Journal of Environmental Psychology 79 (2022) 101728

Contents lists available at ScienceDirect

Journal of Environmental Psychology

journal homepage: www.elsevier.com/locate/jep

Exploring how climate change subjective attribution, personal experience with extremes, concern, and subjective knowledge relate to pro-environmental attitudes and behavioral intentions in the United States

Gabrielle Wong-Parodi [a,b,*], Nina Berlin Rubin [b]

[a] Earth Systems Science, Stanford University, 473 Via Ortega, Rm. 140, Stanford, CA, 94305-4216, USA
[b] Stanford Woods Institute for the Environment, Stanford University, 473 Via Ortega, Stanford, CA, 94305-4216, USA

ARTICLE INFO

Handling editor: Sander van der Linden

Keywords:
Subjective attribution
Wildfires
Coronavirus disease 2019 (COVID-19)
Personal experience
Pro-environmental attitudes
Behavioral intentions

ABSTRACT

Opportunity for direct experience with a range of climate change-related extremes is growing worldwide – from wildfires to transmissible disease. This experience may be associated with attributions to climate change, as well as with pro-environmental attitudes and behavioral intentions. Given the United States' (US) recent devastating wildfires and widespread coronavirus disease 2019 (COVID-19), we conducted two national surveys (study 1: n = 502, study 2: n = 1,493) of US adults examining how subjective attribution is associated with personal experience with extremes, as well as with concern and subjective knowledge about climate change. We also examine the extent to which these factors are associated with pro-environmental attitudes and behavioral intentions, and whether these relationships are amplified or attenuated by subjective attribution. We find that personal experience, concern, and subjective knowledge are associated with the belief that wildfires and COVID-19 are attributable to climate change. These in turn are all associated with pro-environmental attitudes (carbon tax policy support) and behavioral intentions (electric vehicle purchase). Subjective attribution of COVID-19 amplifies the positive relationship between personal experience with COVID-19 and electric vehicle purchase intentions (study 1 and 2), and subjective attribution of wildfire or COVID-19 amplifies the positive relationship between subjective knowledge and carbon tax policy support (study 2). These findings highlight the importance of personal experience and subjective attributions as they relate to individuals' intentions to perform pro-environmental actions and support policy.

1. Introduction

A growing number of people are personally experiencing climate change-associated impacts such as extreme weather events (McClure & Jaffe, 2018; Radeloff et al., 2018; Syphard et al., 2019; Westerling, Turner, Smithwick, Romme, & Ryan, 2011) and extreme transmissible disease outbreaks (Smith et al., 2014; Wu, Lu, Zhou, Chen, & Xu, 2016). Direct personal experience with these extremes may provide powerful evidence for individuals that climate change is happening, potentially influencing pro-environmental attitudes and behavioral intentions, and ultimately motivating the adoption of pro-environmental behaviors essential for climate change mitigation. One potential key link between personal experience and subsequent pro-environmental attitudes, intentions, and behaviors is subjective attribution – an understanding that an extreme event is caused by or signals climate change (Ogunbode, Doran, & Böhm, 2020), with recent evidence suggesting subjective attribution is positively associated with pro-environmental behavioral intentions (Ogunbode, Böhm, et al., 2019). In this paper, we explore how subjective attribution is associated with personal experience with extremes, as well as with concern and subjective knowledge about climate change. We also explore the extent to which these factors are associated with pro-environmental attitudes and behavioral intentions, and whether these relationships are amplified or attenuated by subjective attribution.

In recent years, extreme wildfire events and transmissible disease have moved to the forefront of climate change-related phenomena imperiling populations worldwide. Extreme wildfire events have recently impacted communities from the western United States, to

* Corresponding author. Department of Earth System Science and the Woods Institute for the Environment, Stanford University, 473 Via Ortega, Stanford, CA, 94305, USA.
E-mail addresses: gwongpar@stanford.edu (G. Wong-Parodi), nberlin@stanford.edu (N. Berlin Rubin).

https://doi.org/10.1016/j.jenvp.2021.101728
Received 5 March 2021; Received in revised form 12 November 2021; Accepted 15 November 2021
Available online 19 November 2021

southeastern Australia, to the Brazilian Amazon (Congressional Research Service, 2021; Futurearth, 2020). Wildfires are projected to increase in intensity and frequency over this century (Dutta, Das, & Aryal, 2016; Flannigan et al., 2013; Westerling, Hidalgo, Cayan, & Swetnam, 2006), with potentially devastating ecological (e.g., reduction in evapotranspiration impacting precipitation in forests, release of carbon), economic (e.g., loss of property and industry), and social impacts (e.g., loss of life and property, premature deaths due to poor air quality, water contamination) (Futurearth, 2020). The incidence and prevalence of transmissible disease may be related to and increasing due to climate change and related ecological pressures (Smith et al., 2014; Wu et al., 2016). Very limited evidence suggests that the coronavirus disease 2019 (COVID-19) may also be related to climate change-related ecological pressures (Beyer, Manica, & Mora, 2021; Gorji & Gorji, 2021), which put more people in contact with insects and wildlife (as was the case with SARS, MERS, and the avian flu (Keni, Alexander, Nayak, Mudgal, & Nandakumar, 2020)). However, more scientific evidence is needed to establish this link with confidence. The impact of COVID-19 has been profound, with more than 250 million confirmed cases and more than 5 million deaths according to the World Health Organization at the time of writing this article (November 10, 2021) (WHO, 2021). The United States has had the highest numbers of cases and deaths, with more than 46 million confirmed cases and nearly 750 thousand deaths.

Therefore, we explore the relationships between personal experience, concern about climate change, subjective knowledge about climate change, subjective attribution, and pro-environmental attitudes and behavioral intentions in the United States (US). We chose the US for this study given the recent number of extreme wildfires and widespread COVID-19, and focused on a realistic pro-environmental attitude and behavioral intention: supporting carbon tax policy (Barron, Fawcett, Hafstead, McFarland, & Morris, 2018) and purchasing an electric vehicle (EV) (U.S. Department of Energy, 2020).

2. Key concepts

In this study we are primarily interested in how personal experience with and subjective attribution regarding specific extreme events are associated with **pro-environmental attitudes and behavioral intentions**. Specifically, we identify two foci for our study: carbon tax policy support (Boven, Ehret, & Sherman, 2018; Carattini, Kallbekken, & Orlov, 2019; Dolšak, Adolph, & Prakash, 2020; Drews & Van Den Bergh, 2015; Hagmann, Ho, & Loewenstein, 2019) and intention to purchase an electric vehicle (Rezvani, Jansson, & Bodin, 2015; Schuitema, Anable, Skippon, & Kinnear, 2013; Smith, Olaru, Jabeen, & Greaves, 2017; Spurlock et al., 2019), viewed as being important for addressing climate change and having been the focus of previous work on attitudes and behavioral intentions.

From an attribution theory perspective, the experience of a negative and unexpected outcome spurs the search for its cause (Weiner, 1985, 2006, 2011). Take for example an individual who suddenly loses power; all of their lights and appliances turn off. To determine the cause of this sudden loss of electricity, this individual may go outside to see if there are lights off in other homes in their neighborhood indicating a power outage, or go to their circuit breaker box to see if circuits were tripped. Any subsequent action taken, such as a call to the local electric utility company to report a power outage, or resetting circuit breakers, depends on which cause the individual attributed the issue to. This approach is driven by the desire to understand and master the environment, guiding future behavior that hopefully results in more effective management of the self and the environment (Weiner, 1985, 2011). This approach is also driven by the desire to understand other people's behavior, guiding interpersonal relationships that may support/maintain social systems or society (Weiner, 2011).

In this study we focus on wildfires and COVID-19 as recent unexpected and/or negative outcomes that many have personally or indirectly experienced. As described by attribution theory, individuals will have the tendency to try to understand the cause of these events. Whether their understanding of the cause is accurate or not, that understanding will affect subsequent behavior. One causal ascription that people may make regarding wildfires and COVID-19 is to climate change, lately referred to in the literature as **subjective attribution** (Ogunbode et al., 2020), defined as "a personal understanding that an *extreme weather event* is causally connected to climate change or is a sign of climate change" (p. 2245, Ogunbode et al., 2020). Here, we expand that definition to include any type of "extreme event," including extreme transmissible disease outbreaks. Ascribing these outcomes to climate change may subsequently result in the choice of actions to address the problem of climate change, such as the support of a carbon tax policy or intention to purchase an electric vehicle.

In a recent study, Lacroix, Gifford, and Rush (2020) found those with an above-average perception that climate change influences the frequency and intensity of forest fires expressed above-average support for climate policy at the beginning of forest fire season. However, this subjective attribution was not associated with change in policy support over time (Lacroix et al., 2020). Another recent study conducted in New Zealand found that subjective attribution of infectious disease to climate change was positively associated with climate change mitigation policy support and behavioral intentions (Thaker & Cook, 2021). In their measure of subjective attribution, the authors consistently used the term "infectious disease outbreaks" and at times used the term "coronavirus." Hence, given the timing of the study, the authors assumed participants had COVID-19 in mind when responding to the questions. Therefore, our aim here is to build on these recent findings and to further explore climate-relevant attitude (carbon tax policy support) and behavioral intention (electric vehicle intention) consequences of subjective attribution in the context of wildfires and COVID-19 in the US (Fig. 1; **Research Question 2(i)**); add to the growing body of literature on subjective attribution; and extend concepts from attribution theory to climate change.

3. Literature review

3.1. Subjective knowledge

Knowledge about environmental problems and potential solutions is arguably a necessary albeit insufficient precursor for pro-environmental behavior (Gifford & Nilsson, 2014). Indeed, prominent theoretical models such as Responsible Environmental Behavior (REB) (Hines, Hungerford, & Tomera, 1987) and Kollmuss's and Agyeman's (2002) model of pro-environmental behavior include knowledge as an important antecedent for pro-environmental behavior (Kollmuss & Agyeman, 2002). Hines et al. (1987), in a meta-analysis of 128 pro-environmental behavior studies, found that knowledge of environmental issues and/or knowledge of actions to address those issues, in addition to other key factors such as psychosocial, demographic, and situational factors, were positively associated with responsible environmental behavior. Thus, the REB model suggests that those expressing greater intent to act in an environmentally responsible manner are more likely to engage in an action, and that factors such as knowledge of the existence of an environmental problem and of actions to address the problem are precursors to action. In their examination of pro-environmental behavioral models, Kollmuss and Ageyman (2002) identify environmental knowledge as one common factor generally acknowledged to be associated with pro-environmental behavior, although environmental knowledge can only be directly linked to a small number of pro-environmental behaviors. Kollmuss's and Agyeman's model suggest that environmental knowledge together with values, attitudes, and emotional involvement comprise a certain "pro-environmental consciousness" embedded within individuals' broader set of values and personality traits and external factors (e.g., political situation, cultural factors). These factors may act synergistically to influence pro-environmental behavior. However, there are a number of barriers that can impede pro-environmental behavior,

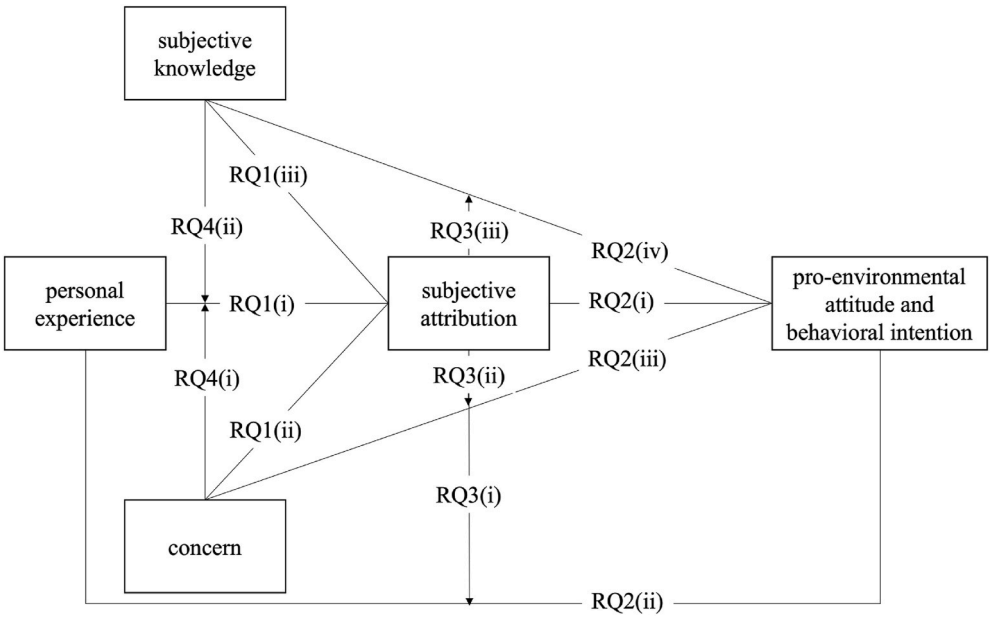

Fig. 1. Conceptual model showing research questions.

such as existing habits, or negatively impact environmental consciousness, such as lack of positive feedback for performing pro-environmental behaviors. Thus, these models suggest a relationship between environmental knowledge and pro-environmental behaviors, as well as with behavioral intentions (Fig. 1).

Environmental knowledge is generally assessed as either objective (i.e., measured knowledge) or subjective (i.e., perceived knowledge) (Ellen, 1994). A growing body of evidence suggests that objective knowledge across a range of environmental domains is positively associated with concern about climate change (Shi et al., 2016; van der Linden, 2015), pro-environmental attitudes (Aertsens, Mondelaers, Verbeke, Buysse, & van Huylenbroeck, 2011), and pro-environmental behaviors (Frick, Kaiser, & Wilson, 2004; Gifford & Nilsson, 2014; Pothitou, Hanna, & Chalvatzis, 2016; Siegel Levine & Strube, 2012). Indeed, Rotman, Weber, and Perkins (2020) found that those shown a video describing the mechanisms that underlie the greenhouse gas effect reported increased intent to perform sustainable behaviors and to make a charitable donation 6 weeks later (Rotman et al., 2020). Objective knowledge, preferably assessing different aspects of knowledge including cause, consequence, and positive action using multiple items, is generally thought to be a stronger assessment of knowledge (Shi et al., 2016; van der Linden, 2015) than single-item or self-report assessments.

Although subjective knowledge is a weak predictor of objective knowledge (Ellen, 1994), due most likely to people tending to inaccurately perceive how much they know (Casaló, Escario, & Rodriguez-Sanchez, 2019), subjective knowledge has also been found to be positively associated with pro-environmental attitudes (Aertsens et al., 2011), intentions (Fielding & Head, 2012), and behaviors (Aertsens et al., 2011; Casaló et al., 2019; Fielding & Head, 2012; Siegel Levine & Strube, 2012). In a recent representative national sample of 2,494 Spanish citizens, Casaló et al. (2019) found subjective knowledge to be positively associated with four surveyed pro-environmental behaviors, such as separating recycling and using energy-efficient light bulbs, whereas objective knowledge was found to only be associated with using energy-efficient light bulbs. Subjective knowledge may be more associated with regular, habitual pro-environmental behaviors (e.g., recycling), while objective knowledge may play a role in less common behaviors that necessitate deeper understanding of the link between personal action and environmental consequences. Furthermore, Ellen (1994) found that while subjective knowledge was associated with more pro-environmental behaviors, it wasn't clear whether people were choosing those behaviors that were the most effective or performing them well. Hence, more study is warranted to explore the relationship between subjective knowledge and less commonly acted upon pro-environmental attitudes and behaviors such as support for carbon tax policy or intention to purchase an electric vehicle (**Research Question 2(iv)**).

Acknowledging its limitations, we use subjective knowledge in this study as it has been found to be a predictor of pro-environmental attitudes and behavioral intentions. Subjective attribution can be accurate (e.g., anthropogenic climate change has increased wildfire activity in the western U.S.) or inaccurate (e.g., anthropogenic climate change has increased the frequency of meteor showers). If subjective knowledge is a good indicator of how much is known about the consequences of climate change, then we would expect that greater subjective knowledge would be associated with greater subjective attribution. Conversely, it is also likely given the observed weak link between subjective and objective knowledge (Ellen, 1994) that there would be no relationship between subjective knowledge and subjective attribution. These relationships will be interesting to examine as they have heretofore been largely unexplored, and especially so for wildfire and transmissible disease subjective attributions (**Research Question 1(iii)**).

3.2. Concern

While concern about environmental issues such as climate change is often studied (Shi et al., 2016) and seen as an important component of general environmental attitudes (Minton & Rose, 1997), it is typically not a strong predictor of pro-environmental behaviors (Gifford, 2011; Gifford & Nilsson, 2014) due to a multitude of structural (Hines et al., 1987) and psychological barriers (Gifford, 2011). Nevertheless, environmental concern can be viewed as a "general orientation pattern" that can direct behavior in certain situations (p. 21, Bamberg, 2003). Environmental concern has also been found to be indirectly associated with pro-environmental behaviors through behavioral intentions (Bamberg & Möser, 2007), and other attitudes such as support for environmental policy (Poortinga, Steg, & Vlek, 2004). Here we explore whether concern about climate change is associated with support for carbon tax policy or intention to purchase an electric vehicle, which would be consistent with previous findings (**Research Question 2(iii)**).

Concern about environmental issues has been found to be associated with stronger climate change beliefs (Hornsey, Harris, Bain, & Fielding,

2016) and greater knowledge (Malka, Krosnick, & Langer, 2009), at least among those who trust scientists on environmental issues and among Democrats and Independents. As subjective attribution in the case of our study is also indicative of perceived understanding about the consequences of climate change, those who express greater concern about climate change may also express higher levels of subjective attribution. As far as we are aware, the relationship between climate concern and subjective attribution is understudied, especially in the case of transmissible disease such as COVID-19 where people may be making the link to climate change whether it is supported by scientific evidence or not (**Research Question 1(ii)**).

3.3. Personal experience

As detailed in Marx et al. (2007), personal experience plays an important role in how information is *processed* (experiential processing) through the comparsion of past experience to a current situation, and subsequent plans of action are quickly assembled from past actions in similar situations. Personal experiences are particularly salient, as they can evoke strong emotions and ultimately weigh heavily in how information is processed. Moreover, people tend to rely more on personal experience rather than descriptions of a risk when making a decision (Marx et al., 2007). For example, having suffered health impacts from wildfire smoke exposure in the previous year may more strongly inform health protective behaviors taken this year than projections of low wildfire risk in an individual's area. Thus, it is likely that personal experience with climate-related extreme events would be associated with expressions of concern, perhaps insofar as individuals causally ascribe their experiences to climate change. Indeed, a growing body of evidence suggests that personal experience with climate change and extreme weather events such as wildfires, droughts, heatwaves, and storms are positively associated with concern, including sense of certainty (Myers, Maibach, Roser-Renouf, Akerlof, & Leiserowitz, 2013), about climate change (Demski, Capstick, Pidgeon, Sposato, & Spence, 2017; Krosnick, Holbrook, Lowe, & Visser, 2006; Myers et al., 2013; Reser, Bradley, & Ellul, 2014b; Reser, Bradley, Glendon, Ellul, & Gallaghan, 2012; Spence, Poortinga, Butler, & Pidgeon, 2011; Taylor, de Bruin, & Dessai, 2014; van der Linden, 2015, 2017; Wong-Parodi, 2020; Wong-Parodi & Feygina, 2018). Zanocco et al. (2018 and 2019) found that personal experience – specifically harm in the form of self-reported damages from extreme weather – was positively associated with attributing events to climate change. While it could be the case that these personal experiences confirm pre-existing values, attitudes, and beliefs regarding climate change through processes of motivated reasoning (Druckman & McGrath, 2019; Nisbet, Cooper, & Garrett, 2015), it would nonetheless be informative to explore whether there is a relationship between personal experience and subjective attribution, especially for COVID-19, which to many may appear to be very removed from climate change (**Research Question 1(i)**).

These studies underscore how personal experience may importantly be related to how people understand and see climate change (Reser et al., 2014), and subsequently how they respond to it. Evidence indicates that personal experience with extreme weather events may indirectly be associated with pro-environmental intentions (Demski et al., 2017; Spence et al., 2011). For example, Demski et al. (2017) found that personal experience with flooding was associated with greater behavioral intention to act on climate change (e.g., buy more energy efficient appliances, conserve energy), mediated through negative emotions about flooding, concern about climate change, and climate change issue salience. They also found a positive association between personal experience and support for climate policy (e.g., increase renewables through taxes), mediated by concern and issue salience. More research is needed to understand whether personal experience in other domains such as wildfires or infectious disease are also related to pro-environmental attitudes and behavioral intentions (**Research Question 2(ii)**).

Ogunbode, Demski, Capstick, and Sposato (2019) found that subjective attribution modulated the indirect relationship between personal experience with a flood and climate change mitigation intentions, as well as the indirect relationship between personal experience and climate policy support (Ogunbode, Demski, et al., 2019). Thus, in this study, we explore whether subjective attribution moderates any observed relationship between personal experience and pro-environmental attitudes and behavioral intentions in the context of wildfires and COVID-19 (**Research Question 3(i)**). We further explore whether subjective attribution moderates any observed relationships between subjective knowledge or concern and pro-environmental attitudes and behavioral intentions (**Research Questions 3(iii) and 3(ii)**). We are also interested in exploring whether subjective knowledge and concern may act as moderators of any observed relationship between personal experience and pro-environmental attitudes or behavioral intentions, given possible associations between subjective attribution and concern and subjective knowledge (**Research Questions 4(i) and 4 (ii)**).

4. Conceptual framework and research questions

Here we draw from the empirical literature, as well as from the rich tradition of theoretical frameworks and models such as attribution theory (Weiner, 1985, 2011), Responsible Environmental Behavior (Hines et al., 1987), and Kollmuss's and Agyeman's (2002) model of pro-environmental behavior, to construct a conceptual framework (Fig. 1) exploring how personal experience, subjective attribution, subjective knowledge about climate change, and concern about climate change are associated with pro-environmental attitude and behavioral intention. Specifically, we ask:

RQ1. What is the relationship of subjective attribution with (i) personal experience, (ii) concern, and (iii) subjective knowledge?
RQ2. What is the relationship of pro-environmental attitude/behavioral intention with (i) subjective attribution, (ii) personal experience, (iii) concern, and (iv) subjective knowledge?
RQ3. Does subjective attribution moderate the relationships of pro-environmental attitude/behavioral intention with (i) personal experience, (ii) concern, and (iii) subjective knowledge?
RQ4. Does (i) concern and (ii) subjective knowledge moderate the relationship between personal experience and subjective attribution?

Understanding these relationships, especially in the context of COVID-19, may yield insights into how individuals think about climate hazards and process and make sense of their personal experiences with a growing suite of extreme events. Furthermore, understanding whether subjective attribution, especially in the context of COVID-19, amplifies or attenuates important precursors of pro-environmental behavior may provide insight into not only understanding psychological processes aiding sustainability, but also potential pathways for more effective science communications.

We explore our research questions in two studies. Study 1 surveys a nationally representative sample of 502 American adults. Study 2 replicates the procedures of study 1 with a national sample of 1,493 American adults randomly assigned to take our survey. Each survey began with respondents being introduced to a short vignette describing a hypothetical wildfire burning near where they were located. Respondents then completed a questionnaire assessing their personal experience with wildfire smoke and COVID-19, subjective knowledge regarding climate change, concern about climate change, wildfire and COVID-19 subjective attribution, carbon tax policy support (attitude), and intention to purchase an electric vehicle (behavioral intention).

5. Materials and methods

5.1. Study 1

5.1.1. Sampling

A nationally representative sample of 502 adults was surveyed using random digit dialing by ReconMR, a survey research firm based in the United States. Pilot interviews ($n = 43$) took place on May 28, May 30, and June 1, 2020 to train the interviewees and refine the survey instrument. Full fielding took place between June 8 and August 10, 2020, with a response rate of 22% for landline telephone interviews and 5% for cell phone interviews. Interviews took approximately 28 min to complete, and cell phone interviewees were compensated $10 upon request. A priori power analysis for multiple linear regression with a medium effect size (f^2=.15), power of .8, and alpha of .05 with 10 predictors suggested a sample size of 118. We oversampled to ensure that we had enough people who had personal experience with wildfire smoke and COVID-19.

5.1.2. Procedures

The interviews began with interviewers reading to the respondent a short vignette describing a hypothetical wildfire burning near where the respondent was located:

> *Imagine that a large wildfire burns about 50 miles from where you live for 17 days. The fire kills 85 people, burns more than 150,000 acres, and destroys more than 18,000 homes, businesses, schools, and other buildings. People hundreds of miles away smell smoke from the fire, and the smell of smoke is very strong for people living within 100 miles of it. The smoke near you is very thick for one week, and you can smell it getting into your clothes. If you go outside for a few minutes, your eyes sting and water, and your throat burns. During the day, the sky is so brown that you can't see the sun.*

Respondents then completed a questionnaire assessing their personal experience with wildfire smoke and COVID-19, concern about climate change, subjective knowledge regarding climate change, wildfire and COVID-19 subjective attribution, carbon tax policy support, and intention to purchase an electric vehicle. All procedures were approved by our organization's Institutional Review Board (IRB-56437) for applicable ethics policies, standards, and regulations, and respondents provided informed consent.

5.1.3. Measures

- *Subjective knowledge.* Subjective knowledge was assessed by asking participants to report how much they felt they knew about climate change, with a four-point response scale ranging from *nothing* to *a lot.* This item was reverse coded such that higher values indicated greater subjective knowledge.
- *Concern.* Concern was assessed by asking participants to report how serious of a problem climate change would be for the world if nothing was done to reduce it in the future, with a 4-point response scale ranging from *not serious at all* to *very serious.* This item was reverse coded such that higher values indicated greater concern.
- *Personal experience.* Personal experience was assessed by asking participants about their prior exposure. Personal experience with wildfire was assessed by asking participants if they had ever smelled wildfire smoke that lasted more than one week. Personal experience with COVID-19 was assessed by asking respondents if they had been told by a doctor or health professional that they had the coronavirus "going around now." For both measures, responses were coded as 0 (*have never experienced/been told that*) or 1 (*have experienced/been told that*). These items were developed by the authors and collaborators for this study.
- *Subjective attribution.* Wildfire subjective attribution was assessed by asking the following question after reading the vignette, "If a fire like this were to happen near you, how likely do you think it is that global warming made it bigger than it would have been?" COVID-19 subjective attribution was assessed by asking, "How likely is it that the coronavirus pandemic has been made worse by global warming?" Both items had a five-point response scale ranging from *not likely at all* to *extremely likely*, and were reverse coded so that a higher value represented greater likelihood. These items were developed by the authors and collaborators for this study.
- *Pro-environmental attitude.* To measure pro-environmental attitudes, policy support for a carbon tax were assessed. Participants responded whether they thought the government should (coded as 1) or should not (coded as 0) charge companies that emit greenhouse gases a tax on their emissions by ton after reading information describing how burning oil, coal, and natural gas emits greenhouse gases and what a carbon tax would entail. This item included an experimental component. Three-quarters of respondents were told that the government would distribute increasing annual payments to American adults and children from this taxation to offset the higher costs that companies may charge consumers for products given the increased taxes on their emissions. One-quarter of participants were told this payment would be $200 next year, one-quarter were told $600, and one-quarter were told $800. The remaining quarter of respondents were not told that the government would provide payments to Americans in advance of asking them whether the government should or should not charge this tax. Responses for each of the experimental groups were considered together.
- *Pro-environmental behavioral intention.* To assess pro-environmental behavioral intention, participants who reported that they intended to buy a car in the future ($n = 339$) were asked if they would consider buying a car that runs only on electricity when they next purchase a car. Responses were coded as 0 (*will not consider*) or 1 (*will consider*).
- *Demographics.* Participants also answered demographic questions and identified their sex, age, income, combined race and ethnicity, educational attainment, and political party affiliation.

Subjective knowledge, concern, and pro-environmental attitude and behavioral intention are questions/items developed by Krosnick et al. with Resources for the FutureKrosnick, MacInnis, and McDonald (2021).

5.1.4. Weighting

Post-stratification weights were iteratively constructed from respondents' design weights, using probability estimates based on multiple demographic characteristics (age, sex, education, census region, combined race and ethnicity, and telephone use), region of residence, and phone type (cellphone or landline). These weights then adjust for discrepancies between the final obtained sample and U.S. Census benchmarks, so as to enable population-based inferences. The final weighted sample closely matches data from the March 2020 Current Population Survey (U.S. Census Bureau, 2019) for distributions of age, sex, education, census region, and combined race and ethnicity, and data for the first six months of 2019 on telephone use by the National Center for Health Statistics (Blumberg & Luke, 2020). Unless otherwise indicated, all descriptive and inferential statistics were weighted using study-specific post-stratification weights.

5.1.5. Statistical analyses

Analyses were conducted using Stata (version 16.0; StataCorp). To explore RQ1(i-iii), ordinary least squares (OLS) regression analysis was used to predict subjective attribution by personal experience, concern, and subjective knowledge. To explore RQ2(i-iv), logistic regression analysis was used to predict pro-environmental attitude and pro-environmental behavioral intention by subjective attribution, personal experience, concern, and subjective knowledge. To explore RQ3(i-iii), logistic regression analysis was used to predict pro-environmental

attitude and pro-environmental behavioral intention by subjective attribution interacted separately with personal experience, concern, and subjective knowledge. To explore RQ4(i-ii), OLS regression analysis was used to predict subjective attribution with personal experience interacted separately with concern and subjective knowledge. All analyses controlled for age, sex, income, combined race and ethnicity, education, and political party affiliation, and were performed separately for wildfire and COVID-19. Models were run using multiple imputation by chained equations to account for missing responses in the dataset. All models used a total of 100 imputations. Imputed estimates for wildfire personal experience (0.81% of sample), COVID-19 personal experience (1.42%), pro-environmental attitude (4.26%), wildfire subjective attribution (2.03%), COVID-19 subjective attribution (4.67%), concern (1.01%), and subjective knowledge (0.41%) were generated based on demographics (sex, age, race/ethnicity, education, state, income, and political party). Analyses for RQ2(i) and RQ4(i-ii) were pre-registered prior to data analysis at the Center for Open Science: https://osf.io/48rzh/?view_only=ed9bd3b5ab704f95a9766526bd4d79ca. Additional analyses for RQ1(i-iv), RQ2(ii-iii), and RQ3(i-iii) were not explicitly stated in our pre-analysis plan. We use the Benjamini-Hochberg correction with a q-value (or, false discovery rate adjusted p-value) cutoff of < 0.05 given the multiple tests performed.

5.1.6. Participants

The final representative sample of 502 individuals included a roughly equal proportion of males and females (50.3% female), with an average age of 47.7 years ($SD = 19.1$), and a mean household income of between $50,000 and $75,000. The majority of the sample identified as White (71.9%), while the remaining participants identified themselves as Black or African American (13.3%), American Indian or Alaska Native (1.8%), Asian (1.5%), Native Hawaiian or Other Pacific Islander (0.6%), other (2.9%), two or more identities (6.5%), or missing/refused (1.6%). Slightly more than half of the sample had not completed college (52.1%). In terms of political party affiliation, 33.4% of participants identified as Democrats, 20.0% as Republicans, 32.6% as Independents, 10.1% as other, and 3.9% as unsure or refused.

5.2. Study 2

5.2.1. Sampling

Respondents were randomly recruited from a panel of volunteer participants maintained by Dynata, a survey research company based in the United States. A total of 1,493 adults completed the survey through the online survey platform, Qualtrics, between August 11, 2020 and August 25, 2020, with a response rate of 3%. The survey took approximately 17 min to complete, and participants were compensated panel points equivalent to $1.50. See section 5.1.1for discussion on sample size determination.

5.2.2. Procedures, measures, weighting and statistical analyses

The procedures, measures, and statistical analyses for study 2 were identical to study 1 (section 5.1.25.1.2) but were conducted online rather than by phone and the analyses were conducted unweighted. The 1,089 respondents who reported they intended to buy a car in the future were asked if they would consider buying a car that runs only on electricity when they next purchase a car to assess *pro-environmental behavioral intention*. Multiple imputation by chained equations was used to impute estimates for carbon tax attitudes (0.13% of sample), and wildfire attribution (0.07%) based on demographics (sex, age, race/ethnicity, education, state, income, and political party).

5.2.3. Participants

Study 2 included a total of 1,493 individuals, with slightly more females than males (57.2% female). Mean age in the sample was 50.3 years ($SD = 16.6$) and average household income was between $50,000 and $75,000. Most of the sample identified as White (80.8%), while 8.5% identified as Black or African American, 1.4% as American Indian or Alaska Native, 6.5% as Asian, 0.6% as Native Hawaiian or Other Pacific Islander, and 2.3% as two or more identities. More than half of the sample had received at least an associate degree (52.5%). With respect to political party, 32.6% of participants reported they were Democrats, 31.5% as Republicans, 29.4% as Independents, and 6.4% as other.

6. Results

6.1. Descriptive statistics

Roughly a quarter of participants reported personal experience with wildfire through prolonged exposure to wildfire smoke (study 1: 23.8%; study 2: 23.8%), with much fewer indicating they had contracted COVID-19 (study 1: 3.8%; study 2: 8.3%). On average, participants were moderately concerned about climate change (study 1: $M = 3.19$, $SE = 0.07$; study 2: $M = 3.11$, $SE = 0.03$), reported moderate levels of subjective knowledge about climate change (study 1: $M = 3.01$, $SE = 0.05$; study 2: $M = 2.71$, $SE = 0.02$), expressed moderate levels of wildfire subjective attribution (study 1: $M = 3.07$, $SE = 0.09$; study 2: $M = 2.97$, $SE = 0.04$), and expressed lower levels of COVID-19 subjective attribution (study 1: $M = 2.08$, $SE = 0.07$; study 2: $M = 2.42$, $SE = 0.04$). Of those who intended to purchase a vehicle in the future, 57.7% of participants in study 1 and 46.8% in study 2 indicated that they would consider purchasing an electric vehicle. The majority of participants expressed support for a carbon tax (study 1: 63.5%; study 2: 69.7%). (See Appendix for descriptive statistics).

Two-sided t-tests comparing means between study 1 and study 2 on the variables of interest were conducted on the datasets prior to multiple imputation. Results indicated that participants reported significantly higher subjective knowledge about climate change in study 1 compared to study 2, while participants in study 2 expressed COVID-19 subjective attribution significantly more than those in study 1. A two-sample *t*-test comparing proportions suggests that significantly more participants in study 2 reported contracting coronavirus disease than in study 1. Additionally, findings demonstrate that significantly more participants in study 1 would consider purchasing an electric vehicle than in study 2, while significantly more participants in study 2 expressed support for a carbon tax than in study 1. (See Appendix for study 1 and 2 comparisons and correlation matrix of key study measures).

6.2. Personal experience, concern, and subject knowledge predict subjective attributions

On balance, personal experience, concern, and subjective knowledge were associated with wildfire and COVID-19 subjective attribution. Across both studies, greater concern was associated with both stronger wildfire subjective attribution (study 1: $B = 0.79$; 95% CI: 0.67–0.90; $q < 0.001$; study 2: $B = 0.76$; 95% CI: 0.70–0.82; $q < 0.001$; see Table 1, Model 2) and COVID-19 subjective attribution (study 1: $B = 0.42$; 95% CI: 0.30–0.54; $q < 0.001$; study 2: 0.51; 95% CI: 0.44–0.57; $q < 0.001$; see Table 1, Model 2). Personal experience was associated with stronger wildfire subjective attribution ($B = 0.40$; 95% CI: 0.23–0.56; $q < 0.001$; see Table 1, Model 1) and stronger COVID-19 subjective attribution ($B = 1.10$; 95% CI: 0.86–1.35; $q < 0.001$; see Table 1, Model 1) in study 2 but not study 1. Greater subjective knowledge was associated with stronger wildfire subjective attribution ($B = 0.49$; 95% CI: 0.41–0.57; $q < 0.001$; see Table 1, Model 3) and stronger COVID-19 subjective attribution ($B = 0.36$; 95% CI: 0.28–0.44; $q < 0.001$; see Table 1, Model 3) in study 2 but not study 1.

Table 1
OLS regression models with concern and subjective knowledge interacted with personal experience separately predicting subjective attribution of wildfire and COVID-19. Regression coefficients displayed, q-values (false discovery adjusted p-values) in brackets.

	Wildfire subjective attribution				COVID-19 subjective attribution			
	Study 1		Study 2		Study 1		Study 2	
Model 1								
Personal experience	−0.07 [.799]		0.40 [<.001]		0.57 [.470]		1.10 [<.001]	
Model 2								
Concern	0.79 [<.001]	0.74 [<.001]	0.76 [<.001]	0.74 [<.001]	0.42 [<.001]	0.41 [<.001]	0.51 [<.001]	0.46 [<.001]
Personal experience		−0.54 [.089]		0.08 [.780]		−0.29 [.768]		0.05 [.924]
Concern x experience		0.17 [.126]		0.05 [.499]		0.25 [.540]		0.28 [.037]
Model 3								
Subjective knowledge	0.18 [.179]	0.18 [.252]	0.49 [<.001]	0.40 [<.001]	0.17 [.170]	0.13 [.341]	0.36 [<.001]	0.28 [<.001]
Personal experience		−0.32 [.808]		−0.52 [.103]		−2.83 [.126]		−0.43 [.398]
Knowledge x experience		0.07 [.889]		0.28 [.007]		1.10 [.106]		0.47 [<.001]

Note: All models control for age, sex, income, combined race and ethnicity, education, and political party affiliation (see Appendix for expanded tables).

6.3. Stronger subjective attributions, personal experience, concern, and subjective knowledge are associated with greater pro-environmental attitude and behavioral intention

On balance, stronger subjective attribution for both wildfires and COVID-19 was associated with higher odds of pro-environmental attitude and behavioral intention. Across both studies, the odds of intention to make one's next vehicle purchase electric (study 1: $OR = 1.79$; 95% CI: 1.37–2.34; $q < 0.001$; study 2: $OR = 1.56$; 95% CI: 1.41–1.73; $q < 0.001$) and support for a carbon tax (study 1: $OR = 1.77$; 95% CI: 1.40–2.25; $q < 0.001$; study 2: $OR = 1.71$; 95% CI: 1.56–1.89; $q < 0.001$) (Table 2, Model 1) were higher among those expressing greater wildfire subjective attribution. For study 2 but not for study 1, greater COVID-19 subjective attribution was associated with greater odds of EV purchase intention ($OR = 1.46$; 95% CI: 1.31–1.61; $q < 0.001$) and support for a carbon tax ($OR = 1.64$; 95% CI: 1.48–1.82; $q < 0.001$) (Table 3, Model 1). In study 2, personal experience was associated with greater odds of EV purchase intention and support for a carbon tax. For study 2 but not for study 1, personal experience with wildfire was associated with greater odds of EV purchase intention ($OR = 2.10$; 95% CI: 1.55–2.84; $q < 0.001$) and support for a carbon tax ($OR = 1.74$; 95% CI: 1.30–2.34; $q < 0.001$) (Table 2, Model 2). For study 2 but not study 1, personal experience with COVID-19 was associated with greater odds of EV purchase intention ($OR = 3.13$; 95% CI: 1.87–5.25; $q < 0.001$) and support for a carbon tax ($OR = 2.84$; 95% CI: 1.68–4.80; $q < 0.001$) (Table 3, Model 2). Greater concern was associated with greater odds of pro-environmental attitude and behavioral intention. Greater concern was associated with greater odds of EV purchase intention (study 1: $OR = 3.00$; 95% CI: 2.04–4.40; $q < 0.001$; study 2: $OR = 1.90$; 95% CI: 1.62–2.23; $q < 0.001$) and support for a carbon tax (study 1: $OR = 3.07$; 95% CI: 2.26–4.16; $q < 0.001$; study 2: $OR = 2.99$; 95% CI: 2.59–3.44; $q < 0.001$) (Table 2, Model 3). Greater subjective knowledge was associated with greater odds of pro-environmental attitude and behavioral intention in one of the two studies. For study 2 but not study 1, greater knowledge was associated with higher odds of EV purchase intention ($OR = 1.88$; 95% CI: 1.58–2.23; $q < 0.001$) and support for a carbon tax ($OR = 1.46$; 95% CI: 1.27–1.69; $q < 0.001$) (Table 2, Model 4).

6.4. Subjective attribution moderates the relationship of pro-environmental attitude and behavioral intention with personal experience, subjective knowledge, and concern

In general, greater subjective attribution appeared to amplify the relationship between personal experience with COVID-19 through contracting the disease and pro-environmental behavioral intention. Greater wildfire or COVID-19 subjective attribution also appeared to amplify the relationship between subjective knowledge and pro-environmental attitude. Finally, greater COVID-19 subjective attribution appeared to attenuate the relationship between concern and pro-environmental attitude.

For study 2 but not study 1, wildfire subjective attribution moderated the relationship between subjective knowledge and support for a carbon tax ($OR = 1.19$; 95% CI: 1.07–1.32; $q = .003$; see Table 2, Model 4). At high levels of wildfire subjective attribution, having greater subjective knowledge was associated with a greater odds of support for a carbon tax than for those with low levels of wildfire subjective attribution (Fig. 2a). Across both studies, COVID-19 subjective attribution moderated the relationship between personal experience and EV purchase intentions (study 1: $OR = 28{,}100{,}000$; 95% CI: 572,704–1,380,000,000; $q < 0.001$[1]; study 2: $OR = 1.62$; 95% CI: 1.09–2.41; $q = .029$; see Table 3, Model 2). Specifically, at high levels of COVID-19 subjective attribution, having had COVID-19 was associated with a greater odds of intending to purchase an EV than for those with low levels of COVID-19 subjective attribution (Fig. 2e and f). For study 2 but not study 1, COVID-19 subjective attribution moderated the relationship between subjective knowledge and support for a carbon tax ($OR = 1.15$; 95% CI: 1.03–1.28; $q = .028$; see Table 3, Model 4). At high levels of COVID-19 subjective attribution, having greater subjective knowledge was associated with a greater odds of support for carbon tax than for those with low levels of COVID-19 subjective attribution (Fig. 2b). For study 2 but not study 1, COVID-19 subjective attribution moderated the relationship between concern and support for a carbon tax ($OR = 0.88$; 95% CI: 0.79–0.99; $q = .042$; see Table 3, Model 3). However, the slope of the positive association between concern and support for a carbon tax is greatest for those with lower levels of COVID-19 subjective attribution (Fig. 2c).

6.5. Concern and subjective knowledge amplifies the relationship between personal experience and subjective attribution for wildfires and COVID-19

In general, greater concern and subjective knowledge appeared to amplify the relationship between personal experience – for wildfires through smoke exposure, or for COVID-19 through contracting the disease – and subjective attribution. (See Appendix Table 4 for results further exploring combinations of concern and subjective knowledge as a proxy for engagement interacted with personal experience on subjective attribution (Myers et al., 2013)).

For study 2 but not study 1, concern moderated the relationship between personal experience and COVID-19 subjective attribution ($B = 0.28$; 95% CI: 0.04–0.53; $q = .037$; see Table 1, Model 2). At high levels of concern, having had COVID-19 was associated with greater COVID-19 subjective attribution than for those who have not had the disease (Fig. 3a).

[1] Coefficients for personal experience x attribution predicting electric vehicle purchase intentions in study 1 should be interpreted with caution given the limited number of individuals (3.8%) reporting a diagnosis of COVID-19 in that sample and that 67.5% intended to purchase a new vehicle.

Table 2
Logistic regression models with wildfire personal experience, concern, and subjective knowledge interacted with wildfire subjective attribution separately predicting attitudes and behavioral intentions. Odds ratios displayed, q-values (false discovery adjusted p-values) in brackets.

	Attitude: Support for carbon tax				Behavioral intention: Electric vehicle purchase intention			
	Study 1		Study 2		Study 1		Study 2	
Model 1								
Subjective attribution	1.77 [<.001]		1.71 [<.001]		1.79 [<.001]		1.56 [<.001]	
Model 2								
Personal experience	0.90 [.842]	0.61 [.687]	1.74 [<.001]	1.03 [.933]	0.88 [.842]	0.51 [.687]	2.10 [<.001]	1.41 [.458]
Subjective attribution		1.70 [<.001]		1.64 [<.001]		1.70 [.004]		1.49 [<.001]
Experience x attribution		1.22 [.727]		1.14 [.342]		1.28 [.687]		1.10 [.494]
Model 3								
Concern	3.07 [<.001]	3.65 [<.001]	2.99 [<.001]	2.89 [<.001]	3.00 [<.001]	1.97 [.126]	1.90 [<.001]	1.65 [.006]
Subjective attribution		2.05 [.293]		1.38 [.103]		0.74 [.768]		1.54 [.060]
Concern x attribution		0.85 [.470]		0.96 [.497]		1.16 [.569]		0.96 [.614]
Model 4								
Subjective knowledge	1.14 [.764]	0.63 [.514]	1.46 [<.001]	0.80 [.194]	1.13 [.768]	1.05 [.943]	1.88 [<.001]	1.35 [.194]
Subjective attribution		0.92 [.943]		1.05 [.780]		1.82 [.540]		1.22 [.370]
Knowledge x attribution		1.24 [.459]		1.19 [.003]		0.99 [.968]		1.06 [.434]

Note: All models control for age, sex, income, combined race and ethnicity, education, and political party affiliation (see Appendix for expanded tables).

Table 3
Logistic regression models with COVID-19 personal experience, concern, and subjective knowledge interacted with COVID-19 subjective attribution separately predicting attitudes and behavioral intentions. Odds ratios displayed, q-values (false discovery adjusted p-values) in brackets.

	Attitude: Support for carbon tax				Behavioral intention: Electric vehicle purchase intention			
	Study 1		Study 2		Study 1		Study 2	
Model 1								
Subjective attribution	1.13 [.613]		1.64 [<.001]		1.39 [.069]		1.46 [<.001]	
Model 2								
Personal experience	0.93 [.943]	1.90 [.768]	2.84 [<.001]	1.79 [.434]	3.15 [.514]	0.00 [<.001]	3.13 [<.001]	0.44 [.333]
Subjective attribution		1.15 [.554]		1.60 [<.001]		1.38 [.093]		1.34 [<.001]
Experience x attribution		0.72 [.687]		0.99 [.961]		28100000 [<.001]		1.62 [.029]
Model 3								
Concern	3.07 [<.001]	4.00 [<.001]	2.99 [<.001]	3.49 [<.001]	3.00 [<.001]	3.05 [.009]	1.90 [<.001]	1.99 [<.001]
Subjective attribution		1.08 [.943]		1.85 [.001]		1.12 [.943]		1.74 [.021]
Concern x attribution		0.91 [.768]		0.88 [.042]		0.98 [.943]		0.92 [.225]
Model 4								
Subjective knowledge	1.14 [.764]	0.62 [.435]	1.46 [<.001]	0.97 [.892]	1.13 [.768]	0.82 [.799]	1.88 [<.001]	1.44 [.060]
Subjective attribution		0.40 [.252]		1.09 [.638]		0.88 [.931]		1.12 [.619]
Knowledge x attribution		1.40 [.170]		1.15 [.028]		1.16 [.687]		1.07 [.370]

Coefficients for personal experience x attribution predicting electric vehicle purchase intentions in study 1 should be interpreted with caution given the limited number of individuals (3.8%) reporting a diagnosis of COVID-19 in that sample and that 67.5% intended to purchase a new vehicle.
Note: All models control for age, sex, income, combined race and ethnicity, education, and political party affiliation (see Appendix for expanded tables).

For study 2 but not study 1, subjective knowledge moderated the relationship between personal experience and wildfire subjective attribution ($B = 0.28$; 95% CI: 0.09–0.46; $q < 0.001$; see Table 1, Model 3). At high levels of subjective knowledge, personal experience with wildfire was associated with greater wildfire subjective attribution than for those with no personal experience (Fig. 3c). In study 2, subjective knowledge moderated the relationship between personal experience and COVID-19 subjective attribution ($B = 0.47$; 95% CI: 0.21–0.73; $q < 0.001$; see Table 1, Model 3). Specifically, at high levels of subjective knowledge, having had COVID-19 was associated with higher COVID-19 subjective attribution than for those who have not had the disease (Fig. 3b).

7. Discussion

In two studies, we generally found that having stronger climate change concern was associated with a stronger belief that wildfires or COVID-19 were attributable to climate change (RQ1(ii)). We also found evidence in study 2 that having had COVID-19, experiencing prolonged exposure to wildfire smoke, and greater subjective knowledge about climate change were associated with a stronger belief that wildfires or COVID-19 were attributable to climate change (RQ1(i) and (iii)). Thus, these findings largely affirm previous work suggesting a positive link between concern with the attribution of extreme weather events to climate change (Reser et al., 2014; Zanocco et al., 2018, 2019). They also provide preliminary evidence suggesting a positive association between personal experience with infectious disease outbreaks like COVID-19 and wildfire smoke and subjective attribution to climate change. Our findings also offer preliminary evidence that higher self-reported knowledge about climate change is associated with the belief that specific events such as wildfires or COVID-19 are attributable to climate change. Subjective knowledge about climate change is not necessarily a good indicator of objective knowledge about climate change (Ellen, 1994), which may be why we see some inconsistencies in results between study 1 and 2. It is likely that the association between subjective attribution and objective knowledge would be stronger than for subjective knowledge, given that objective knowledge entails understanding the causes, consequences, and climate mitigation actions (Shi et al., 2016; van der Linden, 2015). The relationship between objective knowledge and subjective attribution warrants further investigation.

We found greater subjective attribution (RQ2(i); study 1 and 2) and personal experience (RQ2(ii); study 2) with COVID-19 or wildfires was associated with greater odds of support for a carbon tax policy and intention to purchase an electric vehicle. Thus, supporting recent work in the context of flooding (Ogunbode, Böhm, et al., 2019) and transmissible disease outbreaks (Thaker & Cook, 2021), our findings extend to the extremes of wildfire. Moreover, our findings offer additional

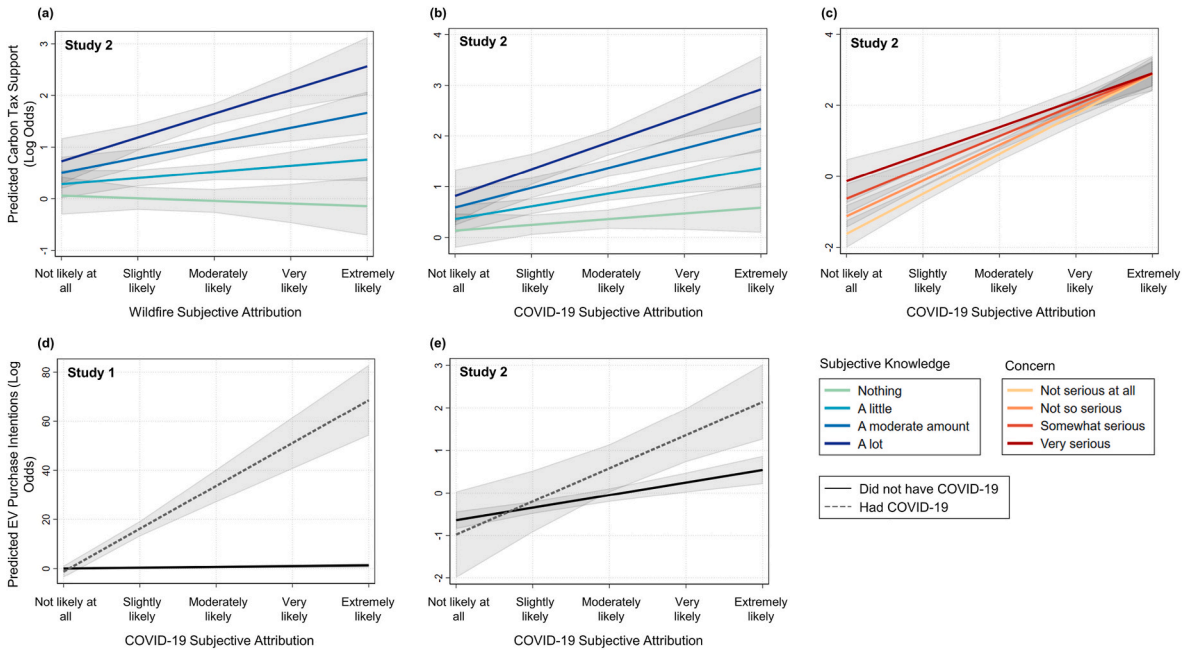

Fig. 2. Moderation of the relationship between pro-environmental attitude and behavioral intention with subjective knowledge, concern, and personal experience by subjective attribution. Panels a–b show the association between subjective knowledge and the log odds of support for a carbon tax, as moderated by wildfire and COVID-19 subjective attribution, respectively for study 2. Panel c displays the association between concern and the log odds of support for a carbon tax, as moderated by COVID-19 subjective attribution, for study 2. Panels d–e show the relationship between personal experience with COVID-19 and the log odds of intentions to purchase an electric vehicle, as moderated by COVID-19 subjective attribution for studies 1 and 2. Confidence intervals are displayed in gray.

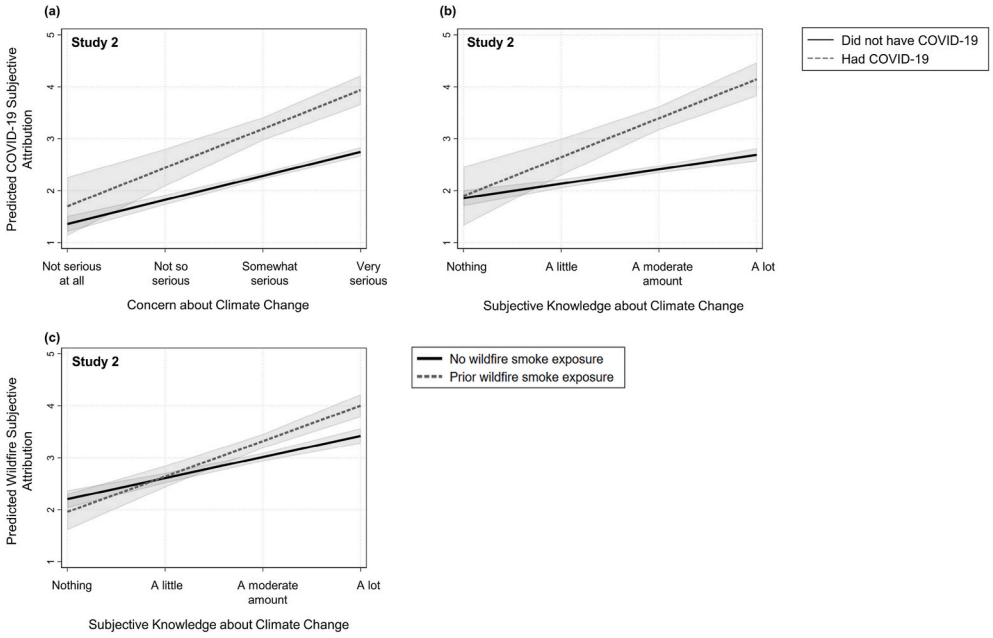

Fig. 3. Moderation of the relationships between personal experience and subjective attribution by concern and subjective knowledge for study 2. Panels a–b show that concern about climate change and subjective knowledge about climate change moderated the relationship between personal experience with COVID-19 and COVID-19 subjective attribution. Panel 3 demonstrates that subjective knowledge about climate change moderated the relationship between personal experience with wildfire and wildfire subjective attribution. Confidence intervals are displayed in gray.

support for the growing evidence suggesting that the extent to which people attribute events or their personal experiences to climate change may matter for pro-environmental attitudes and intentions. As has been in observed in previous studies, we also found concern (RQ2(iii); study 2) (Bamberg & Möser, 2007; Poortinga et al., 2004) and subjective knowledge (RQ(iv); study 2) (Aertsens et al., 2011; Fielding & Head, 2012) about climate change were associated with greater odds of support for carbon tax policy and intention to purchase an electric vehicle.

We found that greater COVID-19 subjective attribution amplified the positive relationship between having had COVID-19 and intention to purchase an electric vehicle (RQ3(i)). This work builds upon and extends previous research that found an indirect relationship between personal experience and pro-environmental behaviors in the context of flooding (Ogunbode, Demski, et al., 2019). We also found that greater subjective attribution of COVID-19 or wildfires amplified the positive relationship between subjective knowledge about climate change and support for a carbon tax in study 2 (RQ3(iii)). Previous research suggests indirect and direct relationships between subjective knowledge about climate change and pro-environmental attitudes, intentions, and behaviors (Aertsens et al., 2011; Casaló et al., 2019; Fielding & Head,

2012; Siegel Levine & Strube, 2012). Hence, our findings offer further support for the body of evidence finding a positive association between subjective knowledge and pro-environmental attitudes. However, as far as we are aware, we provide new evidence that understanding of that causal link – or attribution of specific extreme events like wildfires or COVID-19 – can amplify this relationship. Thus, both subjective knowledge and the belief that specific events are attributable to or are a sign of climate change may act together to strengthen pro-environmental attitudes.

Interestingly, we found that greater subjective attribution of COVID-19 attenuated the positive relationship between concern about climate change and support for a carbon tax (RQ(ii)). While this seems somewhat counterintuitive, closer inspection reveals that the pattern of findings largely fit with what might be expected. We observe a steeper increase in support for a carbon tax as concern increases among those expressing low levels of subjective attribution compared to those expressing high levels. Future study should further unpack these relationships to understand why subjective attribution appears to have a stronger association with pro-environmental attitudes like policy support at lower levels of concern about climate change.

Finally, we generally found that greater concern and subjective knowledge about climate change amplified the positive relationship between having had COVID-19 or prolonged exposure to wildfire smoke and subjective attribution of COVID-19 or wildfires in study 2 (RQ4(i-ii)). Our findings build on and expand scholarship demonstrating that personal experience with extreme weather events is positively associated with attribution of those events to climate change (Zanocco et al., 2018, 2019) to personal experience with extreme infectious disease outbreaks. While our data and study design do not allow us to assess causal pathways, the amplification of the relationships between personal experience and subjective attribution in the presence of greater concern and subjective knowledge suggest the importance of these perceptions in how people may interpret their experiences. Future research could examine these pathways using a prospective longitudinal or experimental design to further elucidate the relationships between subjective attribution, personal experience, subjective knowledge, and concern about climate change.

7.1. Limitations

While our studies have their strengths, including a large sample size (study 1: $n = 502$; study 2: $n = 1{,}493$) and a nationally representative sample (study 1), some weaknesses remain. First, while our nationally representative sample in study 1 allows us to make generalizations to the United States, its relatively small size limited our ability to obtain a substantial proportion of respondents with previous exposure to wildfire smoke or COVID-19. To address this concern, we replicated this study (study 2) with a national albeit not representative sample of Americans to ascertain if the patterns we observed in study 1 would also be observed with a larger sample. Indeed, the same pattern of results largely did emerge in study 2 and in study 1, enhancing our confidence in the results. Second, we did not assess whether exposure to prolonged wildfire smoke and COVID-19 diagnoses were perceived as negative experiences. Other research suggests that how people feel about their experiences can affect their responses (Grothmann & Patt, 2005), especially as it may relate to pro-environmental attitudes and intentions. Future studies could investigate how attribution beliefs may vary depending on the severity of adverse impacts or perceptions thereof in prior experiences (health impacts from wildfire smoke). Furthermore, future studies could explore the role of personal negative experience as a causal mechanism driving changes in attribution beliefs over time by using longitudinal datasets. Third, our design does not explicitly account for those who reject the premise that climate change is a real problem, likely associated with subjective attributions and pro-environmental attitudes and behavioral intentions. However, we do assess concern about climate change and control for political party affiliation which may serve as proxies for positions on the reality of climate change. Future studies could more explicitly explore positions on the reality of climate change, and how they may relate to subjective attributions and pro-environmental attitudes, intentions, and behaviors.

8. Conclusions

In summary, people's experiences and perceptions about climate change may inform how they understand extreme events. These experiences, perceptions, and processes, such as subjective attribution of extreme events to climate change, appear to be associated with pro-environmental attitudes and behavioral intentions across a range of extremes, including wildfire and COVID-19. Moreover, attribution of extreme events such as wildfires or COVID-19 to climate change may act to amplify the experiences that people have and what they believe they know about climate change. These results provide insight into the connections between personal experience with specific climate-related hazards, especially those that may seem more tangential, such as transmissible infectious disease, and perceptions with pro-environmental attitudes and behavioral intentions. Findings here demonstrate that public engagement initiatives may be enhanced by placing local, personal experiences with extreme events in the context of climate change in public-facing communications. Further, this study highlights the importance of personal experience and subjective attributions as they relate to individuals' intentions to perform pro-environmental actions and support policy.

Funding

This work was funded by the School of Earth, Energy, and Environmental Sciences and the Woods Institute for the Environment at Stanford University.

CRediT author statement

Gabrielle Wong-Parodi: Conceptualization, Methodology, Data analysis planning, Investigation, Writing - Original draft, Writing - Review & Editing, Project administration, Resources, Supervision, Funding acquisition. **Nina Berlin Rubin:** Data analysis, Writing - Original draft, Writing - Review & Editing.

Declaration of competing interest

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

Acknowledgements

The authors would like to acknowledge Jon Krosnick and Bo MacInnis for their invaluable and generous feedback on the development of the survey questions, for allowing the authors to use the survey questions they developed for the joint recruitment and survey efforts with Resources for the Future, and for providing the funding and support for the collection of the study 2 results. The authors would also like to thank Matt Berent for his assistance in collecting the study 2 results. Finally, the authors would like to thank Stephanie Fischer, Natalie Herbert, and the rest of the Behavioral Decisions and the Environment lab for their assistance and feedback.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2021.101728.

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