



Shifting Republican views on climate change through targeted advertising

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It is essential to increase public understanding of the existence, causes and harms of climate change. In the United States, Republicans are one important audience, as the bipartisan support needed for ambitious and durable climate policy is currently lacking. An important limitation of most climate change message testing is that it is usually based on controlled experiments, which may or may not be equally effective in the real world. Here we report the effects of a one-month advertising campaign field experiment ($N = 1,600$) that deployed videos about the reality and risks of climate change to people in two competitive congressional districts (Missouri-02 and Georgia-07). The videos were designed to appeal to Republicans and were targeted to this audience via online advertisements. The study finds that, within the targeted congressional districts, the campaign increased Republicans' understanding of the existence, causes and harms of climate change by several percentage points.

Climate change threatens people and ecosystems around the world and, given current levels of carbon pollution, its impacts are projected to get much worse¹. Large-scale action is needed to address climate change, and therefore it is critical to build public understanding of the problem and demand for solutions (that is, public will)². In the United States, there has been a substantial increase in public awareness of climate change over the past decade. For example, in 2010 only 57% of Americans thought that global warming is happening³. But in 2020, 73% of Americans thought global warming is happening. Likewise, an increasing proportion of Americans understand that global warming is caused by human activities (2010, 46%; 2020, 62%), and are worried about global warming (2010, 49%; 2020, 66%).

Although the changes in public opinion over the past decade are substantial, they have mostly been driven by changes among Democrats, widening the opinion gap between Democrats and Republicans. For example, when asked how high a priority global warming should be for the president and Congress, 83% of Democrats said it should be a 'high' or 'very high' priority, whereas only 22% of Republicans said so⁴. Because ambitious and durable climate policies require bipartisan support, it is important to engage more Republicans. Although shifting basic beliefs and attitudes about climate change does not always lead to changes in behaviours or policy support, educating people about basic climate realities is an important foundation for problem recognition and solution seeking⁵.

Fortunately, researchers have identified several strategies that can help persuade Republicans of the existence, causes and risks of climate change. For example, laboratory-based studies have found that messages are more likely to be persuasive to Republicans and conservatives if advocated by Republican or conservative messengers^{6,7}, or use language and arguments more consistent with conservative moral values^{8,9}. However, there are limitations to assessing the practical impact of these insights outside the laboratory.

First, such experiments are conducted within a controlled laboratory setting, where the respondents are asked to devote their full attention and are aware of the artificial nature of the situation. The real world is messier—messages are deployed in a crowded and

competitive information environment, people selectively allocate their attention, and responses cannot be measured immediately. Therefore, it is unclear whether communication strategies shown to be effective in the laboratory will also be effective in the field.

Second, although laboratory experiments are excellent for estimating effect sizes with precision, they often do not speak to the scalability or feasibility of a strategy. Even though oppositional audiences can be exposed to and persuaded by a counter-attitudinal climate change message as respondents in a laboratory experiment, patterns of selective exposure and attention make it more difficult to reach such an audience with counter-attitudinal messages outside the laboratory. As such, laboratory experiments measure effects among only 'treated' individuals, whereas the treatment effect of an actual communication campaign may be substantially diluted by individuals in the target population who did not end up seeing or attending to the messages. This raises the importance of assessing the intent-to-treat effect in a field experimental setting, which captures the effect of treatment assignment or attempting to treat a group, regardless of whether every individual in the group is exposed to the message. Field experiments are uniquely suited to answer these questions, and we use this approach in the current study.

Accordingly, this field experiment used targeted advertisements to deploy persuasive messages about climate change in two congressional districts in the United States. The field experiment assessed the effects of a one-month advertising campaign on people's beliefs, worry and risk perceptions about global warming through surveys ($N = 1,600$) administered in the congressional districts to independent samples before and after the campaign.

The campaign content was a series of videos called New Climate Voices (<https://www.newclimatevoices.org>). The campaign design drew on several theory- and experiment-based guidelines for communicating about climate change. These include frameworks that emphasize the importance of social identity, in-group messengers and elite cues. Social identity theory states that "people derive a part of their self-concept from their social groups and categories they belong to—their social identity" (pages 8–9 in ref. ¹⁰). Further, theories of public opinion often emphasize the effect of elite cues¹¹,

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especially cues coming from credible messengers^{12,13} and members of one's own political party^{14,15}. Finally, theories of persuasion show that high-quality informational arguments are especially important for generating enduring persuasion^{13,16}.

The New Climate Voices campaign used this combination of insights to design messages to maximize the persuasive effects of the campaign. Professional videos were created to appeal specifically to Republicans by using spokespeople more likely to resonate with conservative values. For example, one video features a retired Air Force General, Ron Keys, who explains that climate change poses a national security threat and creates challenges for the US military. In another video, Dr Katharine Hayhoe, a climate scientist and evangelical Christian, speaks about the consistency between her faith and caring about climate change. In another, former US Representative (Republican–South Carolina) Bob Inglis describes how his conservative values motivate his drive for political action on climate change. The videos were iteratively improved based on dial-testing and feedback from small focus groups with Republican voters. Our Open Science Framework (OSF) project page (<https://osf.io/6emgj/>) includes a report of a preliminary lab experiment that investigated the effect of these videos and concluded that all of these messengers were viewed as credible and trustworthy (for a brief summary, see 'Treatment development' in the Supplementary Information).

Within two US congressional districts (Missouri-02 and Georgia-07), individual zip codes were randomly assigned into either the treatment or the control group. Respondents were recruited with the goal of balancing the treatment and control groups based on age, sex and political ideology. Analyses of the sample characteristics show that there were no significant differences between treatment and control groups with regard to age, sex, race/ethnicity, political party, political ideology, and whether respondents lived in an urban, suburban or rural geographic area (Supplementary Table 2).

Deployment of the treatment video ads was managed by Centro, an advertising software provider. Advertisements were deployed via Centro's proprietary media-buying software platform, Basis, to serve advertisements to respondents in the treatment group on Facebook, YouTube and across the open web with Centro's demand side platform, Basis DSP (for example, using videos and banner advertisements). Within treatment group zip codes, Centro used internal predictive models to target ads towards people who were politically conservative and those in the middle of the spectrum on climate change beliefs. Centro did not serve ads to people who were either already alarmed about climate change or are dismissive of the issue. These targeting criteria were used to maximize the chances of successful persuasion by engaging people who did not already feel strongly about the issue and by matching the treatment messengers and messages with Republican and conservative identities. People living in control zip codes were not shown any advertisements.

Throughout the one-month campaign period, advertisers aimed to show the advertisements to people in the target population (that is, within treatment zip codes) as many times as possible. Respondents in the treatment group were exposed to an average of seven videos during the campaign (7.1 times in Georgia-07 and 6.7 times in Missouri-02). Banner advertisements were used to complement the videos. Most of the treatment content (74%) was displayed through videos, including 17% via Facebook, 21% via YouTube and 37% via Basis DSP. The remaining 26% of messaging was experienced through banner display ads (Supplementary Table 1).

Treatment effects were calculated using ordinary least squares regression (see Methods for details). Figure 1 displays the campaign's treatment effects on each dependent measure for the full sample, which included people along the full spectrum of political party and ideology (see Supplementary Table 2 for sample characteristics and randomization checks). Overall, the campaign

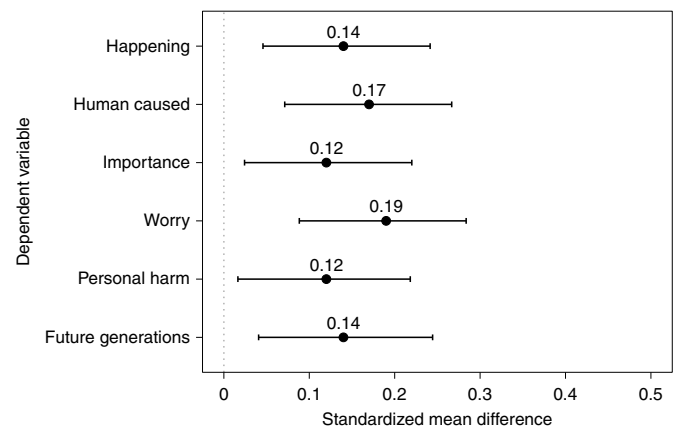


Fig. 1 | Average treatment effects on global warming beliefs, importance, worry and risk perceptions. Treatment effects were estimated using ordinary least squares. Error bars represent 95% CIs. $N=1,477-1,600$.

significantly increased the following: belief that global warming is happening (Cohen's $d=0.14$, $P=0.004$, 95% confidence interval (CI) (0.05, 0.24)) and human caused ($d=0.17$, $P<0.001$, 95% CI (0.07, 0.27)); personal importance of global warming ($d=0.12$, $P=0.015$, 95% CI (0.02, 0.22)); worry about global warming ($d=0.19$, $P<0.001$, 95% CI (0.09, 0.28)); risk perceptions of personal harm ($d=0.12$, $P=0.023$, 95% CI (0.02, 0.22)); and risk perceptions of harm to future generations ($d=0.14$, $P=0.006$, 95% CI (0.04, 0.24)). Maximum likelihood estimation was then used to create a factor-score index of the six items (Methods) and found a significant effect of the campaign on the index ($d=0.16$, $P=0.002$, 95% CI (0.06, 0.26)).

To provide an alternative, intuitive description of the effect sizes, we recoded the items to reflect whether respondents gave a 'positive' response on the response scale (for example, 'yes' global warming is happening or 'caused mostly by human activities'), and examined the percentage of respondents that fell into that positive category. This type of descriptive comparison shows how much the treatment changed the valence of the outcome variables (that is, negative or positive), as opposed to only affecting intensity (for example, changing from 'somewhat' to 'very' worried).

As shown in Fig. 2, for treatment condition zip codes, the campaign resulted in a 5-percentage-point increase in belief that global warming is happening, an 8-point increase in belief that global warming is 'caused mostly by human activities', a 10-point increase in respondents reporting that the issue of global warming is 'somewhat', 'very' or 'extremely' personally important, an 8-point increase in those who reported they are 'somewhat' or 'very' worried about global warming, a 5-point increase in people reporting that global warming will personally harm them 'a moderate amount' or 'a great deal', and an 8-point increase in people reporting that global warming will harm future generations 'a moderate amount' or 'a great deal'.

Next, to maximize measurement precision, a six-item factor-score index of global warming beliefs was constructed, including worry, issue importance and risk perceptions to estimate effect sizes separately by political party. The results indicate that the campaign had no effect on Democrats or Independents, but had substantial effects on Republicans and on people who reported they do not affiliate with a political party (Fig. 3). Z-tests demonstrate that the overall effect size was significantly larger for Republicans than for Democrats ($Z=2.33$, $P=0.020$) and Independents ($Z=2.41$, $P=0.016$).

Our findings indicate that nearly the entire effect of this campaign can be attributed to its persuasive effects among Republicans

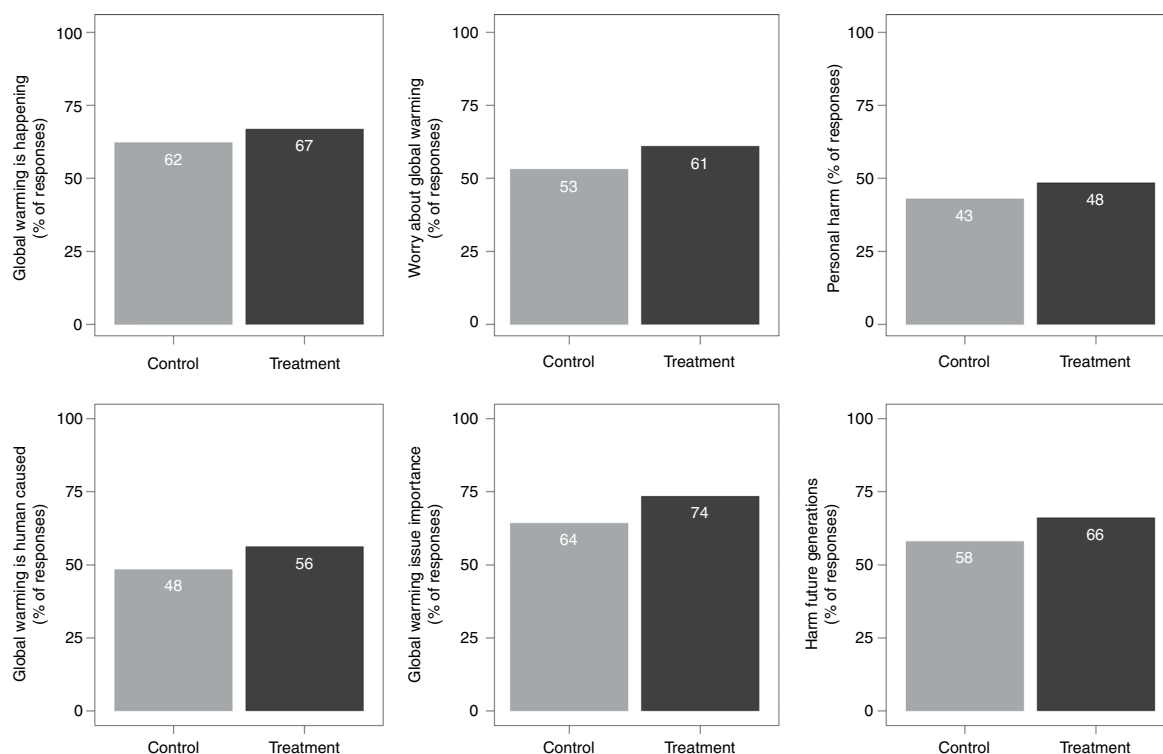


Fig. 2 | Descriptive differences between experimental groups on each dependent measure. To facilitate intuitive interpretations of the campaign treatment effects, items were dichotomized to reflect the percentage of ‘positive’ responses to the corresponding item: ‘yes’ global warming is happening; global warming is ‘caused mostly by human activities’; the issue of global warming is ‘somewhat’, ‘very’ or ‘extremely’ personally important; one is ‘somewhat’ or ‘very’ worried about global warming; global warming will personally harm oneself ‘a moderate amount’ or ‘a great deal’; and global warming will harm future generations ‘a moderate amount’ or ‘a great deal’. All positive response options listed above were coded as one, and all other responses (including ‘don’t know’) were coded as zero. $N = 1,600$.

and those who do not identify with a political party, which is probably due to the targeting of the ads (that is, who the ads reached). Thus, the difference in treatment effects between political groups is driven more by differential exposure than by differential persuasion.

Analysing the descriptive results by political party similarly indicates that the campaign successfully engaged Republicans (Fig. 4). Among Republicans, the campaign resulted in a 7-percentage-point increase in belief that global warming is happening, a 10-point increase in understanding that global warming is human caused, an 11-point increase in global warming issue importance, a 13-point increase in worry about global warming, a 12-point increase in perceptions of personal harm, and a 16-point increase in perceptions of harm to future generations. These values represent the intent-to-treat effect among all targeted Republicans, and therefore probably underestimates the effect among people in the targeted group who were actually exposed to the ads (~87% of the target population; for more detail, see ‘Advertising metrics’ in the Supplementary Information).

Large increases were also observed for people who did not affiliate with any political party (Fig. 4), but this estimate is relatively uncertain due to the small sample size of this group ($n_{\text{Other}} = 140$) relative to the other political groups included in our sample ($n_{\text{Democrat}} = 418$, $n_{\text{Independent}} = 502$, $n_{\text{Republican}} = 540$). Two plausible explanations for the large effect in this political group are that this group may have inadvertently received higher exposure to the ads, or that this group was highly persuadable because their beliefs and attitudes about global warming are relatively weak. Although these are plausible explanations, neither can be confirmed with the data from this study.

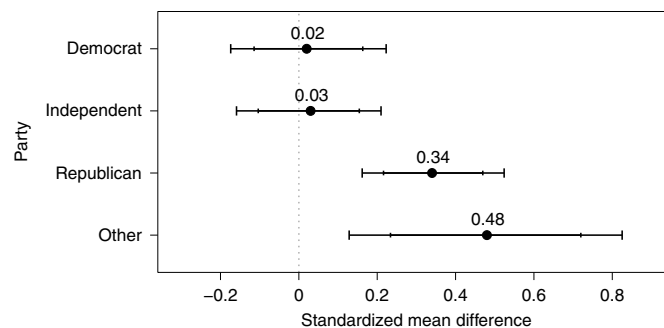


Fig. 3 | Average treatment effects on the global warming beliefs and risk perceptions index, by party. Treatment effects were estimated using ordinary least squares. Outer error bars represent 95% CIs. Inner error bars represent 83% CIs to facilitate visual comparisons of significant differences between groups²². $N = 1,432$ ($n_{\text{Democrat}} = 395$, $n_{\text{Independent}} = 456$, $n_{\text{Republican}} = 458$, $n_{\text{Other}} = 123$).

In this research design, it is important to rule out two threats to internal validity: that differences already existed between people in the treatment and control conditions; and that global warming beliefs and risk perceptions were already on the rise, regardless of the advertising campaign. The first threat was mitigated by the sampling procedure and randomization checks (Supplementary Table 2). To rule out the second threat, we tested for differences between pre- and post-campaign responses on all dependent variables within treatment and control zip codes. To convincingly rule out alternative explanations for the difference between the treatment and

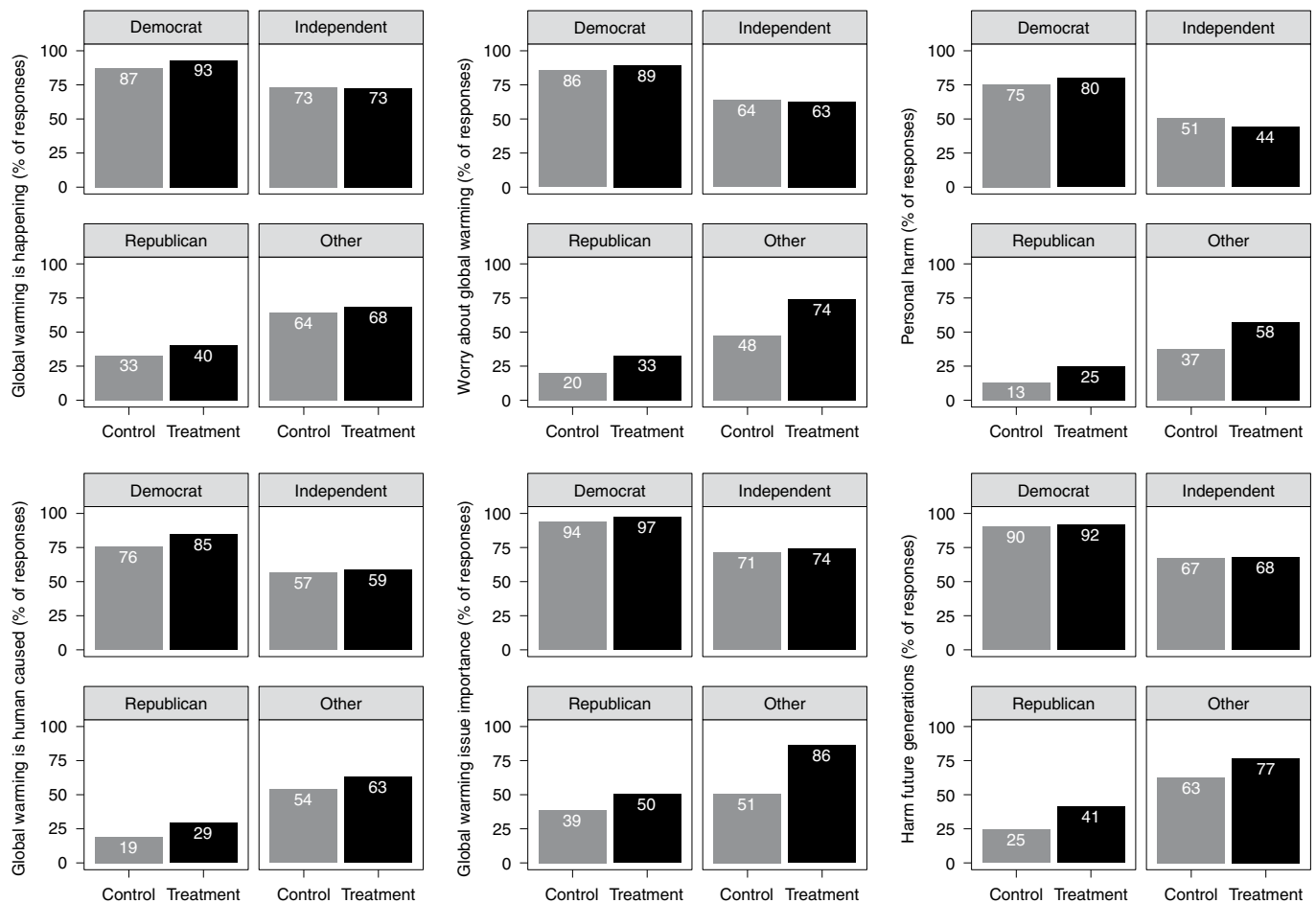


Fig. 4 | Descriptive differences between experimental groups on each dependent measure, by party. Results are reported according to self-reported political party. To facilitate intuitive interpretations of the campaign treatment effects, items were dichotomized to reflect the percentage of ‘positive’ responses to the corresponding item: ‘yes’ global warming is happening; global warming is ‘caused mostly by human activities’; the issue of global warming is ‘somewhat’, ‘very’ or ‘extremely’ personally important; one is ‘somewhat’ or ‘very’ worried about global warming; global warming will personally harm oneself ‘a moderate amount’ or ‘a great deal’; and global warming will harm future generations ‘a moderate amount’ or ‘a great deal’. All positive response options listed above were coded as one, and all other responses (including ‘don’t know’) were coded as zero. $N=1,600$ ($n_{\text{Democrat}}=418$, $n_{\text{Independent}}=502$, $n_{\text{Republican}}=540$, $n_{\text{Other}}=140$).

control groups, there should be no difference over the campaign period within control zip codes, whereas there should be increases only in the treatment zip codes. Extended Data Fig. 1 shows that, over the campaign period, there was virtually no change in responses on any of the dependent variables in the control zip codes, but there were significant increases in responses on all dependent variables in the treatment zip codes—closely mirroring the treatment versus control comparisons reported above. This constitutes strong evidence for the interpretation that the treatment (the campaign) caused the observed significant shifts in the dependent variables in the treatment group zip codes. Additionally, treatment effects were similar across the two congressional districts in our sample, lending some confidence to the idea that treatment effects are unlikely to vary substantially depending on geographic location (Extended Data Fig. 2).

Overall, these findings demonstrate that targeted advertising can be highly effective in increasing: people’s beliefs that global warming is happening and human caused, worry about global warming, personal importance of the issue, and risk perceptions that global warming will harm oneself and future generations. In particular, this digital advertising campaign successfully shifted the beliefs and attitudes of Republicans in two congressional districts. These

findings indicate that the persuasive effects of strategic climate change communication are not limited to artificial laboratory settings, but rather can be achieved in a highly scalable field setting via online advertising.

The magnitude of the treatment effects is also worth noting. For example, polling data show that the percentage of registered voters in the United States who say they are ‘somewhat’ or ‘very’ worried about global warming has increased by 16 percentage points in the past 10 years, with an increase of only 6 points among Republicans⁴. This context highlights the practical significance of this campaign, which increased worry by 8 points in the full sample and by 13 points among Republicans.

In addition, there are theoretical insights from this field experiment. Importantly, this study provides real-world support for the effectiveness of messaging strategies identified by previous theory and laboratory experiments (for example, utilizing in-group messengers and appealing to social identity and shared values)^{10,12}.

The results, however, should be interpreted with caution. First, this field experiment was conducted in only two congressional districts in the United States, and it is unclear how much results might vary depending on geographic location or cultural context. Previous research in the United States suggests that there might be

effect-size variability depending on location. But those are probably differences in the magnitude of the effects rather than in sign or in their presence or absence¹⁷. Ultimately, the extent to which the current findings can be generalized to other locations and cultural contexts is an empirical question for further research¹⁸. An additional caveat is that similar communication campaigns might have different effects in a more competitive context (for example, with competing campaign efforts)¹⁹, or when the dependent measure is a behaviour (for example, voting)²⁰. Influencing beliefs and attitudes may be a comparatively easy first step that does not necessarily lead to behaviour change.

An additional caveat is that, because the overall campaign deployed multiple advertisements, we cannot determine from this study whether some advertisements were more persuasive than others. Further, we were not able to measure attitude/opinion change at an individual level. A within-subjects design would have afforded more precision by measuring the persuasive change within each person in pre- and post-campaign measurements. However, an advantage of the present design is participant naïveté—that is, participants in the treatment condition saw the ads without prior awareness of the study and with no priming about the topic of climate change.

Further, it is unclear how long the observed treatment effects lasted after the campaign ended. Although the durability of the treatment effects is unknown for this field experiment, research suggests that persuasion effects are most likely to last when they are informational—introducing new considerations instead of merely increasing the salience of existing ones¹⁶. The current campaign emphasized the importance of using credible, in-group messengers, but all treatments included important informational content, giving us some confidence that the observed treatment effects were not fleeting. Additionally, research shows that approximately half the magnitude of these kinds of treatment effects persists over time, with the other half of the treatment effect probably decaying after about 10 days^{16,21}. Ultimately, however, it is important to extend the current work by testing this empirically.

Lastly, it is difficult to assess whether or how the timing of this ad campaign affected the results. For a few days during the month-long ad campaign, there was a large spike in news about fires in the Amazon rainforest, and mainstream news outlets occasionally emphasized their connections to climate change. Although this would have affected both the treatment and the control group, it is possible that this news interacted with the treatment to produce the observed effects. Ultimately, the influences of context and simultaneous events on our results are unknowable with the current data in hand, and constitute an important area for future research.

Despite these constraints, the results demonstrate strong promise for the use of targeted video advertisements as a method of shifting public opinion on climate change. Belief and concern about climate change have increased relatively less for Republicans than for Democrats in recent years. Thus, it is particularly important to develop scalable communication strategies to engage Republicans on climate change. This study shows that targeted advertisements using trusted messengers with consonant worldviews can have strong positive effects on Republicans' views about climate change.

Online content

Any methods, additional references, Nature Research reporting summaries, source data, extended data, supplementary information,

acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at <https://doi.org/10.1038/s41558-021-01070-1>.

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Methods

Sample and design. All measures, data and analysis code are available on our OSF project page at <https://osf.io/6emgj/>. This study involves the analysis of secondary, de-identified data collected by a partner organization, and is therefore exempt from review by the Yale University Institutional Review Board. Using a voter file, a partner organization randomly selected respondents to recruit from two US congressional districts, Missouri-02 and Georgia-07. These districts were chosen because they included a similar proportion of Democrats and Republicans (that is, ‘purple’ districts), and because they were demographically different from one another. Testing the intervention on substantively different samples increases the evidentiary value of the overall study²³.

Recruitment was conducted using three different methods: interactive voice response (IVR) to recruit people via landlines, text messages to recruit people via their cell phones, and an online survey panel. Although there was no reason to believe that treatment effects would differ by recruitment mode, using three different recruitment methods helps diversify potential biases from any individual method.

Zip codes were randomly assigned to either the treatment or the control group, that is, all respondents within a zip code were assigned to the same condition. This allowed the advertising campaign to target only the treatment group zip codes with the video ads, while not deploying the video ads to the control group zip codes. Recruitment was executed with the goal of making treatment and control group respondents as similar as possible based on age, sex and political ideology (Supplementary Table 2). Quotas were set to ensure that treatment and control samples were balanced on these variables. These variables were chosen because they (1) are known to predict beliefs and attitudes about climate change^{24,25}, (2) were available and appended to the voter file, and (3) are variables for which it was practically feasible to set and monitor quotas. When more respondents were needed for a particular bin (for example, people in the 65+ age bracket), respondents were randomly sampled from the voter file until someone from the chosen bin could be recruited.

The advertising campaign included video and banner advertisements that ran for one month (19 July to 20 August 2019). Centro, an advertising software provider, ran and managed the advertisements. Centro’s team ran advertisements using their proprietary media-buying software platform, Basis, to serve advertisements in real time to people in the target population within the treatment condition on Facebook, YouTube and across the web with Basis DSP, Centro’s demand side platform. Centro used platform usage levels to ensure targeted respondents would be highly likely to see the advertisements (see ‘Platform penetration’ in the Supplementary Information). Respondent exposure to the advertisements was maximized by monitoring media performance metrics (that is, video completion rate and cost per completed video displayed) and adjusting the campaign as needed (for example, spending more on the methods showing better performance). Performance of the advertisements was known only on the group level and not on the individual level. That is, it was possible to assess the average number of videos displayed to people in the treatment group, but not the number of times a given individual was exposed to a video.

To gauge the effects of the campaign, independent samples of respondents were surveyed before and after the treatment campaign in each of the treatment and control zip codes (total $N=3,200$; $n_{\text{pre-campaign}}=1,600$; $n_{\text{post-campaign}}=1,600$). Treatment effects were evaluated by comparing post-campaign global warming beliefs, worry and risk perceptions ($n_{\text{treatment}}=800$, $n_{\text{control}}=800$). The pre-campaign samples made it possible to rule out potential confounding effects of time and space. That is, comparing pre- versus post-campaign respondents within treatment and control groups can determine whether increases in global warming beliefs, worry and risk perceptions only occur in treatment zip codes and not in control zip codes. This would rule out alternative explanations for the observed effect (for example, that the dependent measures were already on the rise, or that respondents in the treatment zip codes were already higher on the dependent measures). The results confirmed that there was no difference between pre- and post-campaign results in the control group, and treatment effects were nearly identical to those reported in the results section above when comparing pre- versus post-campaign data within the treatment group (Extended Data Fig. 1).

Measures. To measure people’s beliefs about whether global warming is happening, respondents were given a descriptive prompt introducing the topic of global warming (for example, see ref. ³) and then asked “Do you think that global warming is happening?” (1, no; 2, don’t know; 3, yes). Beliefs about whether global warming is caused by humans or not was measured by asking “Assuming global warming is happening, do you think it is...”, with the response options: none of the above because global warming is not happening; caused mostly by natural changes in the environment; and caused mostly by human activities. Issue importance was measured with the question “How important is the issue of global warming to you personally?” (1, not at all important; 5, extremely important). To measure worry about global warming, we asked respondents “How worried are you about global warming?” (1, not at all worried; 4, very worried). Global warming risk perceptions were measured with two items with the same question stem: “How much do you think global warming will harm” (you personally; future generations of people) (1, not at all; 4, a great deal; don’t know responses were coded as missing for regression analyses reported in the main text, $n_{\text{Personal harm}}=93$, $n_{\text{Future generations}}=123$).

Our OSF project page includes comparisons between results when analyses employed listwise deletion versus multiple imputation. Results were substantively the same regardless of the method used. For demographic, political and other sample-descriptive questions asked in the survey, see our OSF project page at <https://osf.io/6emgj/>.

Beliefs and risk perceptions index. To reduce measurement error, and therefore increase the precision of our measure of belief differences²⁶, we created an index that included all six global warming items. An exploratory factor analysis using maximum likelihood estimation supported this decision. All items had high loadings on a single factor (all >0.74), and the factor explained 75% of the variance in the six items. Thus, we created a regression-based factor score and used this as an index representing global warming beliefs and risk perceptions. To facilitate interpretation as a standardized effect size, the index was rescaled to have a mean of zero and a standard deviation of one.

Analytic strategy. Treatment effects were assessed using ordinary least squares regression models, with each dependent variable and the dependent variable index regressed on the experimental condition variable. All tests were two-tailed. Available data from our partner organization did not include zip codes that were matched to individual respondents. This made it impossible to use multilevel modelling to assess how much treatment effects varied based on a respondent’s zip code, or how much geographic location accounted for the similarity of respondents in the same zip code. Although this is a drawback, analyses split by congressional district exhibit strong consistency in the size of the treatment effects, which lends some confidence to the claim that treatment effects are unlikely to vary drastically based on geographic location (Extended Data Fig. 2). We make the non-interference assumption that any individual’s status (that is, being in the treatment or control group) does not affect whether another respondent is treated (pages 39–45 in ref. ²⁷). Although it was possible that treatment respondents shared information from the advertisements with control respondents through screenshots or conversation, potentially violating the non-interference assumption, the study design, sampling strategy, and the inability to digitally capture and share the advertisements made this highly unlikely.

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

All data used in this article are available on our OSF project page at <https://osf.io/6emgj/>.

Code availability

All code used to analyse data and create figures for this article is available on our OSF project page at <https://osf.io/6emgj/>.

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Author contributions

All authors consulted with the partner organizations throughout the development of the study. M.H.G. collected all necessary documents and data from corresponding partner organizations, and conducted the statistical analyses. M.H.G. and A.G. wrote the first draft of the manuscript. M.H.G., A.G., S.A.R. and A.L. interpreted the results and revised the manuscript.

Competing interests

The authors declare no competing interests.

Additional information

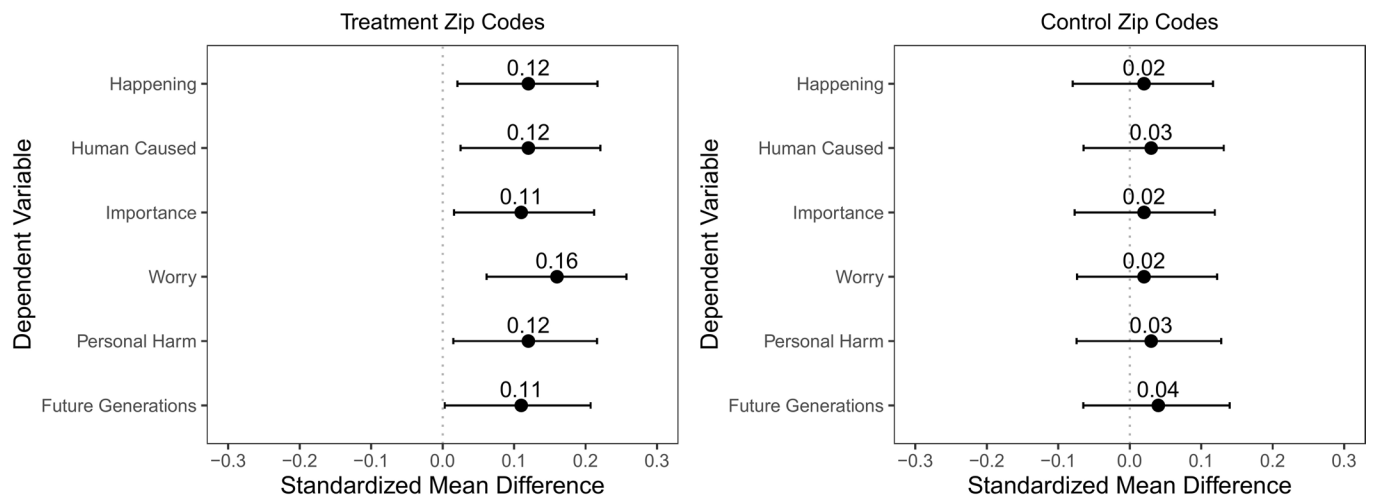
Extended data is available for this paper at <https://doi.org/10.1038/s41558-021-01070-1>.

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1038/s41558-021-01070-1>.

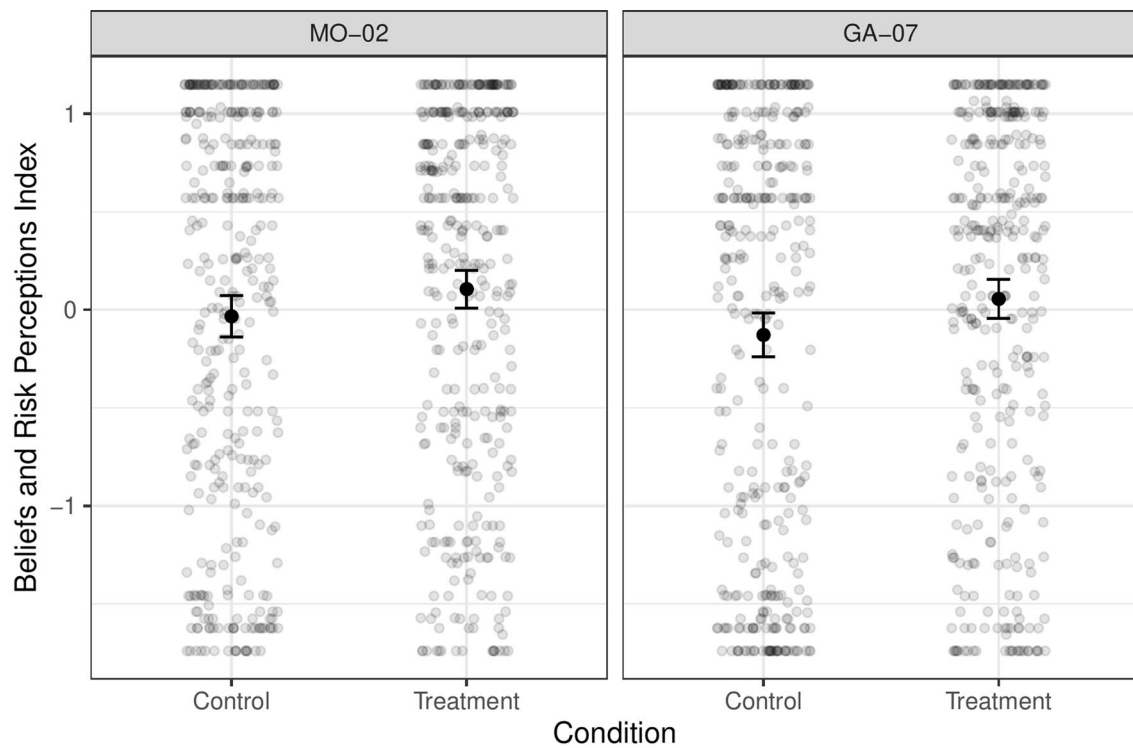
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Extended Data Fig. 1 | Pre- versus post-campaign comparisons within treatment and control group zip codes. A threat to internal validity is that pro-climate opinion could have already been increasing regardless of the campaign. This could create apparent treatment effects that were instead driven by asymmetric changes in public opinion in the direction of the intended treatment. To rule out this explanation, we tested for differences on all dependent variables on independent samples *within* treatment and control zip codes. This figure shows that there were only significant positive changes in beliefs, worry, and risk perceptions among people in treatment zip codes (left panel), and virtually no changes among people in control zip codes (right panel). Error bars represent 95% confidence intervals.



Extended Data Fig. 2 | Treatment effects in each congressional district. To examine whether the overall treatment effects varied depending on geographic location, we examined treatment effects on the beliefs and risk perceptions index separately for each of the two congressional districts. Results show that the overall treatment effect was very similar across the two districts. Error bars represent 95% confidence intervals. Gray points represent predicted individual respondent scores on the dependent measure. A small horizontal jitter was applied to aid visibility of predicted individual points. MO-02 = Missouri congressional district 02; GA-07 = Georgia congressional district 07.

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Software and code

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Data collection

Qualtrics was used to collect and store the survey data. Centro, an advertising software provider, ran and managed the advertisements. Centro's team ran advertisements using their proprietary media buying software platform Basis, to serve advertisements in real time to people in the treatment condition on Facebook, YouTube, and across the web with Basis DSP (i.e., Centro's demand side platform).

Data analysis

All analysis code is available on our Open Science Framework project page at <https://osf.io/6emgj/>. Analyses were conducted using R.

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Behavioural & social sciences study design

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Study description	This is a quantitative study that examines the persuasion effects of an advertising campaign aimed at engaging Republicans with the issue of climate change.
Research sample	Respondents were residents from one of two congressional districts (Missouri-02 and Georgia-07).
Sampling strategy	Recruitment was conducted using three different methods: interactive voice response (IVR) to recruit people via landlines, text messages to recruit people via their cell phone, and an online survey panel. Recruitment was executed by a partner organization. Given the independent samples compared in the study, with 800 respondents in each condition, we had 80% power to detect $d = .14$ at $p < .05$.
Data collection	Data were entered and stored on the Qualtrics survey platform. Centro, an advertising software provider, ran and managed the advertisements, and collected relevant metrics. Centro's team ran advertisements using their proprietary media buying software platform Basis, to serve advertisements in real time to people in the treatment condition on Facebook, YouTube, and across the web with Basis DSP (i.e., Centro's demand side platform).
Timing	Data were collected one week before and one week after the time span of the campaign, which ran from July 19, 2019 to August 20, 2019
Data exclusions	Most analyses did not include any missing data. For two items, "don't know" responses were coded as missing ($n = 93$ for the personal harm item and $n = 123$ for the future generations item) and therefore such cases were not included when analyses involved those items. Because the data had already been collected by a partner organization, we could not specify these decision rules in advance of data collection. To test for robustness of the results depending on how missing data were handled, we ran the analyses employing listwise deletion and ran the analyses again using multiple imputation. Results were substantively the same regardless of the method used to handle the missing data. Results using listwise deletion are reported in the main text.
Non-participation	The study included independent samples of respondents so, by design, there was no possibility of selective attrition or participation in only one part of the study. We obtained the data from a partner organization, which only included complete cases.
Randomization	In the chosen congressional districts, zip codes were randomly assigned to either the treatment or control group. All respondents within a zip code were assigned to the same condition. This allowed the advertising campaign to target only the treatment group zip codes with the video advertisements, while not deploying the video ads to the control group zip codes. Recruitment was executed with the goal of making treatment and control group respondents as similar as possible based on age, sex, and political ideology.

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Population characteristics

See above.

Recruitment

Recruitment was conducted using three different methods: interactive voice response (IVR) to recruit people via calling landline phones, text messages to recruit people via their cell phone, and an online survey panel.

Ethics oversight

This study involves the analysis of secondary, de-identified data collected by a partner organization, and is therefore exempt from review by the Yale University Institutional Review Board.

Note that full information on the approval of the study protocol must also be provided in the manuscript.