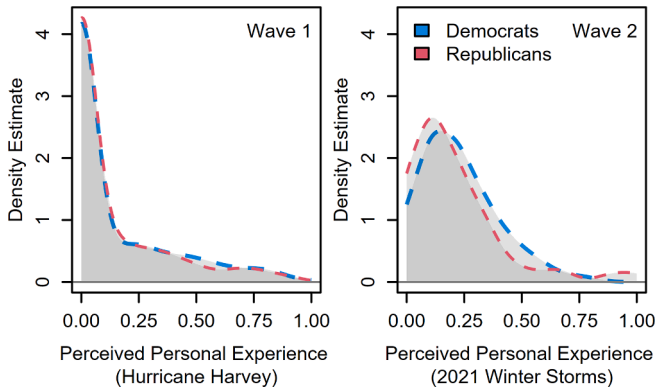

Fig. 2. Distribution of perceived personal experience with Hurricane Harvey (Wave 1) and the 2021 North American winter storms (Wave 2) in Texas, rescaled to the unit interval.

2.4. Data availability, analysis, and results reproduction

All analysis for our study was conducted in `R v4.4.1` (R Core Team, 2024). Estimation for the difference-in-differences models was done with the `fixest v0.11.1` package (Bergé, 2018). All marginal effect calculations were done with the `marginaleffects v0.9.0` package (Arel-Bundock, 2023). All reproduction code is publicly available under the MIT license at https://github.com/tedhchen/floodStorm. All study data is publicly available under the CC BY 4.0 license at https://zenodo.org/doi/10.5281/zenodo.13621323.

3. Personal experience with extreme weather events

Personal experience is difficult to measure, and any singular measurement approach has its shortcomings. We therefore opted to examine personal experience in drastically different but complementary ways: as perceived personal experience and as externally-validated geographic exposure.

3.1. Perceived personal experience with extreme weather

To measure perceived personal experience with Hurricane Harvey, which caused severe damage in southeast Texas in August 2017, we asked participants in the first wave of our survey whether they were personally harmed by Hurricane Harvey on three dimensions, personal health, financial situation, and property damage. In the second wave, we similarly measured perceived personal experience with the 2021 winter storms with a set of fourteen questions about whether they experienced different negative events during the winter storms, including perceived danger, injury, and property damage (adapted from Harville et al., 2015). For both waves, we summed responses from the different questions then rescaled them to the unit interval to obtain our measure of perceived personal experience.[5]

Fig. 2 shows the distribution of the self-reported exposure for both waves by partisanship, which illustrate that while our results differed by respondent's partisanship, it is not due to differences in their perceived experiences.

To test whether perceived personal experience with extreme weather promote pro-climate attitudes, we fit linear models that examine how various climate attitudes are associated with our measure. Further, to examine how partisan identity moderates the relationship between perceived personal experience and climate attitudes, we included an interaction term between partisanship and experience in the models. We also included a set of individual-level control variables in all models: ideology, age, gender, education, and indicators for Hispanic and Black identification.

We find a large difference between Republicans and Democrats (Fig. 3). In general, among Republicans, perceived personal experience with both Hurricane Harvey (Wave 1) and the 2021 winter storms (Wave 2) are positively and statistically significantly associated with pro-climate attitudes. Specifically, with the single exception of beliefs about anthropogenic climate change in Wave 1, responses indicating

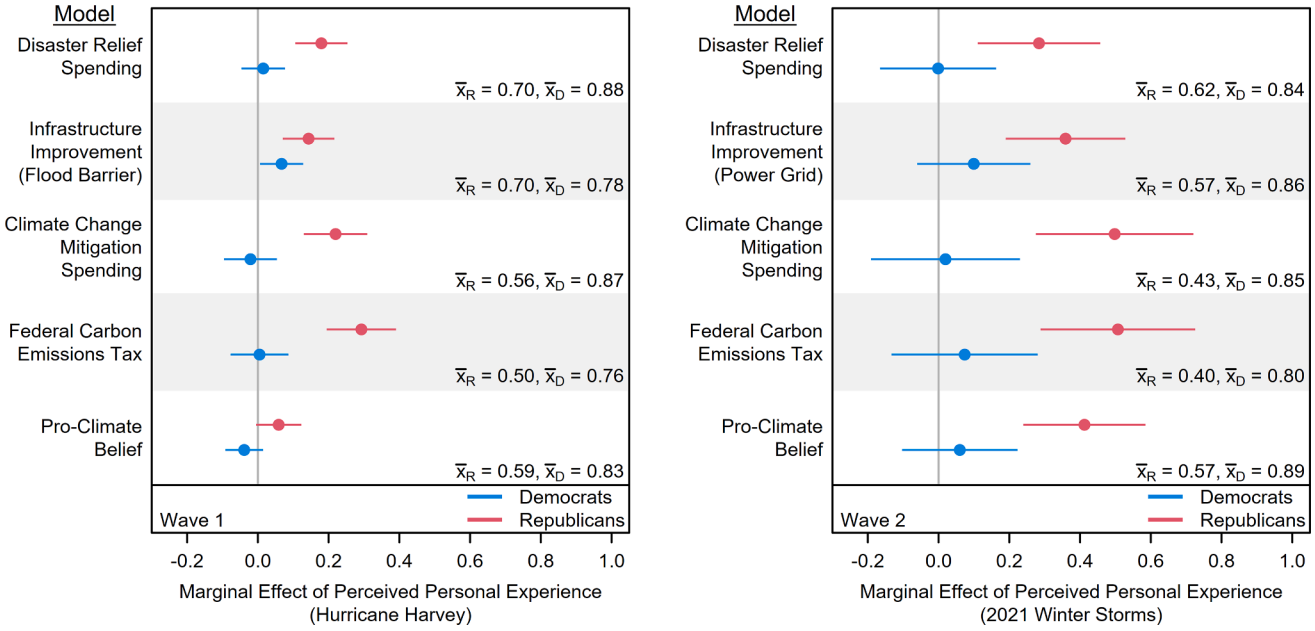

Fig. 3. Relationships between perceived personal experience and climate attitudes (point estimates and 95% CIs), for Wave 1 survey respondents (left) and for Wave 2 survey respondents (right). $\bar{x}_R$ and $\bar{x}_D$ refer to, respectively, the sample mean of the outcome variable for the Republican and Democrat groups.

[5] Additional information on our perceived personal experience measures, including distributional breakdowns, are in Supplementary Information S1.

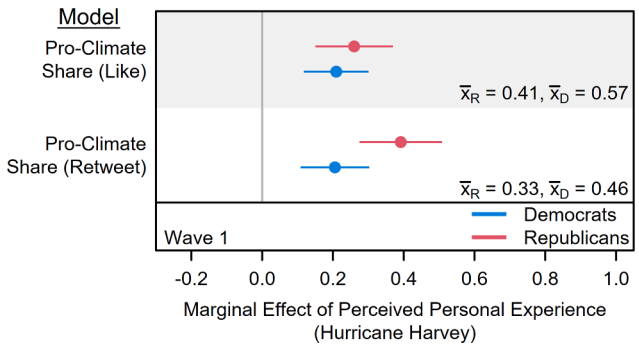

Fig. 4. Relationships between perceived personal experience and willingness to share pro-climate information on social media (point estimates and 95% CIs), for Wave 1 survey respondents. $\bar{x}_R$ and $\bar{x}_D$ refer to, respectively, the sample mean of the outcome variable for the Republican and Democrat groups.

more experience with disaster damages is predictive of greater support for both climate change mitigation and disaster resilience policies.[6]

In contrast, among Democrats, there is no statistically discernible relationship between perceived personal experience and our outcomes. While this discrepancy may appear counterintuitive, additional tests show that the null finding among Democrats can be attributed to a ceiling effect (Gillis et al., 2023; Zanocco et al., 2019), whereby many Democrats already possess high levels of pro-climate beliefs – see Democrat group means $\bar{x}_D$ in Fig. 3 – and therefore cannot increase their support. In anticipation of this potential ceiling effect, we included in Wave 1 two items on willingness to share pro-climate information on social media, which tends to have a low baseline tendency among both partisan groups. We asked respondents how likely they are to retweet and to 'like' on Twitter a pro-climate mitigation report,[7] both of which are costly public acts of engagement.

As expected, as shown in Fig. 4, because the baseline tendency to engage in social media activism is generally low, we do not observe the ceiling effect for Democrats. Instead, we find a positive relationship between perceived personal experience and social media activism for both partisan groups. This finding suggests that the mechanism underlying the relationship between personal experience and pro-climate attitudes is similar across partisan lines.

3.2. Natural experiment of geographic exposure to the 2021 winter storms

In February 2021, three months after we fielded our first survey, two overlapping winter storms (Uri and Viola) struck various parts of North America, including Texas. The timing of this event, occurring right before our Wave 2 survey, allows us to implement a convincing pre-test–posttest design to examine the causal effect of geographic exposure to the winter storms as the treatment in a natural experiment.

For this study, we measured geographic exposure to the winter storms, which is an externally validated measure of exposure, as the extent to which individuals experienced power outages during mid-late February 2021. We estimated this using data from PowerOutage.US, a data aggregation company that tracks outage reports from utility companies in the U.S. In Texas, this comprised raw data from 62 utility providers tracking the accounts of 13.4 million customers. We aggregated the raw data (counts of outages and non-outages by geographical area) to the city level or county level depending on data availability as the proportion of customers exposed to outage during the specified time period. Specifically, counties exceeding a certain proportion of tracked-but-not-geolocated households are aggregated to the county level whereas counties with city-level data exceeding the information threshold were kept at the more precise city level. We refer to this hybrid-level geographical unit as the ZIP-associated region.[8] Then, using respondents' self-reported ZIP codes, we matched them to the average power outage in their ZIP-associated region during the February 13–21 period which we take as our measure of geographic exposure treatment. Fig. 5 shows that Texas residents experienced unusually high levels of outages when the storms hit in February 2021 compared to February 2020.

Using this geographic exposure treatment variable and outcomes from our surveys, we used a generalized difference-in-differences design to estimate the impact of geographic exposure to extreme weather events on individuals' climate beliefs and policy preferences. As before, we consider how this effect varies by partisanship by including an interaction term between the treatment variable and partisanship. We fit the following linear regression model:

$$Y_{izt} = \alpha_i + \tau_t + \gamma(outage_z \times storm_t) + \delta(democrat_i \times outage_z \times storm_t) + \epsilon_{izt}, \quad (1)$$

where Y_{izt} is the belief or attitude of individual i at time t, and z indicates the ZIP-associated region individuals reside in. $outage_z \times storm_t$ is the

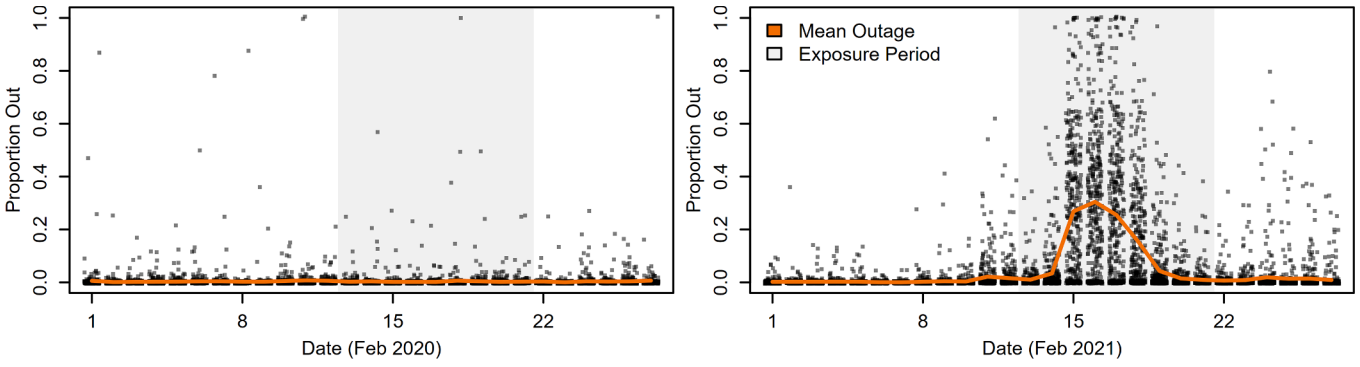

Fig. 5. Proportion of households experiencing power outage by tracked administrative unit (i.e., counties or cities) in Texas during February 2020 (left) and during the winter storm in February 2021 (right).

[6] We show in Supplementary Information S3 that subsetting the Wave 1 analysis to only respondents retained in Wave 2 yields similar results. We also discuss evidence that alleviates concerns about selection bias for Wave 2 results.

[7] Self-reported willingness to share information on social media tends to predict observed retweeting patterns (Mosleh et al., 2020).

[8] See Supplementary Information S3 for evidence that our main findings (Fig. 6), which was based on a 25% threshold, are robust to thresholds ranging from 5–45%.

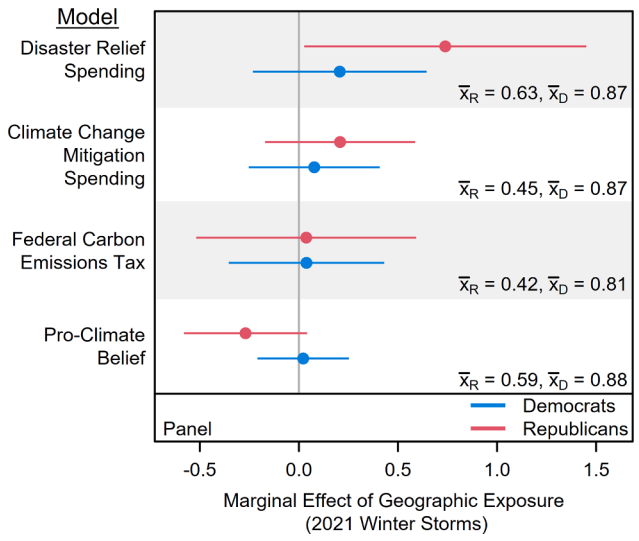

Fig. 6. Treatment effects of geographic exposure to the 2021 power outages on climate attitudes (point estimates and 95% CIs), using a panel design for survey respondents who participated in both Wave 1 and Wave 2 surveys. $\bar{x}_R$ and $\bar{x}_D$ refer to, respectively, the sample mean of the outcome variable for the Republican and Democrat groups.

treatment of the 2021 winter storms. We are interested in the difference between Republicans and Democrats, so we further interacted the treatment with partisanship (i.e., the *democrat* indicator). γ and $\gamma' \equiv \gamma + \delta$ therefore capture, respectively, the treatment effects for Republicans and Democrats. We additionally included in our model individual and time fixed effects (α_i and τ_t). Because the treatment was assigned to the geographical unit, we conducted the analysis using standard errors that were clustered at the level of the administrative unit.

Fig. 6 shows the treatment effects of geographic exposure to power outage during the 9-day period when Texas was hit by the winter storms (February 13–21, 2021). We find that, on balance, the effect of geographic exposure to power outages on climate attitudes is much weaker than the effect we found for perceived personal experience to the winter storms. Among Republicans, for whom perceived personal experience strongly predicts greater support for all tested climate mitigation and disaster resilience policies, geographic exposure to power outages only affects preferences toward disaster relief spending.

Additional evidence (see Supplementary Information S4) suggests that our null findings are attributable to the low precision in the operationalized measure of exposure to power outage – in line with prior work showing that individuals only accurately perceive very localized extreme weather (Akerlof et al., 2013) – and would otherwise be stronger if exposure could be measured with greater precision at the individual level. Specifically, our ZIP-associated regions are large and there is likely to be non-negligible variation in power outages within a region, presenting a type of measurement error that should bias the estimated effect toward zero.

4. Scientific information experiment with attribution of winter storms to climate change

To examine whether scientific information that attribute extreme weather and its costs to climate change reduces the partisan divide on climate attitudes, we embedded an experiment in Wave 2 of our survey that emphasizes the link between the winter storms' extreme southward extension and climate change.[9] Specifically, Wave 2 respondents were randomly assigned with equal probability into treatment and control conditions, where the former were exposed to the highlighted portions of Fig. 7 that explain the link between raising temperatures in the arctic and extreme winter storms in Texas. To standardize respondent familiarity with the winter storms, the baseline (unhighlighted) portions

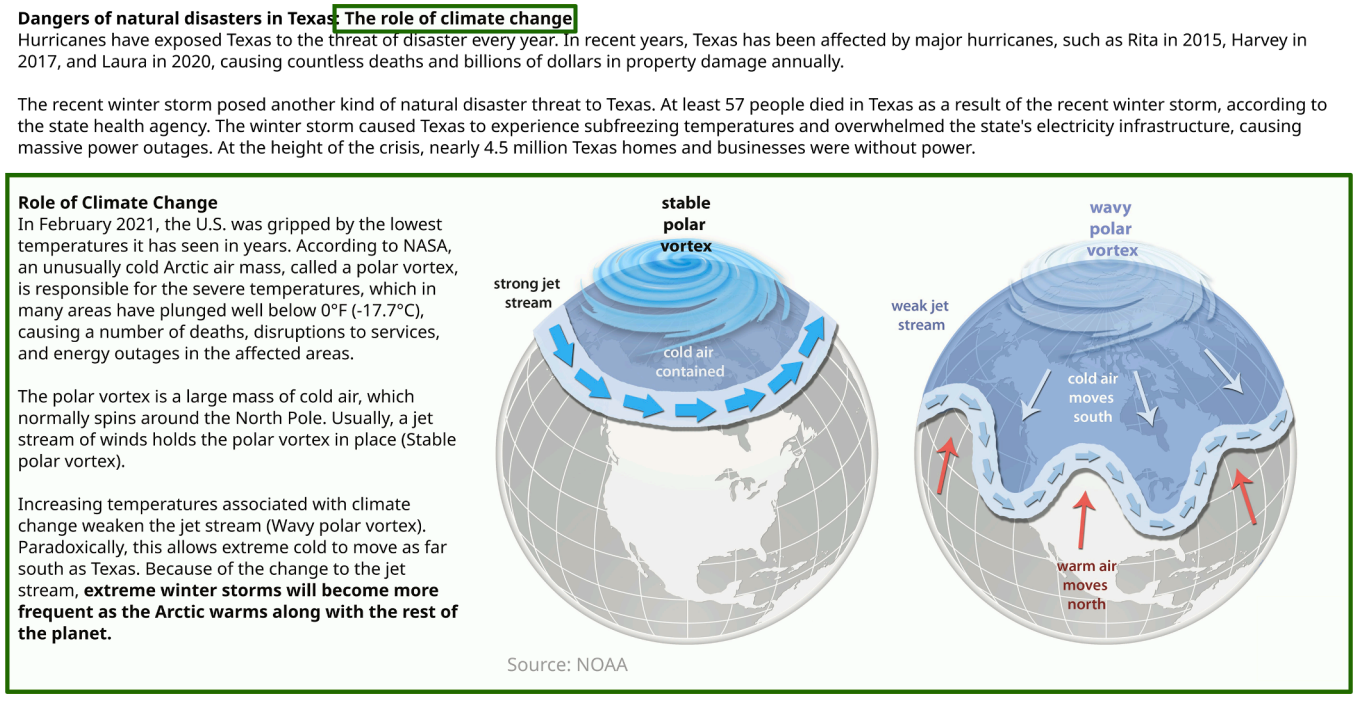

Fig. 7. Experimental stimuli from the scientific information study. Parts highlighted in green are shown to the treatment group only, while unhighlighted parts are shown to treatment and control groups. (Diagram obtained from the National Oceanic and Atmospheric Administration (2019)).

[9] Supplementary Information S6 contains our preregistration plan.

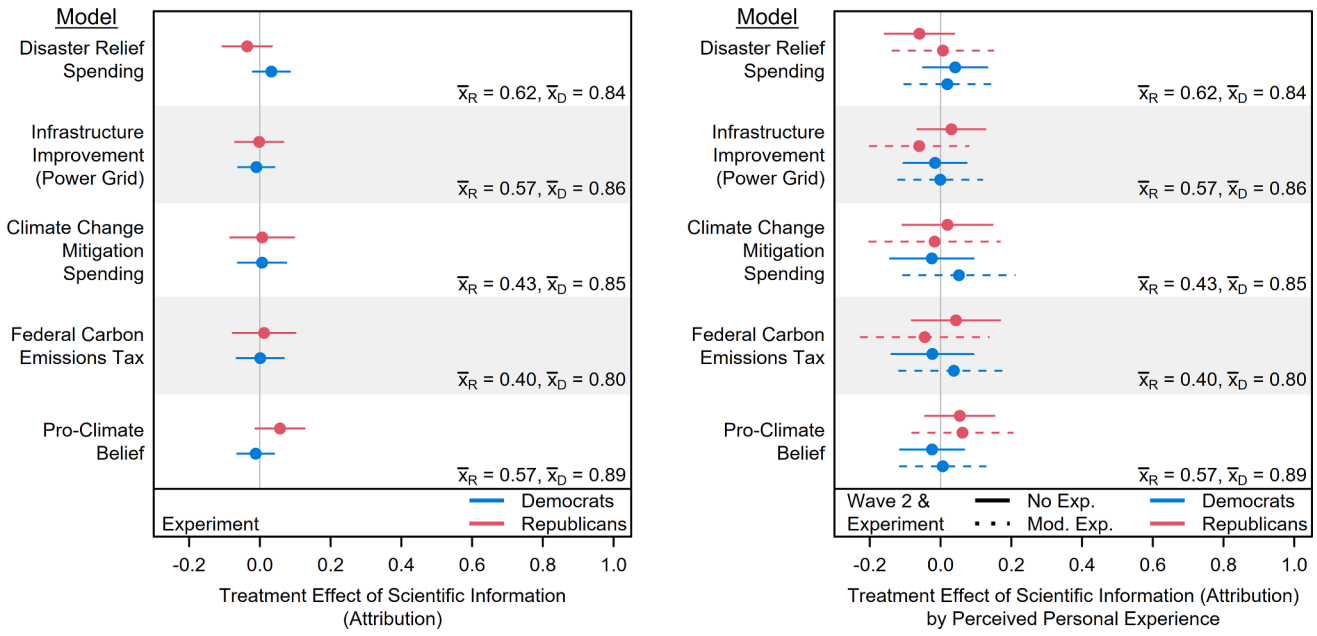

Fig. 8. Treatment effect of scientific information attributing extreme weather to climate change (point estimates and 95% CIs), for Wave 2 survey respondents (left), and the same effects moderated by respondents' perceived personal experience (right). $\bar{x}_R$ and $\bar{x}_D$ refer to, respectively, the sample mean of the outcome variable for the Republican and Democrat groups.

outlining the outcome of recent extreme weather events in Texas were shown in both conditions.

To account for the possibility of failure in experimental stimuli uptake due to respondent inattention, we implemented a number of treatment validation checks. First, we included a manipulation check question after presenting the respondents with the scientific information. This question asked respondents which of the following describes what the report they read was about: 1) recent natural disasters, 2) recent natural disasters and scientific explanation for winter storms, 3) recent natural disasters and the COVID-19 pandemic, or 4) the COVID-19 pandemic; respondents could also answer that they 5) do not know. Across the two conditions, 90% of the control group correctly answered with response 1 (10% chose response 2), and 93% of the treatment group correctly answered with response 2 (7% chose response 1). These results indicate a very high rate of compliance with our treatment in terms of understanding the scientific information presented.

Next, we checked how long the respondents spent reading the scientific information, measured in terms of how long they were on the questionnaire page containing the experimental stimuli. In median times, respondents from the control group spent approximately 33 s (23 and 44 s for the first and third quartiles), and those from the treatment group, who were shown a much longer experimental stimuli, spent approximately 72 s (45 and 122 s for the first and third quartiles). On the whole, the time our respondents spent on the stimuli page is in line with our expectations for how long they should spend.

We proceed with our analysis as it appears that the respondents took reasonable care in processing the experimental stimuli. We fit linear models where the effect of the treatment variable (i.e., scientific attribution of extreme weather to climate change) on support for pro-climate attitudes varies by respondent partisanship. Fig. 8 shows that the scientific information treatment has no discernible effect on pro-climate attitudes. Across all models, the difference between the treatment and control conditions is indistinguishable from zero, both in terms of statistical significance and substantive effect.

Finally, to test whether uptake of scientific information depends on existing personal experiences, we fit additional models that let the treatment effect of scientific information vary with the respondent's perceived personal experience with the 2021 winter storms. As we show in Fig. 8, the scientific information treatment still has no effect when subsetting by respondents' personal experiences. Based on likelihood ratio tests, the expanded model (i.e., interaction between scientific treatment and perceived personal experience) and reduced model (i.e., without interaction term) are statistically indistinguishable from each other for all outcome variables.

5. Discussion

There is an ever-growing amount of experiential stimuli and informational stimuli that prompts individuals to link the costs of extreme weather to climate change. Leveraging Texas's exposure to Hurricane Harvey in 2017 and the North American winter storms in 2021, we used a two-wave survey of Texas residents to simultaneously examine and compare the effect of personal experiences with extreme weather events and the effect of scientific information attributing these events to climate change. Across a set of survey, quasi-experimental, and experimental results, we show that personal experiences shape people's belief in anthropogenic climate change and support for pro-climate policies but scientific information does not.

Measuring the first stimuli, personal experience with extreme weather, in two ways, we find that self-reported perceived personal experience was substantially and consistently associated with pro-climate attitudes in various forms while externally-validated geographic exposure to power outages during the 2021 winter storm exhibited weaker, but causally-identified, effects. Due to what are likely ceiling effects for Democrats, the effect of personal experiences differed by partisan groups, which led to an overall closing of the partisan gap. With our outcome and independent variables rescaled to the unit interval, the effect of perceived personal experience for Republicans, averaged across all main outcomes, is 0.16 for Hurricane Harvey and 0.41 for the 2021 winter storms, and statistically significant for all outcomes but one. These effects are, respectively, approximately 33% and 105% increases from the baseline averages of when Republicans have no perceived extreme weather experience. In real-world terms, this means that if everyone in our sample were to perceive the highest level of personal experience with Hurricane Harvey and with the winter

storms, Republicans' pro-climate beliefs would be at approximately 92% and 96% of Democrats' levels.

On the other hand, the effect of scientific information is indistinguishable from zero, both in terms of statistical significance and substantive effect, for all outcomes regardless of whether we included existing personal experiences as a moderator. Given the evidence we provided about respondents reasonably engaging with our treatment stimuli, why is there no effect? Prior work on partisanship and climate beliefs have identified different types of goals in information processing that could lead to Republican individuals rejecting scientific information (Bayes and Druckman, 2021; Druckman and McGrath, 2019). Directional goals (commonly referred to as motivated reasoning) induce individuals to resist belief updating that runs counter to their priors, whereas accuracy goals, when coupled with distrust of the outgroup (e.g., liberal scientific elites (Sarathchandra and Haltinner, 2021)), would result in stronger belief in climate skeptic information from ingroup (i.e., Republican) elites.

In our additional analyses, reported in Supplementary Information S2, we examined how trust in climate science varied by personal experience with extreme weather. This outcome behaves similar to others we examined, with Republicans who report higher personal experiences exhibiting greater trust toward climate science and scientists.[10] This finding has implications for understanding information processing in response to climate impacts, but additional research is needed. Given that we generally still found scientific information to be ineffective despite Republicans showing attitude change toward trust in climate science, it could mean that directional motivated reasoning strongly dominates information processing for Republicans. Alternatively, we might interpret the relationship between personal experiences and increased trust in science as evidence of strong accuracy goals in information processing, where the null effect of scientific information is due to the weakness of our stimulus.

This suggests a fruitful direction for future research seeking to adjudicate between different types of informational processing goals of simultaneously examining trust toward different actors (e.g., scientists and ingroup elites) while varying the strength of the scientific information stimulus. In our experiment, we attempted to strengthen the scientific information stimulus using graphical cues. Could we perhaps strengthen this visual cue with, for example, a short video? Would a full semester undergraduate course be required instead? We cannot answer these questions with our current study design but examining whether stronger treatments could successfully convey scientific information is a promising avenue for future research.

6. Conclusion

What then do our results suggest for other settings and samples? Because extreme weather events are increasingly visible and experienced across the U.S., our expectation is that a growing number of individuals across all states are perceiving these experiences. While we expect that a ceiling effect also exists for Democrats in the broader population because they are likely to have already high support for pro-climate policies, Republicans can still shift their policy preferences toward greater climate policy support. However, consistent with our results on social media behaviors, we expect both Democrats and Republicans to be still capable of changing beliefs and behaviors as they experience climate change-related events. Generally, we speculate that our findings will hold for similarly situated Democrats and Republicans in other states even though we are cognizant of the fact that our Texas sample is not necessarily representative of the U.S. population. We nonetheless have a clear predication for individuals in other states, and we believe extensions of our results to other contexts to be an important area for future research.

Another question related to the generalizability of our findings going forward pertains to the accumulation of experiences with climate change-related events. In July 2024, Hurricane Beryl swept across the Caribbean, Mexico, Texas, and much of the Midwestern and Northeastern U.S., setting the record as the earliest Category 5 storm observed in the Atlantic in a given year. Even as its strength waned over land, Hurricane Beryl brought flash floods and tornadoes. This is just the latest in a continuing string of increasingly frequent and severe climate events. How do cumulative experiences with these events impact individuals' behaviors and policy preferences? This is an important and open question for future research.

Relatedly, personal experience with the Texas winter storm in 2021 differs from regular experiences with hurricanes along with Gulf Coast of Texas in that it is a relatively novel phenomenon. What does this mean for policy beliefs and behavioral changes? Though we find no evidence that scientific information changes beliefs, its effects might actually vary by the mix of how novel and how unfamiliar the information is perceived to be. Further work should look to systematically compare different types of scientific attribution, and even other science-based informational stimuli more broadly.

All of these suggestions for future research would benefit from a multi-wave, panel design that draws a representative sample from across the U.S., which could build on our design and some of the suggestions we have made here. This would be an expensive undertaking but an essential one for both the scientific community and the policy community. In terms of policy implications right now, the results are clear: individuals are supportive of policies that address the effects of climate change when they have experienced climate change related events. Because this experience closes the partisan gap, policy makers should be able to generate bipartisan support on policy solutions on extreme weather events even when there is ideological disagreement about climate change itself.

Overall, our study adds to the nascent body of research indicating that under the right conditions, personal experience with extreme weather or disasters can bridge the partisan gap on climate attitudes (Constantino et al., 2022; Zanocco et al., 2019). We identified a context in which Republicans update their beliefs about climate change and climate policy preferences in response to personally-experienced climate threats. However, questions remain as to whether these effects are strong enough to translate to policy-relevant behavior such as voting, and whether the relative strength between experiential and informational stimuli will hold under different contexts.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

All reproduction code is publicly available under the MIT license at https://github.com/tedhchen/floodStorm. All study data is publicly available under the CC BY 4.0 license at https://zenodo.org/doi/10.5281/zenodo.13621323.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.gloenvcha.2024.102918.

[10] The trust in science questions were asked before respondents were assigned to the scientific information experimental conditions, so there is no treatment effect.

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