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Evaluating the usefulness of Protection Motivation Theory for predicting climate change mitigation behavioral intentions among a US sample of climate change deniers and acknowledgers

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Abstract

Background This paper summarizes data from 7 studies that used Protection Motivation Theory (PMT) to guide climate messaging with the goal of increasing climate-mitigating behavioral intentions. Together, the studies address 5 research questions. 1) Does PMT predict behavioral intentions in the context of climate change mitigation? 2) Does PMT work similarly for climate change deniers vs acknowledgers? 3) Are the effects of threat and efficacy additive or multiplicative? 4) Does adding measures of collective threat and efficacy improve the model accuracy for a collective problem like climate change? 5) Can threat and efficacy appraisals – and ultimately behavioral intentions – be shifted through climate messaging?

Methods Seven online experiments were conducted on US adults ($N = 3{,}761$) between 2020 and 2022. Participants were randomly assigned to a control condition or to one of several experimental conditions designed to influence threat, efficacy, or both. Participants indicated their belief in climate change, ethnicity, gender, and political orientation. They completed measures of personal threat and efficacy, collective threat and efficacy, and behavioral intentions.

Results Multiple regressions, ANCOVAs, and effect sizes were used to evaluate our research questions. Consistent with PMT, threat and efficacy appraisals predicted climate mitigation behavioral intentions, even among those who denied climate change. Different interactions emerged for climate deniers and acknowledgers, suggesting that in this context threat and efficacy are not just additive in their effects (but these effects were small). Including measures of collective threat and efficacy only modestly improved the model. Finally, evidence that threat and efficacy appraisals can be shifted was weak and inconsistent; mitigation behavioral intentions were not reliably influenced by the messages tested.

Conclusions PMT effectively predicts climate change mitigation behavioral intentions among US adults, whether they deny climate change or acknowledge it. Threat appraisals may be more impactful for deniers, while efficacy appraisals may be more impactful for acknowledgers. Including collective-level measures of threat and efficacy

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modestly improves model fit. Contrary to PMT research in other domains, threat and efficacy appraisals were not easily shifted under the conditions tested here, and increases did not reliably lead to increases in behavioral intentions.

Keywords Climate change messaging, Protection motivation theory, Behavioral intentions, Threat, Efficacy, Collective efficacy, Climate change denial

Introduction

How should climate advocates communicate about climate change to motivate individuals to engage in mitigation behaviors? Should they focus on the threat climate change poses? Should they encourage individual action or convey the message "together we can do it?" Should they bother talking to climate change deniers at all? As humanity's window of opportunity to limit catastrophic warming narrows, social scientists are racing to answer these questions. The overarching goal of this paper is to evaluate Protection Motivation Theory (PMT) as a potential theoretical approach to predicting climate mitigation behavior and for guiding climate messaging. Protection Motivation Theory was developed to explain protective behavior in an individual health-related context (e.g. wearing sunscreen [1]). Recent research has begun to explore the application of PMT to the threat of environmental degradation [2], and in the last 4 years, climate change [3–11]. Below we provide a brief introduction to Protection Motivation Theory and identify five open questions about applying PMT to the context of climate change. We then present the results of seven studies that used PMT to guide climate change messaging, with a goal of increasing the likelihood that people would take action to mitigate climate change. The strategies these studies evaluated were largely developed independently of each other and are quite different from each other. However, because they share the same measures of PMT variables, together they provide a robust test of key questions about using PMT in the context of climate change.

Protection Motivation Theory: threat and efficacy working in tandem

According to Protection Motivation Theory [12, 13], responding effectively to a threat requires a realistic assessment of the threat as well as the belief that effective coping strategies exist. In this model, *threat appraisal* is a function of both *perceived vulnerability* (will it happen to me?) and *perceived severity* (how negative will it be?). *Efficacy appraisal* (or coping) is a function of *behavioral efficacy (*can I do something?) and *response efficacy* (will it make a difference?). These appraisals predict motivation to take protective action, which in turn predicts protective behavior. The PMT framework predicts that a person will be more likely to take action against a threat if they believe the threat is big enough to impact them, and they perceive that taking action against the threat is sufficiently accessible to them and effective against the threat.

While PMT was first developed to explain the impact of fear-arousing communication on preventative health behaviors [14–16], it has since been used successfully in a variety of domains ranging from parenting behaviors [17], to disaster preparedness [18], to pro-environmental behavior [2]. Kothe et al.'s [2] review of literature focused on pro-environmental behavior found 22 studies that measured at least some part of the PMT model. However, most of these studies ($K = 17$) were correlational. As a whole, these 22 studies ($N = 12{,}827$) provide broad but piecemeal support for PMT in the context of pro-environmental behavior. Notably, the few experiments in the review had mixed success in shifting threat and efficacy appraisals, in contrast to PMT research in other domains [16]. The authors conclude that there is a clear need for further research on how PMT applies to the domain of pro-environmental behavior. The data reported here help to fill this gap.

The current data also address another question. The original theory by Rogers and Prentice-Dunn [13] posited a multiplicative relationship between threat and efficacy: both threat *and* efficacy must be high for someone to be motivated to take protective action. However, follow-up studies have not supported this hypothesis [19, 20], and instead have demonstrated two independent and additive effects in most (but not all [21]) contexts. In this research we evaluate whether PMT in the context of climate change mitigation behavior is multiplicative or additive. It is possible that the impact of threat and efficacy appraisals is additive in some contexts, and multiplicative in others. For example, Rippetoe and Rogers [21] found that in the context of health threats, high threat appraisals in the absence of high coping appraisals led to only maladaptive behavioral intentions; high coping appraisals were necessary to form adaptive behavioral intentions. We are unaware of studies that have explicitly tested the multiplicative hypothesis in the context of pro-environmental behavior; this is another gap in the literature this research helps address.

Protection Motivation Theory applied to climate change

Because PMT has successfully predicted pro-environmental behavior, it stands to reason that PMT may be useful in the context of predicting climate change mitigation behavior, as climate change is a significant environmental threat. We found several recent studies that used PMT to look directly at climate change adaptation or mitigation behaviors [3–11]. All of these studies supported PMT's usefulness for predicting mitigation behavioral intentions [3–5, 10, 11] and self-reported adaptation behaviors [6, 7, 9].

Despite this, there are still some questions about how PMT might be applied within the context of climate change. Unlike the health threats PMT was designed to address, some individuals deny the existence of climate change. Furthermore, unlike the personal health behaviors that have been researched, climate change is an inherently collective problem that individuals cannot address by themselves. These two factors potentially complicate the threat and efficacy assessments integral to the application of PMT.

Additionally, many of the studies using PMT in the context of climate change were run in countries (e.g., China, Germany, Taiwan, Turkey) with smaller numbers of climate change deniers than in the United States [22]. A 2018 study published in Nature found that "the relationship between conservative ideologies and climate skepticism is unusually strong and consistent within the United States compared to [23] other countries", presumably because the highly polarized U.S. political culture encourages people to evaluate climate science through the filter of party identification. Lobbying and social media also seem to contribute to the link between ideology and climate change skepticism [24]. This raises the question of whether the model works as well in a context like the U.S., where there are larger numbers of climate change deniers who are often quite vocal. How do people who deny the very existence of the threat in question respond to questions about threat and efficacy? Does PMT work on climate deniers? None of the studies we reviewed reported results separately for climate deniers and acknowledgers, representing anothergap in the literature that this research addresses.

From one perspective, PMT makes straightforward predictions for differences between climate change deniers and acknowledgers: increasing threat appraisals is important for deniers (but not acknowledgers), while increasing efficacy appraisals is important for all. However, there is another way to look at the case of climate change deniers. If deniers believe a threat does not exist *at all* (rather than just being a low threat), deniers would presumably have a difficult time giving meaningful answers to questions about the efficacy of taking action to prevent a non-existent problem. In the data presented here, we examined the impact of belief in climate change to determine whether climate change deniers respond in theoretically meaningful ways, or whether the model fails to explain variability in their behavioral intentions.

The collective nature of climate change, both in terms of its threat and its solutions, also raises questions about the applicability of PMT to the context of climate change. As we noted above, Kothe et al. [2] found mixed success in experimental efforts to shift threat and efficacy appraisals. This may be because unlike personal health behaviors, climate change (and environmental problems generally) are inherently collective "commons dilemmas" [23] that require people to act in concert. Bandura [25] argues that for groups to unite as a collective force, three conditions must be met:

1. The effectiveness of protective behavior must be clear (response efficacy).
2. The ability of individuals to engage in behavior must be clear (performance efficacy).
3. *The willingness and likelihood of most individuals to take action must be clear* (collective efficacy).

Thus, it may be that in the context of climate change PMT will have greater predictive power if collective efficacy is included in the model (see Fig. 1). While research has found that both individual [14–18]and collective [18, 26, 27] efficacy are correlated with climate change actions and intentions, we found only one study that tested both within the context of PMT. In their study of adaptation strategies to water shortages, Pakmher et al. [9] included collective efficacy, and found it to be a better predictor of adaptation behaviors than personal efficacy. Chen [28] similarly found collective efficacy to be a better predictor of pro-environmental behavior than personal efficacy. In the studies reported here, we measured collective efficacy as well as personal efficacy; we also measured collective threat appraisals, to test the relative importance of the personal versus the collective across the whole model.

Finally, an important test of PMT's usefulness in the context of climate change is whether it can effectively inform messaging strategies to promote mitigation behaviors. Recent research [29] found messaging successfully shifted climate change threat and efficacy appraisals, which in turn increased climate policy support. However, as noted above, Kothe's [2] review found that efforts to shift threat and/or efficacy appraisals in the environmental domain were not reliably successful in shifting behavior. It is unclear why environmental threat and efficacy appraisals might be more resistant to change than health-related threat and efficacy appraisals. Each of

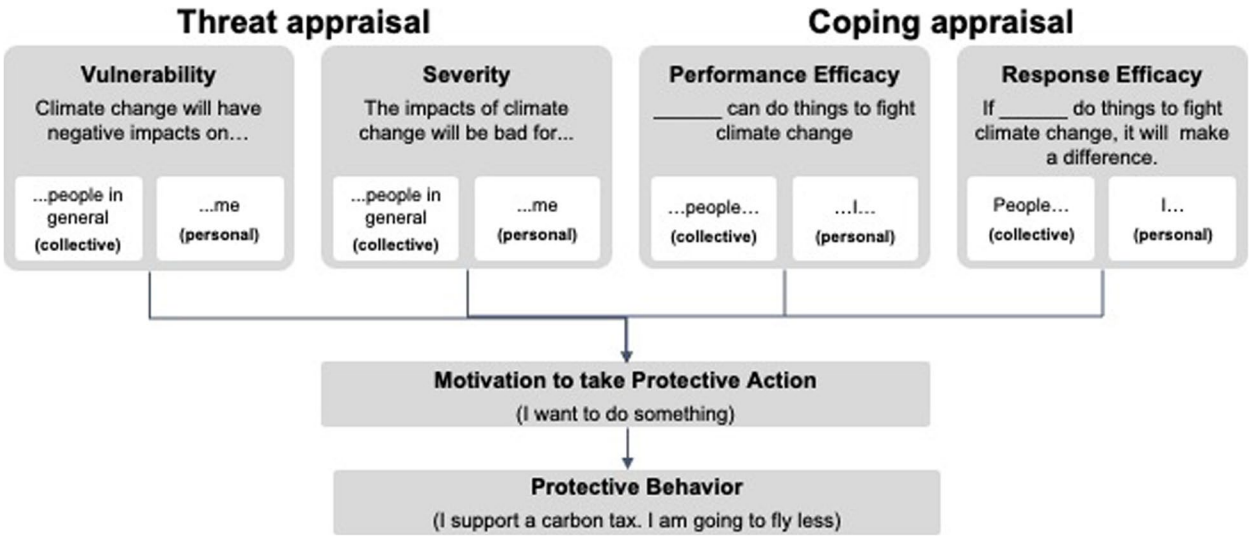

Fig. 1 A modified version of Protection Motivation Theory to include collective-level variables

the seven studies presented here attempted to shift either threat appraisals, efficacy appraisals, or both through a variety of means. Together, these studies provide insight into the malleability of climate change appraisals, and their impact on behavioral intentions.

In sum, there are many reasons to believe that PMT may be a useful framework for understanding action on climate change, and potentially for guiding climate messaging. However a number of open questions remain. The studies presented in this paper provide a test of 1) whether PMT predicts behavior in the context of climate change, 2) whether PMT works similarly for climate change deniers vs acknowledgers in the U.S. cultural context, 3) whether the impact of threat and efficacy are additive or multiplicative, 4) whether measuring collective threat and efficacy improves the model accuracy for a collective problem like climate change, and 5) whether threat and efficacy appraisals and behavioral intentions can be shifted through climate messaging.

Method

The data come from 7 studies conducted between the summer of 2020 and spring 2022 and were approved by the Institutional Review Board of Oberlin College. Studies are presented in Table 1 and are numbered chronologically from earliest to latest.[1] The studies used different manipulations and tested different hypotheses (described below). However, all used Protection Motivation Theory to develop interventions and their predicted effects. Further, all studies used identical measures of PMT constructs (with the exception of Study 1, which used the same items but a different response scale for measures of threat). The items used to measure severity, vulnerability, performance efficacy, and response efficacy appraisals were taken from previous research [30]. Each study also included measures of collective severity, vulnerability, performance efficacy, and response efficacy.

Participants

All seven studies were conducted online using U.S. residents. Six studies used samples obtained through CloudResearch (which uses MTurk workers but provides some quality checks); one study (Study 3) used a purchased Qualtrics panel that was intentionally balanced by race (50% White, 50% People of Color). Studies 3 and 6 were preregistered on OSF; the others (3 of which were pilot studies) were not. The initial combined samples (before removing those who failed the attention check) included 3942 people. It was 61.7% White and 55.7% female. The sample skewed liberal, with 49.7% identifying as liberal, 24.0% as moderate, and 26.3% as conservative. The average age was 40 ($SD = 12$). In our sample, 68.6% acknowledged climate change as happening and human-caused, which is a marginally higher percentage than that found in a recent nationally representative survey [31], $\chi 2 = 3.35$, $p = 0.07$. All participants were paid at a rate of approximately $10/hour (exact amounts varied depending on the length of the study).

Procedure

In all studies, participants provided informed consent and were randomly assigned to experience a

[1] A number of extreme weather events occurred during the time over which data was collected; we tested to see whether levels of threat, efficacy, and behavioral intentions changed as a function of time, but they did not.

Table 1 Overview of seven studies testing Protection Motivation Theory in the context of climate change

Study	Data Collection Period	Study Identifier	No. of conditions	Description	What factor did the manipulation target?	N deniers	N believers	N total
1	Summer 2020	Air Quality Recovery	2	Participants read about sight-seeing in two Indian cities (control) or how air quality dramatically recovered in two Indian cities during the COVID lock-down (efficacy-boosting)	Response efficacy	57	215	272
2	Fall 2020	Prospection 1	4	Participants imagined and wrote about a future in which we successfully addressed environmental challenges (positive prospection) or did not (negative prospection). There were 2 control conditions	Threat & efficacy	199	442	641
3	Spring 2021	Racial Disparities 1	2	White and POC participants read about climate change impacts disproportionately affecting coastal towns (control) or communities of color (threat-reducing for Whites, threat-boosting for POCs)	Threat (by race)	207	431	638
4	Spring 2021	Scientist 1	3	Participants read an article about accurate epidemiologist predictions (COVID), an article about accurate climatologist predictions, or no article at all	Threat & efficacy	77	176	253
5	Summer 2021	Scientist 2	3	Participants read an article about accurate epidemiologist predictions (COVID), an article about accurate climatologist predictions, or no article at all	Threat & efficacy	106	252	358
6	Fall 2021	Racial Disparities 2	2	White and POC participants read about climate change impacts disproportionately affecting coastal towns (control) or communities of color (threat-reducing for Whites, threat-boosting for POCs)	Threat (by race)	337	830	1167

Table 1 (continued)

Study	Data Collection Period	Study Identifier	No. of conditions	Description	What factor did the manipulation target?	N deniers	N believers	N total
7	Spring 2022	Prospection 2	4	Participants saw positive images, negative images, or both. They wrote about living in the future(s) depicted. A control condition skipped this task	Threat & efficacy	142	290	432

manipulation of some kind (described below). Participants then completed questions that measured our main dependent variables and provided demographic information. In all studies, participants also responded to an attention check question (a factual question about the condition they were assigned to). Participants who failed the attention check question were removed from the data set ($N=181$, or 4.6%). This resulted in a final sample size of 3761.

Measures

Copies of all surveys and data are available at https://doi.org/https://doi.org/10.5061/dryad.3j9kd51tc. Below we provide a summary of survey elements that were consistent across all studies and relevant to the research questions explored here.

Threat, efficacy and behavior

Participants responded to a series of single items that measured personal severity, vulnerability, performance efficacy, and response efficacy; and collective severity, vulnerability, performance efficacy, and response efficacy. The item measuring vulnerability was "How likely is it that the effects of climate change will impact you?" and the item measuring severity was "How much negative impact will climate change have on you?". The measure of performance efficacy was "How easy or hard would it be for you personally to address climate change through your actions?" and the item measuring response efficacy was "How effective would it be for you personally to address climate change through your actions?". Measures of collective appraisals had identical wording to personal appraisals but substituted "people in general" instead of "you". For all but Study 1 threat questions (which used an 8-point scale), participants responded on a 6-point scale, with low values indicating lower levels. Vulnerability was measured on a scale of 1; "No chance" to 6; "Very high chance." While Severity was measured on a scale of 1; "No impact at all" to 6; "Very large impact." Consistent with the majority of studies using PMT, severity and vulnerability items were averaged together to create a single measure of threat appraisal (alpha = 0.95). Performance and response efficacy were measured on 6-point scales of 1; "Extremely hard" to 6; "Extremely Easy" and 1; "Extremely ineffective" to 6; "Extremely effective," respectively. As with threat measures, performance and response efficacy were averaged together to create a single measure of efficacy appraisal (alpha = 0.86).

As a measure of climate change mitigation behavioral intentions, participants responded to a list of behaviors preceded by the prompt: "How likely is it that in the next six months you will…". The items were previously validated and used earlier research [32]. Some of the items were individual actions (e.g. reduce air travel) and some were collective (call or write an elected official about climate change). The number of items varied across studies, ranging from 7—11. Participants responded on 6-point scale ranging from extremely unlikely to extremely likely.

Demographic variables

Participants responded to demographic questions about race, gender identity, and political orientation (1 = extremely liberal, 7 = extremely conservative). We measured belief in climate change using two items commonly used in opinion polls [31, 33], "From what you've read and heard before, is there solid evidence of climate change that the average temperature on earth has been getting warmer over the past few decades, or not?" and "Do you believe that the earth is getting warmer (a) mostly because of human activity such as burning fossil fuels or (b) mostly because of natural patterns in the earth's environment?". Participants who answered yes to both questions were coded as acknowledging the reality of climate change; those who answered no to one or both questions were coded as denying anthropogenic climate change.

Manipulations

The manipulations deployed represent three main approaches to climate messaging. Three studies (Studies 1, 4, and 5) evaluated whether COVID 19 comparisons influenced thinking about climate change. Two (Studies 2 and 7) guided participants through a prospection (thinking about the future) task, and two (Studies 3 and 6) highlighted the racial disparities in climate change impacts to White and POC participants.

Study 1: Air quality recovery

This study evaluated whether reading about the swift recovery of natural systems during the COVID lockdown would increase both personal and collective response efficacy for climate change mitigation behaviors. We reasoned that reading about natural systems' recovery would increase participants' sense that reducing carbon-emitting behavior would make a difference, and also that large numbers of people *could* and *would* change their behavior. Participants were randomly assigned to read an article about dramatic air quality recovery in two Indian cities (with before and after lockdown pictures), or a travel blog about the same cities (with after pictures only).

Study 2: Prospection 1

This study evaluated whether imagining a positive or negative future impacted threat and efficacy evaluations. We hypothesized that imagining a positive future would increase response efficacy, as things that we imagine seem more likely [34]. We hypothesized that imagining a negative future would increase vulnerability and severity assessments, for the same reason. We did not have distinct hypotheses for personal vs collective levels of the variables. After reading a brief description outlining current environmental challenges, participants were randomly assigned to one of four conditions. The positive prospection condition was asked to imagine that we had successfully addressed our environmental challenges, and asked to describe their neighborhood 30 years in the future. The negative prospection condition was asked to imagine that environmental challenges had continued to worsen, and were also asked to describe their neighborhood 30 years in the future. Two control conditions either wrote about current events in their neighborhood or did no writing task. (These two groups were identical and were combined.)

Study 3: Racial disparity 1

This study examined whether reading about the racial disparities in climate change impacts had different effects on White people versus People of Color (POC). We hypothesized that White people who read that communities of color are disproportionately impacted by climate change might have lower estimates of vulnerability and severity, relative to a control condition. We predicted the opposite for POC: reading that their communities are more impacted by climate change would increase vulnerability and severity ratings. We did not have distinct hypotheses for personal vs collective levels of the variables. We recruited roughly equal numbers of White-identifying and POC-identifying participants, who were randomly assigned to read an article about climate change's disproportionate impacts on communities of color or a control article about climate change's disproportionate impacts on coastal communities.

Study 4: Scientist 1

We examined whether reading about scientists making accurate predictions would affect participants' threat and efficacy appraisals. We contrasted reading about scientists' COVID-19 predictions to reading about climate predictions. COVID-19 provided a recent, vivid, and tangible example of a highly disruptive threat that everyone had been undeniably affected by. It also provided a recent, vivid, and tangible example of scientists making accurate predictions, as well as showing the value of science-informed public policy and science-based solutions (vaccines). We hypothesized that the COVID article would increase climate threat and efficacy assessments more than an article focused on climate change among climate deniers, as climate change is so politically polarized in the US. We hypothesized that both articles would increase threat and efficacy assessments among those acknowledging the reality of climate change. Participants in our study were assigned to one of three conditions — reading an article about accurate epidemiologist predictions, reading an article about accurate climatologist predictions, or reading no article at all.

Study 5: Scientist 2

This follow-up to Study 4 was identical, except that it included pre-measures of belief in climate change as well as the PMT variables. This created a within-subjects design to boost statistical power. Data included in the merged data set came from the measures collected after reading the articles, to make this data as similar as possible to the other studies.

Study 6: Racial disparity 2

Study 6 was a straight replication of Study 3 with a larger sample size.

Study 7: Prospection 2

As in Study 5, this study used a prescreen survey of PMT variables to create a within-subjects design. We again hypothesized that imagining a positive future would increase efficacy, while imagining a negative future would increase threat assessments. Participants read a brief paragraph outlining the challenge of climate change and our potential to respond to it. They were then randomly assigned to see either a positive image (e.g. solar panels; positive prospection), a negative image (e.g. drought-stricken field; negative prospection), or both (order counterbalanced; positive + negative prospection). Participants were asked to imagine the future depicted and write about what it would be like to live in it. A control condition skipped this task.

Results

Below we present relevant evidence addressing each of our 5 research questions. For most of the analyses, data from all seven studies were combined into a single file. The data from all seven studies is available at https://doi.org/https://doi.org/10.5061/dryad.3j9kd51tc. To address the question of whether threat and efficacy appraisals are malleable, we analyzed each study separately as well as the combined data set. Before merging the data sets, participants who failed the attention check questions were removed. Within each study, the dependent variables were transformed into z scores, to adjust for the fact that the studies varied in the number of scale points used and to adjust for any differences between studies in the grand mean.

Does PMT predict behavioral intentions in the context of climate change?

To evaluate the utility of PMT in the context of climate change, we ran a stepwise multiple regression on the full data set, see Table 2. Demographic variables (political orientation, ethnicity, gender, belief in climate change) were included in Step 1. In Step 2, we added the PMT variables: threat, efficacy, and the threat x efficacy interaction term. We also include the 3-way interaction of threat x efficacy x belief in climate change to evaluate whether belief in climate change moderated the effectiveness of PMT in predicting behavioral intentions.

The demographic variables significantly predicted 24.7% of the variance in behavioral intentions; all but ethnicity were significant (ethnicity was marginally significant). Liberals, people of color (marginally), women, and those who believed in climate change expressed higher behavioral intentions to take action on climate change.

When the PMT variables were included, the percent of variability explained nearly doubled to 45.6%, a significant increase. Ethnicity and gender became nonsignificant. Consistent with PMT, both threat and efficacy strongly predicted behavioral intentions. The two-way interaction between threat and efficacy and the three-way interaction between threat, efficacy, and climate change belief were also both significant and are discussed further below.

Does PMT predict behavioral intentions for both climate change deniers and acknowledgers?

We considered the possibility that climate change deniers might answer questions about efficacy by choosing the highest possible answers, as it is easy to solve a problem that does not exist. Indeed, there were 59 climate change deniers (out of 1184, 5%) who chose the highest value for all efficacy questions. However, the majority of climate change deniers used the whole scale and gave lower efficacy ratings on average than climate change acknowledgers ($M = -0.455$, vs $M = 0.056$, $t(3759) = 16.072$, $p < 0.001$). Because the subset of 59 extreme respondents represented a very different subpopulation, they were removed from the analyses reported below. We ran analyses with these participants included, and also examined them separately. The results remain unchanged, with one exception: when analyzed by themselves, threat still predicted behavioral intentions but efficacy did not, presumably because of restricted range.

Table 2 provides regression equations run separately for climate change deniers ($N = 1125$) and acknowledgers ($N = 2577$). As above, including PMT variables increased the percent of variance explained by the regression equation substantially for both groups, and threat and efficacy strongly predicted behavioral intentions for both groups. The data suggest that PMT effectively predicts behavioral intentions even among those who deny that the threat exists. The 2-way interaction between threat and efficacy was significant for both deniers and acknowledgers, though the regression weights were in opposite directions (the meaning of this is explored in the description of a significant three-way interaction below).

Are the effects of threat and efficacy additive or multiplicative?

The interactions reported above test whether threat and efficacy have additional impact in unique combination, above and beyond their additive effects. When all participants were included, the 2-way threat by efficacy interaction and the 3-way threat by efficacy by belief in climate change interaction were both significant. When looking within deniers and acknowledgers, the threat by efficacy interaction was significant for both groups.

Table 2 Regression equations predicting behavioral intentions from demographic variables, threat, and efficacy

		All Participants			Climate Change Deniers			Climate Change Acknowledgers		
	Variable	**beta**	**95% CI lower bound**	**95% CI upper bound**	**beta**	**95% CI lower bound**	**95% CI upper bound**	**beta**	**95% CI lower bound**	**95% CI upper bound**
Model 1	Political leaning	-0.222[a]	-0.140	-0.105	-0.277[a]	-0.206	-0.137	-0.192[a]	-0.121	-0.082
	Belief in climate change	0.340[a]	0.297	0.358						
	Ethnicity	0.041[a]	0.027	0.138	0.070[a]	0.028	0.252	0.027	-0.017	0.110
	Gender	0.096[a]	0.132	0.241	0.111[a]	0.104	0.315	0.105[a]	0.114	0.240
Model 2	Political leaning	-0.099[a]	-0.070	-0.040	-0.102[a]	-0.092	-0.034	-0.100[a]	-0.071	-0.035
	Belief in climate change	0.140[a]	0.107	0.163						
	Ethnicity	-0.012	-0.024	0.070	-0.002	-0.093	0.087	-0.016	-0.029	0.083
	Gender	0.033[a]	0.018	0.111	0.009	-0.067	0.103	0.050[a]	0.028	0.139
	Threat	0.374[a]	0.347	0.413	0.472[a]	0.387	0.500	0.300[a]	0.308	0.390
	Efficacy	0.331[a]	0.316	0.378	0.381[a]	0.299	0.415	0.351[a]	0.312	0.386
	Threat x Efficacy	-0.036[a]	-0.058	-0.001	0.148[a]	0.040	0.116	-0.059[a]	-0.109	-0.026
	Threat x Efficacy x CC belief	-0.092[a]	-0.077	-0.030						
		Adj R^2	F R^2 change	p R^2 change	Adj R^2	F R^2 change	p R^2 change	Adj R^2	F R^2 change	p R^2 change
Model 1		0.247	305.42	< .001	0.101	42.715	< .001	0.049	45.775	< .001
Model 2		0.460	364.97	< .001	0.430	216.161	< .001	0.273	267.422	< .001

[a] CI does not include 0

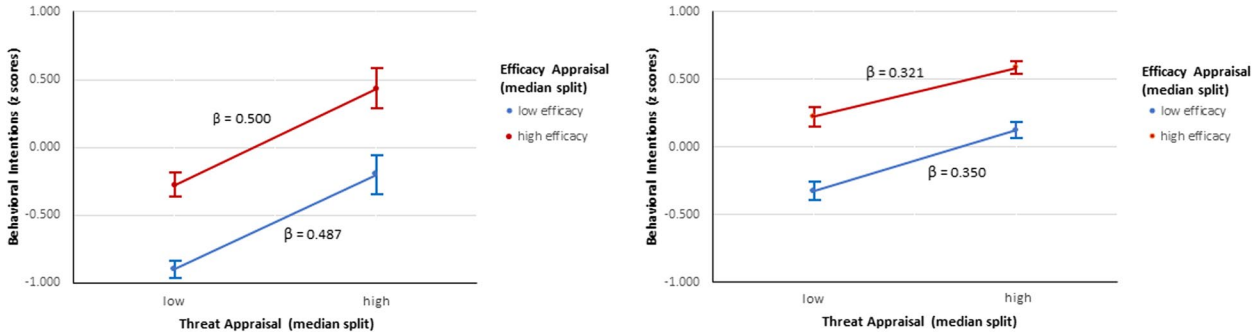

Fig. 2 Three-way interaction between threat, efficacy, and climate change belief predicting behavioral intentions

Table 3 Correlations between personal-level and collective-level threat and efficacy

	All Participants	Climate Change Deniers	Climate Change Acknowledgers	Z	*p*
Personal severity—collective severity	0.807	0.789	0.752	2.56	0.011
Personal vulnerability—collective vulnerability	0.811	0.809	0.748	4.37	< .001
Personal response efficacy—collective response efficacy	0.596	0.718	0.494	10.16	< .001
Personal performance efficacy—collective performance efficacy	0.624	0.696	0.582	5.44	< .001

To depict these interactions, we recoded threat and efficacy into binary variables (high/low) via median splits. Figure 2 depicts the three-way interaction (which qualifies the two-way interactions). For climate change deniers, the impact of threat on behavioral intentions was stronger for those high in efficacy. Among climate change deniers, the high threat/high efficacy group was the only one whose mean behavioral intentions were above the grand mean of zero. For climate change acknowledgers, the impact of threat on behavioral intentions was weaker for those high in efficacy; the low threat/high efficacy group had a higher mean than would be predicted by an additive model. Among climate change acknowledgers, the low threat/low efficacy group was the only one whose mean behavioral intentions were below the grand mean of zero.

It should be noted that these effects were quite small. For all participants, including the interaction terms increased R^2 from 0.456 to 0.460 (an increase of 0.4% of the variance). Among deniers, including the threat by efficacy interaction term increased R^2 from 0.422 to 0.430 (0.8% of variance), and among acknowledgers from 0.270 to 0.273 (0.3% of the variance).

Do collective threat and efficacy measures improve the model accuracy for a collective problem like climate change?

Because climate change is a collective problem, we explored whether measuring collective threat and efficacy, distinct from personal threat and efficacy, improved the PMT model. Table 3 presents correlations between the personal and collective versions of each model component for the whole sample, as well as separately for deniers and acknowledgers. For the whole sample, the correlations between personal and collective variables were high, ranging from 0.494 to 0.811. The threat variables were more highly correlated with each other than the efficacy variables, suggesting that the distinction between personal and collective threat is not as clear to participants as the distinction between personal and collective efficacy. The correlations were also consistently significantly higher for climate change deniers than acknowledgers.

We quantified the additional predictive value of adding collective variables through stepwise regression equations. We included climate change deniers and acknowledgers in the same analysis and also ran separate regressions for each. Demographic variables, personal threat, and personal efficacy were included in Step 1. In Step 2 we added collective threat and collective efficacy.[2] The dependent variable was again behavioral intention.

The full regression models can be seen in Table 4. In all three iterations of the model, adding collective-level variables led to a significant increase in adjusted R^2 (p's < 0.001). However, these increases were modest. All

[2] There were severe tolerance problems when the threat x efficacy x climate change belief interaction terms were included, so they were omitted.

Table 4 Regression equations evaluating the added benefit of including collective threat and efficacy to predict behavioral intentions

		All Participants			Climate Change Deniers			Climate Change Acknowledgers		
	Variable	**beta**	**95% CI lower bound**	**95% CI upper bound**	**beta**	**95% CI lower bound**	**95% CI upper bound**	**beta**	**95% CI lower bound**	**95% CI upper bound**
Model 1	Political leaning	-0.129[a]	-0.086	-0.056	-0.131[a]	-0.110	-0.052	-0.126[a]	-0.084	-0.049
	Belief in climate change	0.163[a]	0.283	0.403						
	Ethnicity	-0.007	-0.060	0.034	-0.009	-0.107	0.073	-0.010	-0.072	0.039
	Gender	0.032[a]	0.016	0.109	0.011	-0.064	0.107	0.048[a]	0.026	0.136
	Personal Threat	0.361[a]	0.333	0.393	0.459[a]	0.391	0.497	0.311[a]	0.294	0.367
	Personal Efficacy	0.296[a]	0.283	0.334	0.356[a]	0.293	0.408	0.3408	0.284	0.352
Model 2	Political leaning	-0.112[a]	-0.077	-0.046	-0.116[a]	-0.101	-0.043	-0.109[a]	-0.076	-0.040
	Belief in climate change	0.139[a]	0.232	0.354						
	Ethnicity	-0.004	-0.055	0.039	-0.009	-0.108	0.072	-0.005	-0.063	0.047
	Gender	0.030[a]	0.013	0.105	0.009	-0.069	0.101	0.047[a]	0.024	0.133
	Personal Threat	0.273[a]	0.234	0.317	0.325[a]	0.233	0.395	0.248[a]	0.215	0.312
	Personal Efficacy	0.263[a]	0.241	0.309	0.330[a]	0.247	0.403	0.296[a]	0.234	0.318
	Collective Threat	0.120[a]	0.077	0.167	0.169[a]	0.074	0.235	0.091[a]	0.054	0.164
	Collective Efficacy	0.500[a]	0.016	0.086	0.054	-0.028	0.126	0.088[a]	0.040	0.132
		Adj R^2	F R^2 change	p R^2 change	Adj R^2	F R^2 change	p R^2 change	Adj R^2	F R^2 change	p R^2 change
Model 1		0.462	457.21	< 0.001	0.426	139.789	< 0.001	0.284	172.698	< 0.001
Model 2		0.468	16.086	< 0.001	0.434	6.155	< 0.001	0.293	12.225	< 0.001

[a] CI does not include 0

Table 5 Percent of variance in behavioral intentions explained by personal- vs collective-level threat and efficacy

	All participants	Climate Change Deniers	Climate Change Acknowledgers
	Adj R^2	Adj R^2	Adj R^2
Personal variables only	0.462	0.426	0.284
Collective variables only	0.400	0.365	0.194
Combined personal and collective	0.459	0.430	0.273

personal-level variables significantly predicted behavioral intentions, and remained significant when collective-level variables were included. Collective-level variables were also significant predictors of behavioral intention, meaning they predicted variability in behavioral intentions above and beyond personal-level threat and efficacy.

When the data were split by climate change belief, collective threat remained significant for both groups. However, collective efficacy did not predict behavioral intentions for deniers ($p=0.211$), while it positively predicted behavioral intentions for acknowledgers.

We also contrasted the variance explained by regression equations that included only person-level variables, only collective-level variables, and both (see Table 5). Whether looking at the entire sample or split by climate change belief, the combination of personal and collective explained roughly the same percentage of variance as models that only included personal-level variables. In sum, collective-level variables predicted independent variance in behavioral intentions, but did not really improve overall model fit.

Can threat, efficacy, and behavioral intentions be shifted through climate messaging?

To evaluate the malleability of threat, efficacy, and behavioral intentions we pursued 2 strategies: we looked at the inferential statistics and effect sizes in each study separately, and also used the combined data set of all seven experiments.

Results of individual studies

For each experiment, we conducted a series of 2-way ANCOVAs evaluating the impact of various messaging (condition) on climate change deniers and acknowledgers. Dependent variables were threat, efficacy, and behavioral intentions. In all analyses we controlled for ethnic identity, gender, and political leaning. A complete summary of the results for each study can be found in Additional file 1.

We found results at least partially consistent with our hypothesized effects for Study 1 (efficacy and behavioral intentions were higher in response to a message about air quality recovery during the COVID lock-down); Study 3 (White participants who read about racial disparities of climate impacts had lower behavioral intentions); Study 4 (efficacy and behavioral intentions were higher for those who read about scientists' accurate predictions about COVID or climate change); and Study 7 (threat marginally increased for those imagining a negative future, efficacy increased for those imagining a positive future). Behavioral intentions increased significantly in two studies (Study 1 and Study 4) and decreased in one study (Study 3, White participants only).

More commonly, however, our hypotheses were not supported. There were no significant effects of prospection (positive or negative) in Study 2; we did not increase threat appraisals and behavioral intentions among POC in Studies 3 and 6; we did not increase threat appraisals in Study 4; there were no significant changes in appraisals or behavioral intentions from reading about scientists' accuracy in Study 5; and there was no change in behavioral intentions as a result of prospection in Study 7.

We also computed simple effect sizes using Cohen's *d* by comparing each condition within a study to the control condition(s) in that study (in studies with more than one control condition they were combined together). We then categorized the remaining conditions based on the a priori predictions made before data was collected. We had four types of conditions: those designed to increase efficacy, those designed to increase threat, those designed to increase both efficacy and threat, and those with the potential to *decrease* threat (in Studies 3 & 6, White participants read that the impacts of climate change would be disproportionately felt by People of Color). The minimum number of participants in a condition was 108; the maximum was 1206. Figure 3 provides a summary of effect sizes within each condition averaged across studies for our three main dependent variables: threat, efficacy, and behavioral intentions. Additional file 1 presents the individual effect sizes for each condition in each study.

There is modest support for the malleability of appraisals. The conditions intended to enhance threat showed the largest increases in threat appraisals relative to the control conditions, average $d=0.208$. Similarly, the conditions intended to enhance efficacy showed the largest

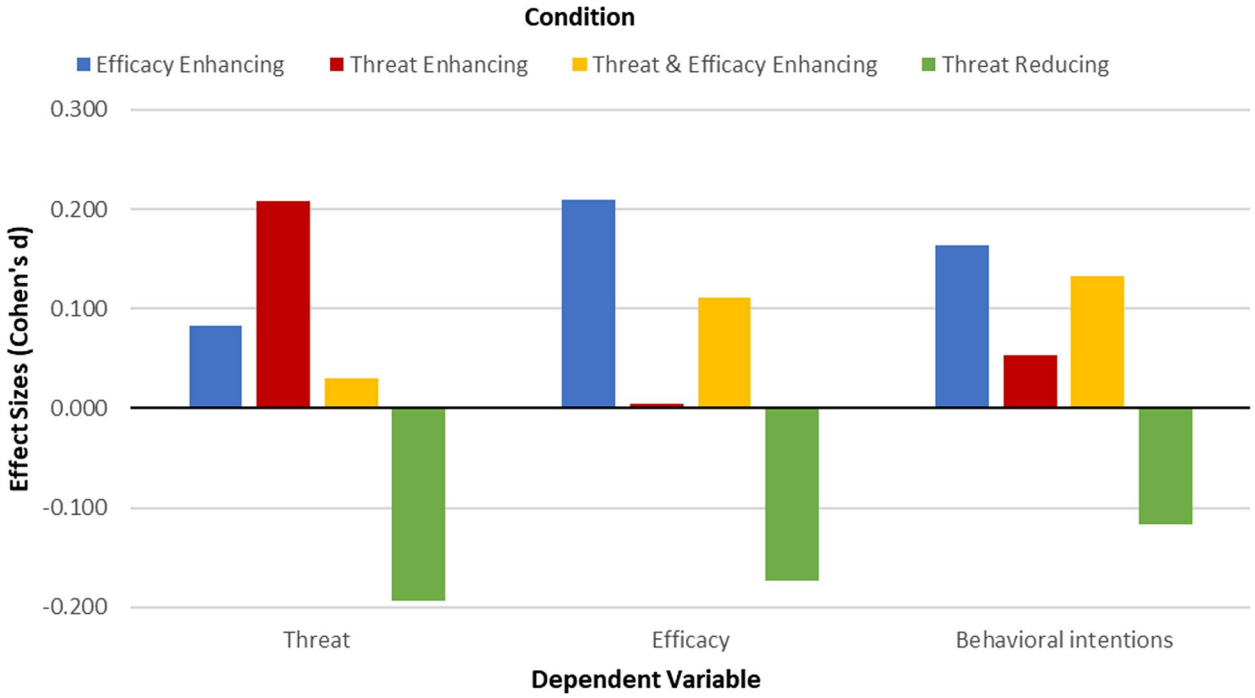

Fig. 3 Summary of effect sizes across seven studies. Each condition is contrasted to the control condition within each experiment, then effect sizes are averaged across experiments

Table 6 Results of 5 (Condition) by 2 (Climate change belief) ANCOVAs (controlling for gender and political leaning) for the combined data set

	Main Effect of Condition			Condition x CC belief interaction		
	F	*p*	η^2	*F*	*p*	η^2
Threat	4.911	< .001	0.005	2.014	0.09	0.002
Efficacy	2.015	0.09	0.002	1.725	0.141	0.002
Behavioral Intention	0.487	0.745	0.001	0.488	0.745	0.001

increases in efficacy appraisals relative to the control conditions, average $d = 0.209$. The effect sizes for behavioral intentions suggest that only those conditions that included an attempt to increase efficacy led to an increase in behavioral intentions (d's = 0.164 and 0.132 for efficacy and efficacy + threat conditions, respectively). All of these effect sizes are considered small by convention. Additionally, as noted above, within each study these effects often did not reach statistical significance.

Combined data set

Three 5 (Condition: control, efficacy boosting, threat boosting, efficacy & threat boosting, threat lowering) by 2 (climate change belief: Yes vs No) ANCOVAs (controlling for gender and political leaning)[3] were conducted on threat, efficacy, and behavioral intentions using data combined from all seven studies. Table 6 summarizes the ANCOVA results, and Figs. 4, 5 and 6 show the effects. (The main effect of climate change belief was significant for all three dependent variables, p's < 0.001; those acknowledging climate change reported higher levels of threat, efficacy, and behavioral intentions.)

For threat appraisals, there was a main effect of condition. The threat boosting condition had significantly higher threat appraisals than the control and threat + efficacy boosting conditions, and marginally higher threat appraisals than the efficacy boosting condition ($p = 0.056$) and threat reducing ($p = 0.052$) conditions. Interestingly, the efficacy-boosting condition had lower threat

[3] Ethnicity could not be included as a control variable because the threat-reducing condition consisted entirely of White people.

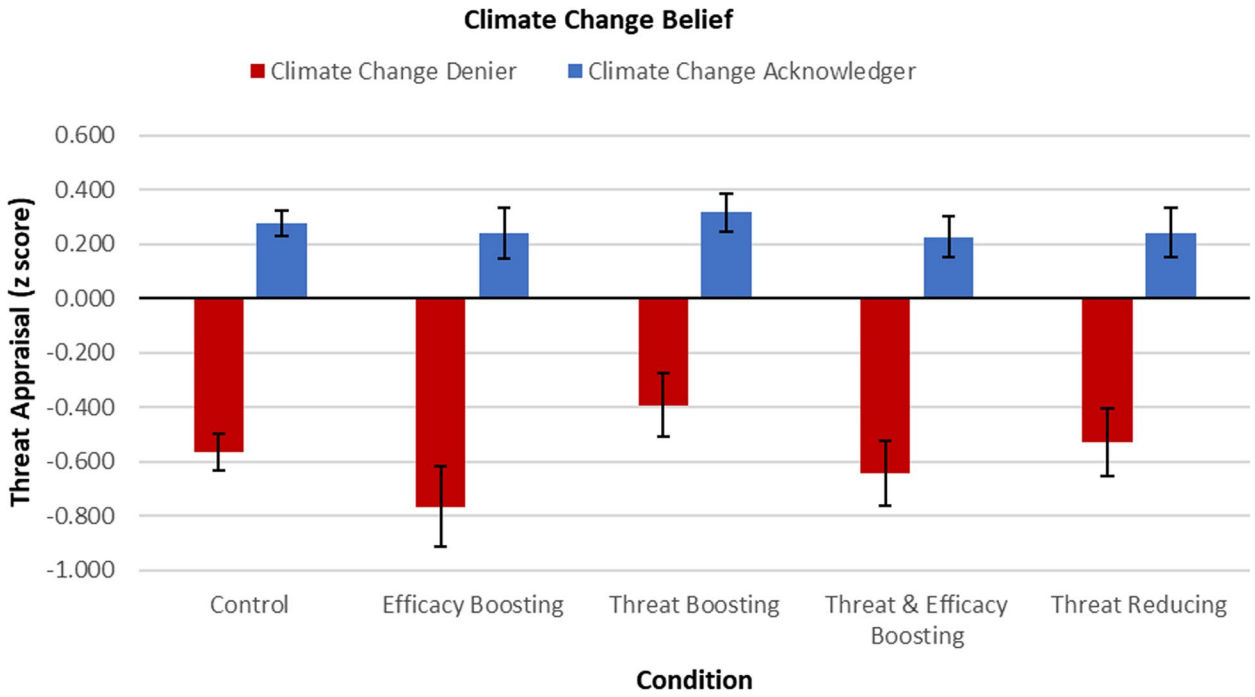

Fig. 4 Impact of condition and climate change belief on threat appraisals in combined data set

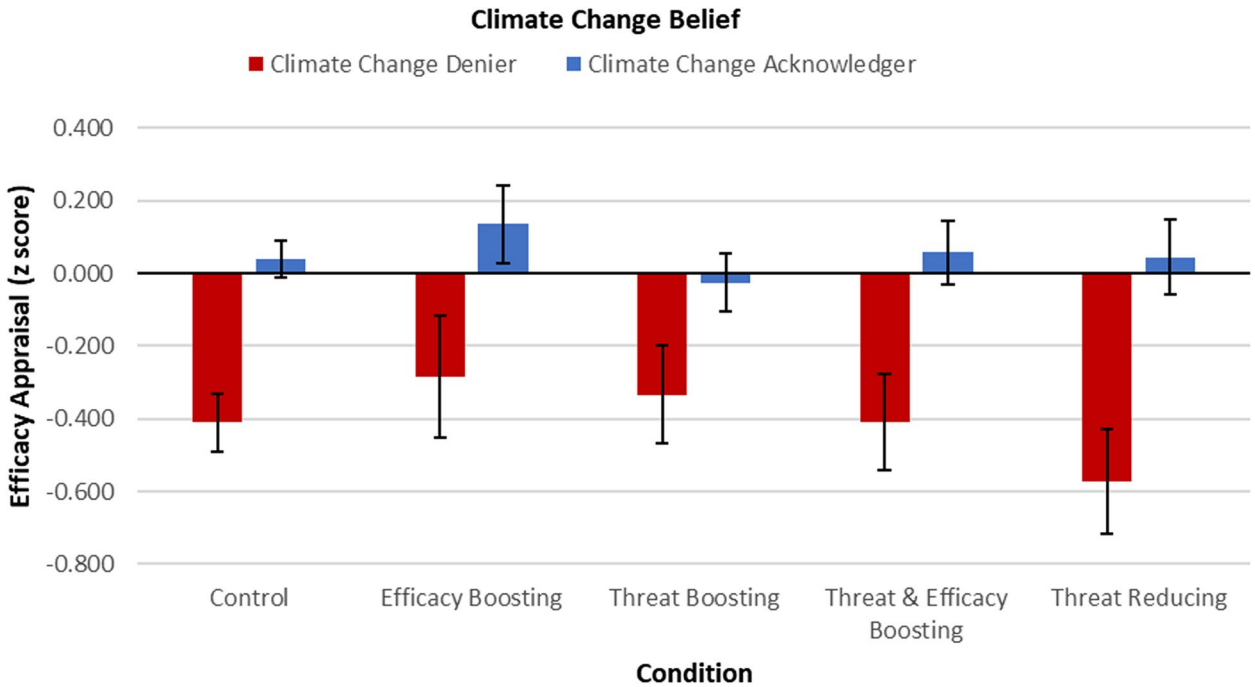

Fig. 5 Impact of condition and climate change belief on efficacy appraisals in combined data set

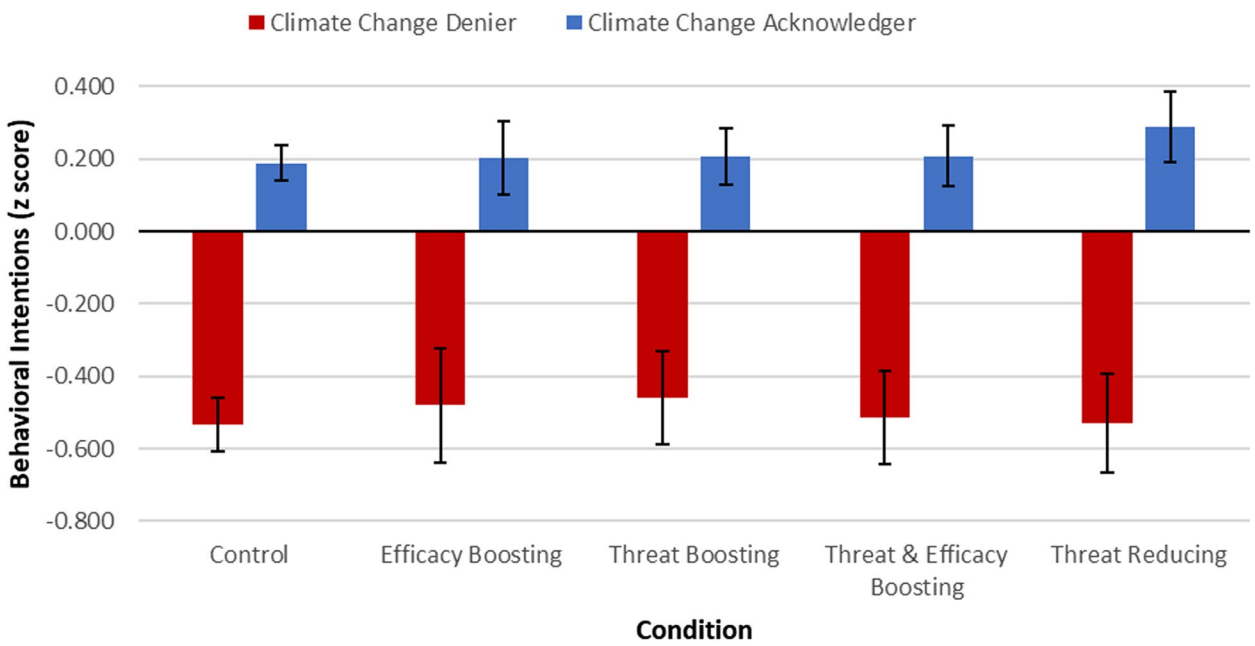

Fig. 6 Impact of condition and climate change belief on behavioral intentions in combined data set

appraisals than all other conditions (*p*'s ranged from 0.048—0.059).

The 2-way condition by climate change belief interaction (see Fig. 4) was marginal; simple comparisons revealed that the differences in threat appraisals between conditions happened primarily among climate change deniers.

For efficacy appraisals, there was a marginal main effect of condition (see Fig. 5). The efficacy-boosting condition significantly increased efficacy appraisals for both climate change deniers and acknowledgers, $p = 0.044$, relative to the control condition.

There was no main effect of condition or a condition by climate change belief interaction for behavioral intentions (see Fig. 6).

In sum, messaging designed to increase threat did seem to increase threat appraisals, primarily among climate change deniers. Messaging designed to increase efficacy did increase efficacy appraisals among both climate change deniers and acknowledgers. We found no evidence that messaging impacted behavioral intentions.

Discussion

The data presented above evaluated Protection Motivation Theory within the context of climate, and addressed five questions. Below we summarize the results and draw conclusions about each research question.

Does PMT predict behavioral intentions in the context of climate change?

The data suggest that PMT can be applied effectively to the context of climate change. While demographic information was important in predicting pro-environmental behavioral intentions, the inclusion of the PMT model variables significantly increased (nearly doubled) the variance explained in participants' climate mitigating behavioral intentions. This result is in line with other research on PMT and pro-environmental behavior [2].

Does PMT predict behavioral intentions for both climate change deniers and acknowledgers?

Our data allowed us to evaluate whether climate change deniers provide meaningful answers to questions about efficacy for addressing a threat they believe does not exist. We are unaware of any other published data sets that have analyzed climate deniers separately from acknowledgers, making this an important contribution of the present work. Across our sample of over 1000 climate change deniers, 5% of them chose the highest possible value for all efficacy items. Among these participants, threat appraisals still predicted behavioral intentions, just as PMT would predict. The other 95% of climate deniers used the full scale for efficacy, though on average

giving lower ratings across the board than climate change acknowledgers. Their efficacy ratings predicted behavioral intentions, as PMT predicts. This suggests that they engaged with the questions seriously, even though their answers were not consistent with their stated belief that climate change does not exist. Overall, PMT effectively predicted behavioral intentions for both climate change deniers and acknowledgers. In fact, the percentage of variance explained by our regression model was higher for climate change deniers (43%) than for acknowledgers (27%). It is possible climate change deniers think about climate change in a less nuanced way, making their responses easier to predict.

Are the effects of threat and efficacy additive or multiplicative?

The significant three-way interaction between threat, efficacy, and belief in climate change suggests that the effect of threat and efficacy is multiplicative, and that the pattern is different for deniers and acknowledgers. The variance explained by these interaction terms was quite small, so we do not wish to over-interpret the results. However, Fig. 2 suggests that among deniers, the combination of high threat and high efficacy is particularly potent; using median splits, the mean of this group was the only denier group above the grand mean for behavioral intentions. For acknowledgers, those high in efficacy and low in threat had slightly higher behavioral intentions than would be predicted by an additive model. This may suggest that among acknowledgers, efficacy buffers against the effects of perceiving low levels of threat; they are willing to act when they feel it will have a positive effect, even if their assessment of the threat is low. This is not true for deniers: they are willing to act primarily when both threat and efficacy are high. Again, we caution that these effects were quite small; replication will be important for establishing if they are reliable and meaningful.

Do collective threat and coping measures improve the model accuracy for a collective problem like climate change?

Our results suggest that adding collective efficacy and collective threat improved model accuracy significantly but very modestly. The regression equation that included both collective and individual factors explained only 2.8% more variance than the equation that included only personal-level variables. When comparing only personal-level variables to only collective-level variables, the personal-level variables clearly outperformed the collective ones.

This is in contrast to our expectations and to previous research [9, 28]. Because climate change is both a collective threat and a problem that can only be solved collectively, we anticipated that collective variables, particularly collective efficacy, would predict behavioral intentions better than personal-level variables did. Collective efficacy did not significantly predict behavior intentions for deniers. As expected, acknowledgers who had higher collective efficacy had higher behavioral intentions. However, this relationship was not nearly as strong as the one between personal efficacy and behavioral intentions. In sum, our data do not strongly argue for an important role for collective efficacy, at least under the conditions tested here.

One possible explanation for this surprising finding could be that the U.S. is a highly individualistic culture [35, 36]. It is possible that U.S. participants are less prone to think in terms of "we". Consistent with this explanation, Pakmehr et al [9] found that collective efficacy did predict the use of water adaptation strategies in Iran, a culture considered at least partially collectivist [37]. We also note that in our data, collective efficacy predicted behavior modestly among climate change acknowledgers. In the U.S., there is a correlation between liberalism and collectivism [38]. Liberals are more likely to believe in climate change, and thus make up the majority of our sample of climate change acknowledgers. The fact that collective efficacy predicts behavior among acknowledgers is also consistent with the idea that a collectivist identity may make collective efficacy more predictive. Future research could evaluate whether collectivist identity moderates the predictive ability of collective efficacy. This research should also be replicated in other cultural contexts.

Can threat, efficacy, and behavioral intentions be shifted through climate messaging?

Seven studies attempted to shift either threat appraisals, efficacy appraisals, or both. These studies represent very different approaches: imagining the future, messages that make comparisons to COVID 19, and highlighting racial disparities in the impacts of climate change. When analyzed separately and together, we found mixed support for the malleability of threat and efficacy appraisals. No one approach proved more successful than the other.

Threat appraisals were increased, but this was true primarily among deniers. A ceiling effect for threat appraisal may exist for acknowledgers, i.e. they already perceive climate change as the highest threat possible. Across all studies, efficacy appraisals were successfully increased by the conditions designed to do so (but not the conditions designed to increase both threat and efficacy). This effect held for both climate change deniers and acknowledgers.

Behavioral intentions were not significantly increased among either group by any condition. Across the board, effect sizes were quite small. Overall, we conclude that the interventions used in these studies were only partially effective at shifting threat and efficacy appraisals, and not at all successful at shifting behavioral intentions (which is ultimately the goal of climate messaging).

Caveats and future directions

There are a number of limitations to these studies that must be taken into account when drawing conclusions about our results. Most obviously, the sample consisted entirely of U.S. adults with internet access who were enrolled to participate in online studies (mostly through Mturk via CloudResearch). Online samples have been demonstrated to be reasonably representative for research on political issues [39] but they are still not fully representative [40]. Most pertinent to this research, our sample skewed liberal, with fewer climate change deniers than in the general population. It also exclusively represents US citizens; as discussed above the US is a highly individualistic culture, and also very polarized on climate change [41, 42]. These results may not generalize to samples taken from other cultural contexts.

Additionally, the context in which participants responded to questions about climate change was very abstract and hypothetical. Most North Americans are not directly dependent on weather patterns or other climatic processes for their livelihood. This likely results in a certain level of psychological distance from the threat of climate change. In contrast, some research has been conducted with people actively facing challenges caused by climate change (e.g., farmers in Africa [3] or Iran [43] coping with drought; people affected by severe storms [6]. This obviously creates a very different psychological reality. The studies referenced above found that threat appraisals tended to predict more strongly than efficacy appraisals. Recent research [7] suggests that climate experience, which is not part of the PMT model, may be one of the best predictors of intention to engage in mitigation or adaptation behaviors. Future research will need to determine whether people directly grappling with the effects of climate change are more (or less) influenced by messaging designed to influence their threat and efficacy appraisals.

In a similar vein, our studies did not measure actual behavior, but only behavioral intentions. While behavioral intentions are reliably significant predictors of actual behavior [44, 45] they are far from perfect. Bamberg & Moser [45] reported that behavioral intentions explained only 27% of the variance in behavior.

Conclusions

To summarize, Protection Motivation Theory successfully predicts climate change mitigation behavioral intentions among both climate change deniers and acknowledgers in a U.S. adult sample. The finding that PMT effectively predicts climate change mitigation behavioral intentions is a logical extension of previous research [2] demonstrating that PMT applies to pro-environmental behavior generally. Demonstrating that the model works well for climate change deniers and acknowledgers alike (better, in fact, for deniers) is a novel contribution of this work. A small percentage (5%) of climate change deniers responded using the highest possible scale points for efficacy questions, which is logically consistent with the belief that the threat of climate change does not exist (i.e., it is easy to address a problem that does not exist). The rest seemed to answer questions about threat and efficacy in much the same way those that acknowledge the reality of climate change did. Their means for threat, efficacy, and behavioral intentions were lower across the board, but these variables related to each other in ways that were identical to climate change acknowledgers. In fact, the relationships between the variables were stronger for climate change deniers than acknowledgers. We conclude that many climate change deniers do not answer survey questions in ways that are consistent with their stated disbelief. This is consistent with research demonstrating that views about climate change of the political right in the US are less stable than those of the left [46]. Perhaps their disbelief is primarily an expression of identity: the answer to the question "is human-caused climate change happening" is predetermined by their political orientation. Yet when invited to think about climate change beyond "is it real", most do so in ways that are similar to acknowledgers.

Another notable finding was that measures of collective threat and efficacy did not substantially improve the prediction of behavioral intentions. When compared to each other, personal-level variables outperformed the collective measures, and the additional variance explained by the collective measures was statistically significant but small. This is surprising because climate change is a collective problem; individual behaviors such as reducing air travel or meat consumption do not have an impact unless others also take action. Collective behaviors such as calling or writing elected officials about climate change are similarly ineffective unless others act. The highly individualistic nature of U.S.culture may explain these surprising findings, but this hypothesis needs further testing.

Finally, the manipulations evaluated in the seven studies reported here were only sporadically successful in shifting threat and efficacy appraisals, and effect sizes were small. It is possible that the manipulations were

simply ineffective, and that better-designed interventions would change how people think about climate change. However, it is also possible that climate change appraisals are not as malleable as appraisals that PMT research has traditionally focused on. Kothe et al. [2] found something similar: experimental efforts to shift appraisals related to environmental protection had mixed success. Our hypothesis was that the collective nature of environmental problems might explain the mixed results. Arguing against this interpretation, our studies measured collective appraisals and did not find that they significantly improved the prediction of behavioral intentions. However, it is also true that our manipulations did not specifically target collective appraisals. It is worth testing whether manipulations designed very explicitly to increase collective efficacy in particular might be effective. This might also increase the predictive power of collective-level variables.

The urgency of climate change necessitates the identification of communication strategies that motivate action. Our research suggests that Protection Motivation Theory has the potential to explain climate change mitigation behavior; whether this behavior can be increased through messages that increase efficacy and threat appraisals has yet to be determined.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40359-024-02088-8.

Supplementary Material 1.

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Authors' contributions
C.M.F. designed Studies 1, 2, 4, & 5, sought funding, oversaw all data collection, curated the data, conducted statistical analyses, and created the first draft of the paper. L.B. sought funding, designed, and collected data for Study 7, conducted statistical analyses, conducted the literature review, contributed to the first draft of the paper, and prepared all tables and figures. D.O. sought funding, designed, and collected data for Studies 3 & 6, conducted statistical analyses, and contributed to writing the first draft. All authors contributed to revisions. All authors read and approved the final manuscript.

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Data availability
The raw data file, metadata, and copies of surveys used to collect data are archived at DOI: https://doi.org/10.5061/dryad.3j9kd51tc.

Declarations

Ethics approval and consent to participate
All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. All experimental protocols were approved by the Institutional Review Board of Oberlin College. Informed consent was obtained from all individual participants included in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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