Climatic Change (2025) 178:100
https://doi.org/10.1007/s10584-025-03941-4

Environmental actions, support for policy, and information's provision: experimental evidence from the US

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Received: 28 October 2024 / Accepted: 19 April 2025

Abstract
We investigate the effectiveness of providing prospective versus retrospective information on local climate change to promote pro-environmental behavior and support for green policies. A randomized experiment on a representative sample of American adults finds that providing prospective local climate change information is most effective at increasing pro-environmental actions and policy support, regardless of partisanship. The impact of this information provision increases when individuals feel responsible for addressing climate change, have young children, and trust the central government. Prospective information on local climate change can thus contribute to promoting the vast support for the necessary actions to address the climate crisis.

Keywords Pro-environmental actions · Support for climate policy · Prospective climate change information · Online randomized experiment

JEL Q54 · D84 · C93

1 Introduction

The most recent 2021 Report of the Intergovernmental Panel on Climate Change (IPCC) highlights the urgency to act to prevent climate breakdown. More than ninety-nine percent of scientists agree that climate change is caused by human activities (Lynas et al. 2021), and an extensive literature has documented the negative impact of both year-to-year (e.g. Carleton et al. 2018) and long-run temperature changes (Waldinger 2022). Well within the next two decades, temperatures are likely to rise by more than 1.5 degree Celsius above pre-industrial levels, breaching the target of the 2015 Paris climate agreement and setting the

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Published online: 08 May 2025

stage for extreme climatic events and increasing devastation. Only rapid and drastic reductions in greenhouse gases in this decade can prevent the worst of this climate breakdown.

In April 2024, the Executive Secretary of the United Nations Framework Convention on Climate Change calls upon both private and public institutions for immediate policy action and upon every citizen for speaking louder and taking actions to tackle climate change.[1] Despite this call to act, public opinion concern about the urgency to tackle climate change varies. In Europe, for example, there is less concern in cooler countries compared to warmer ones (Nowakowski and Oswald 2020). In the United States (US), which is the second biggest carbon polluter in the world and is responsible for about fourteen percent of CO2 global emissions,[2] perceptions of the seriousness of climate change are mainly driven by partisanship and political ideology (Egan and Mullin 2017), even after controlling for individuals' direct experiences with local, long-term climate change (Binelli et al. 2023).

The divisions that characterize the public opinion debate on the urgency to tackle climate change significantly decrease when it comes to individual actions and policy support. Growing evidence suggests that pro-environmental behaviors and support for climate policy are much more aligned and significantly less partisan (Dechezleprêtre et al. 2022; Mildenberger et al. 2019; Binelli et al. 2023; Mayer and Smith 2023). Acting on pro-environmental behavior and policy support may thus be key to addressing climate change.

In this paper, we focus on the US and investigate how to promote pro-environmental behavior and support for green policies by assessing the relative effectiveness of providing prospective or rather retrospective information on the local impact of climate change, and the mechanisms that can explain this effectiveness. Various modes of climate change information's provision have been studied (Bruine de Bruin et al. 2021; Dechezleprêtre et al. 2022) and several studies have stressed the importance of using simple language (Bruine de Bruin et al. 2021) and information on local rather than global climate change (Bruine de Bruin and Dugan 2022; Taylor et al. 2014). On the contrary, to the best of our knowledge, there has been no investigation into the effectiveness of providing prospective or rather retrospective information on climate change.

Typically, most climate change information is retrospective, using historical data on past climate or weather events measured at different levels of aggregation. However, a vast literature has shown that expectations about the future rather than information about the past drive several different types of individuals' choices and behaviors (Manski 2017, 2004). One explanation for the relevance of future rather than past information as a factor that affects current choices is the trade-off between short-term and long-term costs and benefits (Van Lange and Joireman 2008) that characterize many choices. Pro-environmental behavior is an example of such choices since it tends to be costly for the present but beneficial in the future. Therefore, when individuals consider the future beyond the present, they can accept constraints and make efforts to achieve future benefits. Consistently, Strathman et al. (1994) argue that a future time perspective is a key determinant of a more sustainable behavior. More recently, Binelli et al. (2023) find that providing prospective information on future climate change impacts pro-environmental individual actions and support for policy across party lines, and Collet et al. (2023) find that considerations for future consequences positively affect the preferences for a reduction of CO2 emissions.

[1] https://www.youtube.com/watch?v=fJr8NZ7F0MQ

[2] https://climatetrade.com/which-countries-are-the-worlds-biggest-carbon-polluters/

To the best of our knowledge, no previous study has directly tested the effectiveness of providing perspective or rather retrospective information on local climate change by contrasting these two modes of information's provision in one single study. To do this, and to detect potential mechanisms of transmission, we designed an original survey instrument and conducted a randomized online experiment with a large representative sample (N = 2,621) of American residents. We use in-survey information treatments to provide respondents with a concrete description of local climate change by presenting aggregate measures of the long-run past and future changes in temperature and precipitation in the city of residence through an interactive map that delivers information in a simple and direct way. We find that, regardless of partisanship, providing prospective information on the future changes in precipitation and temperature in the city of residence is the most effective instrument to promote individuals' pro-environmental actions and support for climate policy. The size of the positive impact of the prospective information provision increases if respondents have young children and a high degree of trust in the central government, and, for support for green policies, if respondents assign the responsibility for taking action to address climate change to individuals rather than to governments and corporations. These findings indicate that the provision of prospective information on local climate change can provide a means to circumvent the seemingly intractable public opinion divide on taking measures to address the climate crisis.

1.1 Related literature

Several papers have studied the determinants of individuals' pro-environmental actions and support for green policies. For pro-environmental actions, Kollmuss and Agyeman (2002) examine the previous literature and identify the three main categories of influences on pro-environmental behavior: demographic factors, external factors (e.g.: institutional, economic, social, and cultural) and internal factors (e.g.: motivation, pro-environmental knowledge, awareness, values, attitudes, emotion, locus of control, responsibilities, and priorities). Li et al. (2019) also find that demographic variables, and internal factors (identity and psychological factors) are key determinants of pro-environmental actions when these actions are measured by resources' conservation and recycling over the past several decades.

Heinz and Koessler (2021) focus on the social science experiments' literature on promoting pro-environmental behavior by using interventions addressing other-regarding preferences that attach value to the well-being of others. They find that addressing other-regarding preferences is an effective way to increase pro-environmental behavior, and that effectiveness depends on activating regard for others, raising awareness about adverse consequences, evoking empathic concern, and expanding the moral circle. Consistently, Lades et al. (2021) find that, among economic preferences, altruism is most significantly and positively associated with pro-environmental behavior, and Scholler and Ulmer (2023) find that information on the social costs of carbon emissions leads to the largest carbon reduction by consumers with respect to information on carbon kilograms or abatement costs.

For the US, despite the complexity of assessing the impact of many different factors, the most recent research has keyed in on the crucial discovery that, differently from perceptions of climate change, partisanship has little impact both on pro-environmental actions and on support for policy. For example, Mildenberger et al. (2019) find that in the US households with solar installations are slightly more likely to be Democratic than Republican, but

households with solar installations exist across the political spectrum, despite extreme ideological polarization around the anthropogenic nature of climate change. They also find that solar households are more politically active, and that differences in political participation are more substantial than cross-group differences in partisanship (*ibid.* and also Guilbeault et al. 2018).

On support for green policies, Drews et al. (2016) provide a comprehensive summary of the various determinants in empirical and experimental research and draw attention to the importance of perceptions about climate change, climate policy design and its attributes. In a recent study on Italy, Colantone et al. (2024) find that the implementation of green policies and public support depend on the redistributive consequences that the policies have on different groups. For the US, Shwom et al. (2010) use detailed data from Michigan and Virginia to analyze the reasons given by the public for supporting or rejecting several policies to reduce greenhouse gases. They show that a complex combination of economic, political, technological, and moral rationales drives people to support or reject a specific policy. Fang and Innocenti (2023) study how social norms and economic reasoning jointly shape public views towards carbon taxation, and find that video interventions that correct misperceived norms about climate action and/or explain the policy lead to an initial boost in support that fades away after several months and does not increase environmental donations.

In a recent review of the literature on the economic impacts of disasters caused by extreme weather and climate events, Ferreira (2024) discusses how governments can play an important role in adaptation by providing public goods to manage disaster risks or by facilitating private agents' adaptation responses. Using new surveys conducted in twenty countries, Dechezleprêtre et al. (2022) find that support for climate policies is driven by the perception of the effectiveness of the policies in reducing emissions, in addition to their distributional impacts and their impact on respondents' own households.[3] Again, as it was the case for pro-environmental actions, common among this literature on support for green policies is the growing and crucial evidence that partisanship has little impact (Mayer and Smith 2023).

At the same time, one consistent and relevant driver of both support for green policy and individual actions is the provision of climate change information. Previous research has shown that both the use of simple and concrete language (Bruine de Bruin et al. 2021) and reference to the local impact of climate change (Bruine de Bruin and Dugan 2022; Taylor et al. 2014) are crucial for an effective communication strategy. In addition, recent evidence shows that providing prospective information on future climate change impacts pro-environmental individual actions, once again, across party lines (Binelli et al. 2023).

Therefore, our work is related to the literature on information's provision, and to the extensive literature that has shown how expectations about the future are significant determinants of individual attitudes and behaviors.[4] Following the influential work of Charles Manski that proposed to measure expectations about the future using quantitative probability questions that allow for the inter-personal comparability of the provided answers, an

[3] However, Rinscheid et al. (2020) find that climate policy support is unaffected by norm messages communicating an increased diffusion of pro-environmental behaviors and that norm messages communicating the prevalence of non-sustainable behaviors decrease policy support. They also find that in the presence of policy endorsements by political parties, citizens' trust in these parties influences support for climate policies.

[4] The provision of prospective and retrospective climate information could also differently affect behavior since survey respondents react to questions' format and wording used to elicit beliefs in anthropogenic climate change (Motta et al. 2019).

extensive body of work has established that future expectations significantly affect behavior in different settings and countries (Manski 2017, 2004, and Delavande et al. 2011 provide comprehensive literature reviews).[5] The foremost conclusion of this literature is that what people expect to happen in the future shapes their current choices and behaviors. In the specific case of climate change, to the best of our knowledge, Binelli et al. (2023) is the only paper that has tested the impact of providing future information and find that providing information on expected climate change in the city of residence positively impacts pro-environmental individual actions regardless of partisanship. The size of the impact of information's provision on individuals' actions is double for Democrats, but it is also positive and sizable for Republicans.

The relevance of the provision of future information has also been discussed in Psychology and Social Psychology. As argued by Van Lange and Joireman (2008), the impact of future information on current choices lies in the trade-off between short-term and long-term costs and benefits. Pro-environmental behavior tends to be costly for the present but beneficial in the future. Therefore, when individuals consider the future beyond the present, they can accept constraints and make effort to achieve future benefits. Consistently, Collet et al. (2023) find that considerations for future consequences positively affect the preferences for a reduction of CO2 emissions. Their results confirm that having a future time perspective is a key determinant of a more sustainable behavior (Strathman et al. 1994).

2 Methods

2.1 Design of the experiment

To confront these questions, we designed and fielded an online survey experiment which was programmed in Qualtrics and used individuals recruited from the online sample firm Lucid.[6] Lucid provides a pool of respondents that is balanced across demographics such as gender, race/ethnicity, age, region of residence, and partisanship to reflect the demographic profile of the US adult population. Coppock and McClellan (2019) find that Lucid samples respond similarly to experimental treatment effects compared to those from other sample providers such as MTurk and even the General Social Survey.

Importantly, in addition to individuals' demographics, Lucid also provides information on party identification allowing us to avoid prompting respondents on partisanship. Rather, we include in the survey a series of questions to capture traits and attitudes that are typically associated with perceptions of climate change (Egan and Mullin 2017). These include a question on religiosity, a question on world views related to social relationships (whether everyone should have equal opportunities), a measure of social trust, a measure of support for egalitarianism, a scale that captures the extent to which respondents assign responsibility for taking action against climate change to individuals, corporations, or governments, a measure of trust in the national (central) government, a measure of confidence in the

[5] Future expectations have been mainly used in empirical studies conducted in the field of Statistics and Economics. However, this type of data is also becoming more common in other fields. Loveless and Binelli (2020), Delavande and Manski (2015), and Ladner and Wlezien (2007) are three examples demonstrating the substantive power of future subjective expectations in Political Science.

[6] This experiment was ruled exempt by the Tufts University Institutional Review Board (STUDY00000381).

ability to participate in politics, and a measure of interest in government and public affairs. Finally, the survey includes a question on political ideology, which together with partisanship allows to fully control for respondents' political identity but is placed at the very end of the survey so that respondents are not prompted on political ideology while completing the survey. Section 1 of the online Appendix provides full details on all the variables used in the empirical analysis.

Our subjects' pool includes 2,621 individuals who completed the survey, passed an attention check item, and gave consistent demographic information (age and gender) on our questionnaire compared to what they had provided to Lucid.

Subjects began the survey by answering a series of demographic and attitudinal questions before being randomized into one of four conditions. Subjects in the prospective local climate information condition (N = 596, heretofore referred to as the *prospective condition*) saw an interactive map and were asked to select the city they live in (or live closest to). The map then showed them the place in the US that their city's climate would most closely resemble in 60 years, as well as information on how the temperature and precipitation would change. So, for example, if a respondent selected Indianapolis, IN, the map would indicate that in 60 years the climate of Indianapolis would most resemble Jonesboro, AR which is 11.3 degrees (F) warmer and 52.5% wetter in winter.[7] Among subjects assigned to this condition, the median amount of time spent on this task was 90 s.

Subjects in the retrospective local climate information condition (N = 669, heretofore referred to as the *retrospective condition*) saw an equivalent interactive map and were also asked to locate their city on the map, but this map then showed respondents information about how their climate had changed during the previous 60 years. So, for example, respondents selecting Indianapolis, IN would see a message indicating that "Winter has become 2.8°F (1.6 °C) warmer and 17.1% wetter. Summer has become 0.6°F (0.3 °C) warmer and 7.8% wetter." The difference in retrospective and prospective levels of change – in this case, for Indianapolis, IN– further highlight the exponential change in climate. For those assigned to this condition, the median time spent on this task was 81 s. Section 4 of the online Appendix provides full details on the construction of the retrospective and the prospective information treatments.

In a third condition, respondents were not assigned to see information about their local climate but instead were primed to think about partisan politics (N = 686). In this *party labels condition*, subjects were shown images of the Democratic and Republican Party's mascots (a donkey and elephant, respectively) and were asked to identify which mascot was associated with which party. This party labels' treatment is modeled after Guilbeault et al. (2018) who show that party logos are highly effective at priming partisan bias based both on party membership and on political ideology. People finished this task much more quickly, with the median time spent on the page at 14 s.

Finally, subjects assigned to the control group (N = 670) did not see any task and instead moved directly to the section of the survey that includes the questions on the dependent variables of our analysis.

We consider three dependent variables. The first variable is a scale constructed from a set of items that gauge each respondent's support or opposition for seven climate-related policies. The policies are listed here:

[7] The interactive map can be viewed here: https://fitzlab.shinyapps.io/cityapp/

1) Require that 50% of all vehicles sold in the U.S. by 2030 be electric.
2) Require that each State use a minimum amount of renewable fuels (wind, solar, and hydroelectric) in the generation of electricity even if electricity prices increase.
3) Repeal the Clean Power Plant Rules, which calls for power plants to cut greenhouse gas emissions by 32 percent by 2030.
4) Withdraw the United States from the Paris Climate Agreement.
5) Increase taxes on fossil fuels.
6) Increase government subsidies for renewable energy such as solar and wind.
7) Ban the sale of household appliances that do not meet energy efficiency standards.

Respondents could indicate that they either supported or opposed each policy. The pro-climate position would be to support items 1, 2, 5, 6, and 7 and to oppose items 3 and 4. These items were combined into a single scale using an Item Response Theory (IRT) two-parameter logistic model. This approach created a single latent variable with a mean of 0 and standard deviation of 1, which we then re-scaled to range from 0 to 1, with higher values representing more support for policies that address climate change.

The second dependent variable captures the extent to which respondents indicate a willingness to take personal actions to address climate change. Respondents were asked about seven actions and could indicate that they had already taken the action, that they were planning to take the action, or that they were not planning to take that action. The individual actions are as follows:

1) Install solar panels at your home.
2) Purchase a hybrid or electric car.
3) Recycle on a daily or weekly basis.
4) Take steps to increase your home's energy efficiency.
5) Purchase carbon offsets to make up for the carbon you consume.
6) Reduce your weekly amount of meat consumption.
7) Take fewer trips by plane.

Responses were re-coded so that each item was coded as a 1 if the respondent had taken or was planning to take that action and 0 if they were not planning on taking the action. We then combined the items in a similar way as described above, using an IRT two-parameter logistic model and then re-scaling the variable so that values on the scale closer to 1 indicated respondents who were taking more climate friendly actions and those near 0 indicated individuals who were not taking climate friendly actions. Section 2 of the online Appendix provides full details on how we constructed the individual actions and policy support scales from multiple items.

We also collected information on an item that measures both belief in climate change and support for taking action, which reproduces the identical question that was asked in previous versions of the Cooperative Congressional Election Study (CCES). We use this question to construct a third dependent variable to assess the effectiveness of the information treatments on affecting perceptions, in addition to individual actions and policy support.

The question reads as follows:

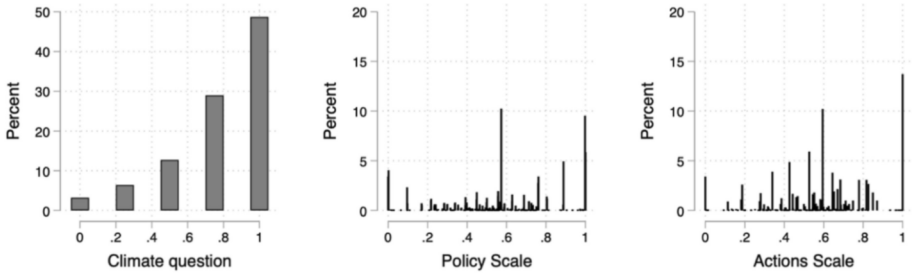
From what you know about global climate change or global warming, which one of the following statements comes closest to your opinion?

1) Global climate change has been established as a serious problem, and immediate action is necessary.
2) There is enough evidence that climate change is taking place and some action should be taken.
3) We don't know enough about global climate change, and more research is necessary before we take any actions.
4) Concern about global climate change is exaggerated. No action is necessary.
5) Global climate change is not occurring; this is not a real issue.

We recode this variable so that it ranges from 0 ("Global climate change is not occurring; this is not a real issue") to 1 ("Global climate change has been established as a serious problem, and immediate action is necessary"), with higher values representing more desire to take action on climate change.

The order in which each of the three dependent variables appeared for respondents was randomized to avoid any ordering effects. Figure 1 presents the distribution of responses for the dependent variables, which show substantial variation across the range of the scales. Notably, almost 80% of respondents chose one of the top two categories on the climate change question, making this variable somewhat skewed. However, the other two items produce much more variation across the range of the scales. As expected, both pro-environmental individual actions and support for policy vary by partisanship in the expected way with Democrats reporting consistently higher pro-environmental actions and policy support than Republicans. Tables 1A and 2A in the online Appendix show the distribution of the responses categories for each of the seven individual actions and green policies by partisanship. Tables 1A and 2A clearly show a partisanship division where Republicans are systematically providing less support for pro-environmental actions and green policies.

In the empirical analysis that follows, we first present treatment effects without statistical controls, and we then estimate our treatment effects from models that include controls for the remainder of the analysis. This allows us to increase the precision with which we can calculate the treatment effects. We include partisanship as one of our control variables and we also explore whether our treatment effects vary by party. Partisanship is coded into three groups – Democrats, Republicans, and independents/other. We assign individuals who identified as independents but then indicated that they lean towards one party as partisans.



Note: Distribution of the respondents' answers to the question on belief in climate change and support for taking action (climate question), and to the scale constructed from respondents' support for or opposition to seven climate-related policies (policy scale), and willingness to act to address climate change considering each of seven pro-environmental individual action (actions scale)

Fig. 1 Distribution of responses on the three dependent variables

Using this approach, our sample includes 1,211 Democrats, 935 Republicans, and 447 independents. We also include the political ideology of the respondents from a 5-point scale which we recoded to range from 0 (very conservative) to 1 (very liberal).

Additionally, we include four attitudinal items. First, we include a measure of social trust, which is based on the question used in the General Social Survey asking "Would you say that people can be trusted or that you can't be too careful in dealing with people." The variable is coded so that higher values relate to more trust. Second, we include a measure of support for egalitarianism, which is based on the extent to which respondents agree or disagree with the statement "Society should make sure everyone has equal opportunity." Higher values indicate more agreement with that statement. Third, we include a measure of government trust by using the question "How much of the time do you think you can trust the government in Washington to do what is right?". The government trust variable is coded so that higher values relate to more government trust.

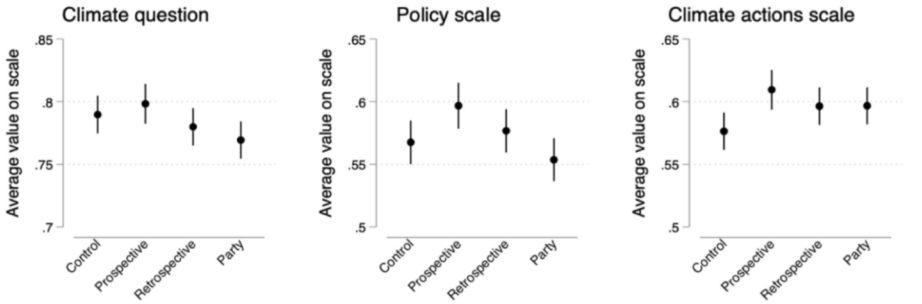
Fourth, we include a scale that captures the extent to which respondents assign responsibility for 'taking action against climate change' to individuals, corporations, or governments. This is examined through the following question "Please indicate whether you think each group has a responsibility to take action to address climate change: Individual people, Governments, Corporations. If you indicate more than one group rank the groups according to which have the most responsibility for taking action." We use the ranking for each of the three groups (individual people, governments, and corporations) to construct three variables with higher values indicating higher ranking based on whether respondents indicated the group as the least (1) or rather the most responsible (3) to address on climate change. We then use these three variables to run a graded response model, and we compute the resulting predicted latent score, which provides an assignment of responsibility scale where higher values indicate individuals assigning more responsibility to governments and corporations rather than to individuals. Section 2 in the online Appendix provides full details on the construction of the responsibility scale.

Finally, we include several demographic items that we also expect to be related to climate change attitudes and actions. These variables include age, gender (coded 0 for men and 1 for women), whether the individual has children under the age of 18, race (whether the individual identifies as white, black, Hispanic, or something else), and what type of community the respondent lives in (urban, suburban, or rural). As an additional variable, we also control for church attendance, which is based on a question asking respondents how often they attend religious services aside from weddings and funerals. We recoded the scale to range from 0 ("never") to 1 ("at least once a week").

3 Results

We begin by plotting the values of our dependent variables across each of the four experimental conditions. Figure 2 presents the mean value for each item in each condition along with 84% confidence intervals.[8]

[8] We plot 84% confidence intervals in this graph to make it easier for the reader to see which estimates are statistically distinguishable. When 84% confidence intervals do not overlap, we can be at least 95% confident that the means are different (Julious 2004).



Note: Average value across the three experimental conditions and the control group for the three dependent variables: belief in climate change and support for taking action (climate question), scale constructed from respondents' support or opposition for seven climate-related policies (policy scale), and scale constructed from respondents' willingness to act to address climate change considering each of seven pro-environmental individual action (actions scale). Vertical lines represent 84% confidence intervals

Fig. 2 Mean level of dependent variables across experimental conditions

Starting with the first panel in Fig. 2, we find very little difference in how subjects answered the climate change perceptions' question based on which experimental condition they were in. Additionally, none of the differences is statistically significant. Moving from perceptions to support for green policies, the second panel in Fig. 2 shows that support for pro-climate policies was marginally higher in the prospective condition, but this 3-point difference was not statistically significant ($p=0.094$). Turning to the third panel, all three treatment conditions produced higher average intentions of taking individual climate friendly actions, though the effect was just statistically significant ($p=0.027$) for the prospective climate condition (relative to the control group). The difference between the prospective and control groups was 3.3 points.

In Table 1, we present our estimates from a model where we include each of the control variables described above. Including control variables helps increase the precision with which treatment effects are estimated (Bowers 2011).

The results in Table 1 show the influence of showing local prospective climate information to individuals, which is consistent with the substantive body of literature showing that expected future outcomes drive behavior and inform choices (Manski 2017, 2004). Subjects assigned to this condition scored 3.5 points higher on the pro-climate actions scale ($p=0.013$) and 3.9 points higher on the climate-friendly policy support scale ($p=0.014$). Notably, subjects were also more likely to say they would take climate friendly actions when exposed to the local retrospective climate information (3.0 points, $p=0.013$) and the party priming condition (2.7 points, $p=0.013$), while exposure to the retrospective climate information and party priming conditions did not lead to significantly higher support for pro-climate policies.[9] On the contrary, the third column of Table 1 shows that none of the treatments statistically significantly affects perceptions of climate change, which confirms the findings of Binelli et al. (2023) that climate change perceptions are unaffected by provi-

[9] The OLS regression results are robust to constructing the dependent variable individual pro-environmental actions' index by using a three-values variable that consider "already done" and "plan to act" as two separate categories instead of combining these two categories into one category.

Table 1 OLS estimates of treatment effects with control variables

Variables	Actions Scale	Policy Scale	CC Perceptions
Prospective local	0.0353**	0.0389**	0.0113
	(0.0131)	(0.0143)	(0.0124)
Retrospective local	0.0296*	0.0249	0.00302
	(0.0127)	(0.0138)	(0.0120)
Party labels	0.0271*	0.00258	-0.00738
	(0.0127)	(0.0138)	(0.0120)
Ind/other	-0.0408**	-0.121***	-0.0562***
	(0.0137)	(0.0149)	(0.0129)
Republicans	-0.0486***	-0.166***	-0.120***
	(0.0132)	(0.0143)	(0.0125)
Ideology (Liberalism)	0.123***	0.242***	0.177***
	(0.0207)	(0.0225)	(0.0196)
Social trust	0.0451*	0.0264	0.0399*
	(0.0183)	(0.0199)	(0.0174)
Egalitarianism	0.136***	0.183***	0.143***
	(0.0204)	(0.0223)	(0.0194)
Institutional vs. individual responsibility	0.0462**	0.193***	0.191***
	(0.0169)	(0.0184)	(0.0161)
Trust in Central Government	0.0378***	0.0295***	0.0329***
	(0.00453)	(0.00493)	(0.00429)
Children under 18	0.0608***	0.0120	0.0144
	(0.0104)	(0.0113)	(0.00984)
Age	-0.00264***	-0.0000308	-0.000996***
	(0.000303)	(0.000330)	(0.000287)
Female	-0.0221*	0.00353	0.0298***
	(0.00944)	(0.0103)	(0.00893)
Church attendance	0.0995***	-0.0337*	-0.0207
	(0.0128)	(0.0140)	(0.0122)
Live in suburbs	-0.00211	0.00500	-0.00716
	(0.0110)	(0.0120)	(0.0104)
Live in rural areas	-0.0527***	-0.0296*	-0.0308*
	(0.0128)	(0.0139)	(0.0121)
Black	-0.0610***	-0.0447**	-0.0280
	(0.0155)	(0.0169)	(0.0147)
Hispanic	0.0271*	-0.00295	0.0125
	(0.0120)	(0.0131)	(0.0114)
Other	0.0396*	0.0375*	0.0122
	(0.0170)	(0.0185)	(0.0161)
Intercept	0.397***	0.202***	0.482***
	(0.0335)	(0.0364)	(0.0317)
Observations	2586	2586	2581
Adjusted-R^2	0.2540	0.3464	0.3333

Standard errors in parentheses, $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

sion of climate change information and remain primarily driven by partisanship.[10] Since the goal of our investigation is assessing the impact of climate change information's provision, the rest of the empirical analysis will focus only on the first two dependent variables: individuals' actions and support for green policies.[11]

Also worth noting from Table 1 is the relationship between each of the control variables and the dependent variables. As expected, Republicans and Independents are substantially less supportive of climate friendly policies and actions than Democrats (the baseline group). Increasing liberalism on the ideology scale is associated with more climate-friendly actions and policy support, as is social trust, egalitarianism, trust in the central government, and the belief that institutions are more responsible for 'taking action on climate change' than individuals. On the latter item, note that this responsibility scale is much more strongly associated with the policy scale than it is with the individual actions' scale, reflecting the fact that attributing responsibility to government and corporations rather than to individuals is strongly related to demanding governments to take action. The role of liberalism, social trust, egalitarianism, government trust,[12] and the attribution of responsibility to tackle climate change show that normative values play a crucial role in determining pro-environmental actions and support for policies. Being black and living in a rural area are similarly and negatively associated with taking actions and supporting green policies. Finally, age is also negatively associated with the individual actions scale and the climate change question, indicating that older adults are less likely to take climate friendly actions.[13]

3.1 Treatment effects by partisanship

So far, we have focused on the effects of our treatments on the full sample of adults. However, given the public opinion partisan divide on climate change in the US, we might expect Democrats and Republicans to respond differently to our information treatments. As we discussed in Sect. 3.1, there is a strong correlation between intentions to engage in pro-envi-

[10] While in both prospective and retrospective treatment conditions respondents are provided with the same set of temperature and precipitation's information, the prospective treatment also includes a visualization of the place in the US that the respondent's city climate would most closely resemble in 60 years, which could enhance the prospective treatment' effectiveness.

[11] The information treatments provide actual changes in both temperature and precipitation in both summer and winter. While descriptively accurate both retrospectively and prospectively, it is more difficult to separate the impact of the information's provision from the impact of the size of the changes in each of the four items. Including three interaction terms for each treatment condition would not accurately capture what we want to measure as each respondent simultaneously, not separately, receives the information on the precipitation and temperature changes in both summer and winter seasons. Subsequently, we would not be measuring the overall impact of the treatment. Therefore, we interpret our findings as the best proxy estimate of the overall impact of providing future (relative to past) information. Importantly, the 2021 IPCC Report shows that future changes in temperature and precipitation will be increasing. Thus, given that providing information on variables that will grow over time, our estimates are a lower bound of the actual impact of information's provision on future climate change.

[12] While theoretically distinct from partisanship, government trust is clearly correlated with it, particularly among strong partisans. However, robustness tests for multi-collinearity show that, while correlated, these variables are not problematic to the estimation of the model.

[13] As a robustness check of the model, we test for heterogeneous treatment effects among unobservables. The results show that there is no heterogeneity and are presented in Sect. 3 of the online Appendix. As an additional robustness check, we adjust the p-values for multiple hypothesis testing using the Bonferroni correction. We run the test for the treatment variables (thus 3 tests for the 3 treatment dummies included in the regression), and the P-values for the treatment variables confirm the results reported in Table 1.

Table 2 OLS estimates of treatment effects with control variables by partisanship

Variables	Actions Scale	Policy Scale
Democrats		
Prospective local	0.0306^	0.0329^
	(0.0187)	(0.0192)
Retrospective local	0.0523*	0.0260
	(0.0182)	(0.0186)
Party labels	0.0384*	0.0006
	(0.0180)	(0.0184)
Observations	1206	1206
Adjusted-R^2	0.1842	0.1401
Republicans		
Prospective local	0.0361^	0.0301
	(0.0203)	(0.0234)
Retrospective local	0.0149	0.0276
	(0.0195)	(0.0225)
Party labels	0.0308	0.0097
	(0.0199)	(0.0231)
Observations	933	933
Adjusted-R^2	0.2823	0.2942

Standard errors in parentheses, $^{\wedge}p<0.10$, $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

ronmental actions and support green policies and partisanship, with Republicans providing less support for pro-environmental actions and green policies. Table 2 presents the treatment effects from the full model estimated separately for Democrats and for Republicans.

Table 2 shows that the prospective information treatment positively affects individual actions for both Republicans and Democrats. For Democrats, the prospective information treatment also impacts support for green policies, whereas individual actions are also responsive to both the retrospective information and party labels treatments. As in Binelli et al. (2023), we find that the prospective information treatment affects individual climate actions across party lines. Binelli et al. (2023) also tested the impact of prospective information's provision on individuals' support for green policies by considering the support for or opposition to four policy items and did not find any statistically significant impact. Here we find that, when using a richer policy scale constructed by considering support or opposition to seven policies, the prospective information treatment also affects support for pro-environmental policy, even if with a decreased level of statistical significance.

Size-wise, if we compute the marginal conditional treatment effects by partisanship holding all control variables at their mean values, we find that the treatment effects are consistent for both Democrats and Republicans and in no instance statistically distinguishable across the two partisan groups. In other words, Republicans and Democrats appear to react to the information treatments in similar ways.[14] Importantly, this result is robust to news' consumption, thus the effectiveness of the information treatment across party groups does not depend on how much time and attention are spent to follow the news on government and public affairs. Specifically, we use a question that asks respondents how much they follow news on government and public affairs and we divide our sample into four groups: (1) Democrats who follow news most of the time (N = 558), (2) Democrats who follow news

[14] The marginal treatment effects by partisanship are available from the authors.

less frequently (N = 653), (3) Republicans who follow news most of the time (N = 439), and (4) Republicans who follow news less frequently (N = 496). The marginal treatment effects, all available upon request, show that, while there are some modest differences in treatment effects across groups, none of these differences is statistically distinguishable at traditional levels of confidence.

3.2 Mechanisms of transmission

The impact of the prospective information treatment on the willingness to take pro-environmental actions across parties brings in some optimism that effective information campaigns could directly promote individual behaviors. In this Section we investigate the mechanisms that could explain the effectiveness of this information's provision.

A first possible channel is family composition, and particularly the presence of young children. We would expect that providing prospective information affects someone's willingness to take individual actions and support green policies more if this person has children, who will be greatly affected by the accelerating changes in the world's climate. To test this hypothesis, we use a survey question that asks respondents if they had children under age 18, and we accordingly divided the respondents into two groups.

In our sample, 65% of respondents have no children under age 18. Among the 35% with children under age 18, the age of the youngest child is 3 for 25% of the sample, and 7 for 50% of the sample. We split the same into two sub-samples of those with and without children under age 18, and we estimate the baseline model separately for each sub-sample. Consistently with our expectations, we find that the impact of providing prospective climate change information is stronger on families with young children both for individual actions (0.05 $p = 0.04$ vs. 0.03 $p = 0.08$) and for policy support (0.06 $p = 0.01$ vs. 0.03 $p = 0.06$). Interestingly, for families with children under age 18, the retrospective information treatment is also effective for individual actions, and with a similar magnitude to the prospective one. However, if we restrict the sample to those with very young children (families with children under age 18 and the age of the youngest child being up to 7 years old), only the prospective information treatment is statistically significant both for individual actions and for policy support.

A second possible channel that could affect the effectiveness of the prospective information treatment on pro-environmental actions, as well as support green policies, is the degree of trust in the central government. As the central government is the body that proposes and implements all major environmental policies, we would expect that those with higher trust in the government will see government interventions and policies as both justified and effective. Conversely, those with lower trust in the government will be less supportive of government interventions. On the contrary, for pro-environmental actions, the impact of the information treatment is potentially ambiguous. On one hand, a higher level of trust in government might correlate with a concerted effort at the individual level. That is, people with higher trust in the government might act in a reinforcing or complementary way. On the other hand, a low level of trust in the government might also lead to greater individual actions whether to 'fill the gap' left by an untrustworthy or ineffective government or as some form of normative, anti-establishment individualism.

We test for the role of government trust by exploiting the following question "How much of the time do you think you can trust the government in Washington to do what is right?" that had four possible answers "Just about always (1)", "Most of the time (2)", "Only some

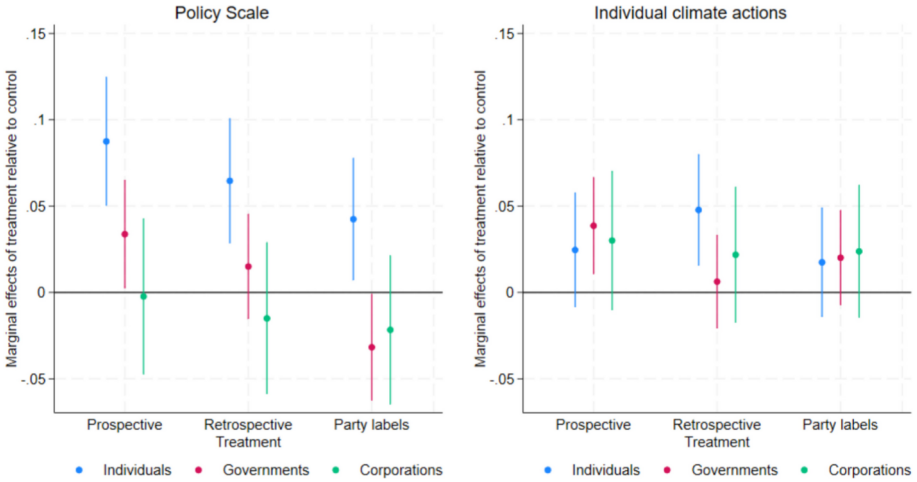
of the time (3)", and "Never (4)". We recoded this variable into a dummy variable by grouping the answers in the first two categories as "high trust", and the answers in the last two categories as "low trust". We split the same into two sub-samples of those with high and low trust, and we estimate the baseline model separately for each sub-sample. For individual actions, we find that both information treatments are statistically significant only for those with high trust in the government, with a similar impact size for providing prospective and retrospective climate change information (for prospective information 0.07 with $p=0.00$; for retrospective information 0.08 with $p=0.00$). For support for policy, we find that the only statistically significant treatment is the provision of prospective information to those with high trust in the government and the impact size is similar to the one estimated for individuals' actions (0.09 with $p=0.00$).[15]

A third channel that could affect the ability of the prospective information treatment to affect pro-environmental actions as well as green policies' support is the assignment of responsibility to tackle climate change. Iyengar (1989) identifies the attributions of responsibility that structures political attitudes and discusses how individuals attributing responsibility to themselves are significantly more supportive of government than those attributing responsibility to society-at-large. He shows that perceptions of responsibility for four prominent national issues (crime, terrorism, poverty, and racial inequality) are distinct and drive the opinions people take on these issues (*ibid.*). Yet, to the best of our knowledge, the relevance of the assignment of responsibility as a factor affecting environmental actions and support for climate policies has not been empirically investigated.

We test the relevance of the assignment of responsibility by using a survey question that asks respondents whether they view individuals or rather governments and corporations as the most responsible to take action to address climate change. In our sample, 44% of respondents said governments were most responsible, 33% assigned primary responsibility to individuals, and 22% said corporations were most responsible. Therefore, most of the respondents hold a systemic (responsibility attributed to governments and corporations) rather than an individualistic view of climate change according to which individuals would be the most responsible.

We estimate the baseline model in Sect. 3 with interaction terms of the information treatments and the responsibility variable. Figure 3 presents the marginal effects of the three treatments by assignment of responsibility. The results indicate that only people who assign more responsibility to individuals rather than to governments and corporations were influenced by the experimental treatments responding both to the prospective and to the retrospective treatments when it comes to their policy attitudes (with a larger size effect of the prospective treatment, 0.09, than the retrospective treatment, 0.06) and, albeit with a small impact, to the retrospective treatment when it comes to individual actions. By contrast, subjects who assigned more responsibility to governments and corporations before our experiment were unaffected by the treatments. Therefore, the effectiveness of the information treatment to promote support for green policies depends on the assignment of responsibility to individuals, which is consistent with Iyengar (1989)'s findings that individuals attributing responsibility to themselves are significantly more supportive of government's actions.

[15] The results are the same if, instead of two levels of trust, we consider three levels of trust by recoding the four answer categories into three groups: "Just about always" and "Most of the time" as "High trust", "Only some of the time" as "Some trust", and "Never" as "No trust".



Note: Estimates represent average marginal treatment effect for each treatment conditional on assignment of responsibility while holding all other control variables at their mean values. Vertical lines represent 84% confidence intervals

Fig. 3 Marginal treatment effects by which actor respondents hold as most responsible for taking action on climate change

One might expect an interaction effect between partisanship and the assignment of responsibility with Republicans holding a more individualistic (i.e.: 'individuals are responsible to take care of themselves and solve problems alone') rather than systemic (i.e.: 'governments or corporations are more responsible') view of climate change. However, the partisan differences along the assignment of responsibility are small. In our sample, if we consider the first ranked group that respondents assign responsibility to act against climate change, Democrats are only about ten points more likely to say that governments are most responsible (48% versus 38%) and Republicans are about eight points more likely to say that individuals are the most responsible (38% versus 30%), while 22% of Democrats and 24% of Republicans hold corporations as the most responsible. Also, if we test for partisanship and responsibility simultaneously by controlling for interaction terms of the information treatments with both variables, we find that only the responsibility variable produces statistically significant conditional treatment effects, which are of a very similar size and direction of those plotted in Fig. 3.

4 Discussion and conclusion

The main contribution of our work to the existing literature is twofold: (i) assess the relative effectiveness of providing prospective versus retrospective information on the local impact of climate change to promote pro-environmental behavior and support for green policies, and (ii) identify the mechanisms that can explain the effectiveness of this information's provision.

Using a randomized online experiment on a large sample of the US population and information treatments on the local impact of past and future climate change, we find that pro-

viding prospective information on local climate change significantly and positively affects both pro-environmental individual actions and support for green policy. We identity three main mechanisms that explain the effectiveness of providing information on future climate change: family composition, government trust and, for policy support, the assignment of responsibility to tackle climate change. Finding which type of information and through which channels does influence climate friendly actions and policy support is crucial to develop effective ways to raise the necessary awareness to bring about significant actions and policies.

The results of our study highlight several important findings. First, both pro-environmental actions and support for green policies respond to the prospective information on local climate change. These results confirm the importance of providing information on climate change that focuses on local (Bruine de Bruin and Dugan 2022; Taylor et al. 2014), and prospective or future expected impacts of climate change (Binelli et al. 2023). Despite a partisan divide in public opinion over climate change, a motivated majority can be moved to pro-environmental actions and policy support with direct communication strategies that use simple and concrete language (Bruine de Bruin et al. 2021) and local, prospective information (Binelli et al. 2023). The effectiveness of providing prospective information on climate change confirms that a future time perspective is a key determinant of a more sustainable behavior (Strathman et al. 1994; Collet et al. 2023).

Second, we find that the effectiveness of providing information on future local climate impacts increases when respondents have young children, a high degree of trust in the central government, and, for support for green policies, when they assign responsibility to individuals rather than to governments and corporations to act on climate change.

Third, we highlight that social trust, egalitarian orientation and values are positively correlated with the outcome variables. This suggests that normative values are relevant determinants of the pro-environmental position. Yet, the public framing of climate change policies and motivations to individual action do not have to derive uniquely from a value perspective or pro-environmental position. The information treatments provided respondents with a concrete description of the long-run changes in temperature and precipitation in the city of residence using simple and direct language that affected their pro-environmental position.

The magnitude of the treatment effects may appear, at first, underwhelming. The information on expected local climate change produced about a 4-point increase in the pro-climate direction on both the individual actions and policy support scales. In terms of actions, this effect would amount to about a 4-point increase in the probability of a respondent saying they were likely to take a pro-environmental action such as the purchase of a hybrid or electric car. Likewise, the movement on the policy scale would be associated with about a 4-point increase in the probability of supporting a green policy such as a policy that requires 50 percent of all cars sold in the US by 2030 to be electric.

However, our intervention was relatively modest. People may be more significantly moved by a similar message that is more forceful and, especially, sustained over time. Research has shown that GPT-3 can be very efficient at conveying information by generating text that is easier to read and understand than text written by humans (Spitale et al. 2023). Therefore, generative artificial intelligence could offer effective tools to promote low-cost information campaigns that are sustained over a long period of time and provide local information on prospective climate change.

One limitation of our analysis is that we have tested the effectiveness of providing information on future local climate change on intentions to support and act pro-environmentally. The next step would be to investigate the impact of providing prospective information on local climate change on actual choices and behavior both in the short and in the long-run. Recent research that has focused on consumption of electricity as one important example of pro-environmental behavior suggests that increases in climate change salience can significantly reduce energy consumption, so that drawing attention to climate change may lead to actual behavioral change, even if the effect is short lived (Bonan et al. 2023). Future research could assess whether the relevance of climate salience and expectations about future climate change also affect other pro-environmental behaviors, and, crucially, support for green policies and vote choices.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10584-025-03941-4.

Acknowledgements We thank Giacomo Trombi for collecting and preparing the retrospective climate data, and Matt Fitzpatrick for helping to build and host the map using the retrospective climate change information. We thank Brian Schaffner for his contribution in designing and fielding the online experiment. We thank two anonymous referees, and participants to the ISA 2022 Annual Convention, the EcoMod2023 Conference, and an invited seminar at the University of Georgia for helpful feedback and suggestions. All remaining errors are ours.

Author contributions Chiara Binelli: Conceptualization, Methodology, Investigation, Writing-Original draft preparation, Writing-Reviewing and Editing.
Matthew Loveless: Methodology, Investigation, Data curation, Writing-Original draft preparation, Writing-Reviewing and Editing.

Funding Open access funding provided by Alma Mater Studiorum - Università di Bologna within the CRUI-CARE Agreement.
The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Data availability The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate The experiment was reviewed and was ruled exempt by the Tufts University Institutional Review Board.

Consent for publication Not applicable.

Competing interests 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.

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