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Hurricane adaptation behaviors in Texas and Florida: Exploring the role of negative personal experience and subjective attribution to climate change

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Abstract

Understanding motivation to adopt personal household adaptation behaviors in the face of climate change-related hazards is essential for developing and implementing behaviorally realistic interventions that promote well-being and health. Escalating extreme weather events increase the number of those directly exposed and adversely impacted by climate change. But do people attribute these negative events to climate change? Such subjective attribution may be one cognitive process whereby the experience of negative climate change-related events may increase risk perceptions and motivate people to act. Here we surveyed a representative sample of 1,846 residents of Florida and Texas, many who had been repeatedly exposed to hurricanes on the Gulf Coast, facing the 2020 Atlantic hurricane season. We assessed prior hurricane negative personal experience, climate change-related subjective attribution (for hurricanes), risk appraisal (perceived probability and severity of a hurricane threat), hurricane adaptation appraisal (perceived efficacy of adaptation measures and self-efficacy to address the threat of hurricanes), and self-reported hurricane personal household adaptation. Our findings suggest that prior hurricane negative personal experiences and subjective attribution are associated with greater hurricane risk appraisal. Hurricane subjective attribution moderated the relationship between hurricane negative personal experiences and risk appraisal; in turn, negative hurricane personal experience, hurricane risk appraisal, and adaptation appraisal were positively associated with self-reported hurricane personal adaptation behaviors. Subjective attribution may be associated with elevated perceived risk for specific climate hazards. Communications that help people understand the link between their negative personal experiences (e.g., hurricanes) and climate change may help guide risk perceptions and motivate protective actions, particularly in areas with repeated exposure to threats.

Keywords

Climate adaptation; vulnerability; local adaptation strategies; disaster preparedness

1. Introduction

Understanding what motivates the public to adopt personal household adaptation behaviors (e.g., having an evacuation plan, purchasing flood insurance) in response to climate change-related hazards (e.g., extreme weather event) is essential for developing and implementing behaviorally realistic interventions to improve collective well-being and health. The experience of extreme weather (e.g., hurricanes) and other climate-related events, which are predicted to increase over this century [1], may be signals that climate change presents direct personal risks and motivate adaptive behaviors. Indeed, such perceptions are important antecedents of behaviors that mitigate harm from climate change-related hazards [2]–[7]. Subjective attribution [4], which research suggests is an important component of overall climate change perceptions [8], [9], is an understudied but potentially important cognitive process that may guide risk appraisal and the adoption of personal household adaptation behavior.

In this study, we examine how negative personal experience with climate change-related threats and subjective attribution are associated with appraisal processes and self-reported personal household adaptation behavior, expanding upon on Grothmann and Patt's (2005) process model of private proactive adaptation to climate change (MPPACC). We explored these relationships in the context of hurricanes, often associated with climate change in the media [10]. We focused on two self-reported personal household adaptation behaviors – anticipatory learning [11] and household protection – pertinent to hurricanes. These are actions that individuals can take in response to the impacts of climate change [12] and whose relationship to subjective attribution is understudied. At the time of our study, experts [13] projected four hurricanes would develop into major hurricanes – Categories 3, 4 or 5 – in the Atlantic with windspeeds of 111 miles per hour or higher. There was also a 69% chance that one of these would make landfall

along the U.S. coast, imperiling the Gulf Coast and Atlantic states. In this context, we surveyed a longitudinal, representative sample of 1,846 residents of Florida and Texas, many who had been repeatedly exposed to prior hurricanes on the Gulf Coast, facing the 2020 Atlantic hurricane season at the time of the survey.

2. Literature review

Climate change has contributed and will likely continue to contribute to the intensification of storm events like hurricanes due to warming temperatures [14]–[16]. Hence, experience with environmental extremes like a major hurricane or intense wildfire is one way individuals are exposed to the impacts of climate change [1]. Research suggests such experiences are often associated with climate change risk appraisals [7], [17]–[20] and adaptation intentions or self-reported adaptation behavior [7], [21]–[25], but not always [26]. For those experiences to be related to climate change risk appraisals, and ultimately adaptation behavior, individuals may need to make a *subjective attribution* [4] that their experiences with environmental extremes is caused by or a signal of climate change. For example, in a survey of 845 private forest owners, Blennow et al. (2012) found a positive association between extreme weather subjective attribution and self-reported adaptation of forest management measures in response to climate change [25]. Yet not all experience with extremes is equal: some may suffer from property loss or injury while others remain relatively unscathed. Those who suffer from a greater number of [27] negative outcomes resulting from hazard exposure tend to express greater hazard risk perceptions [28]–[30]. Thus, it is likely that greater negative experiences with major hurricanes will be associated with greater hurricane risk appraisal. Moreover, this pattern may be similar for subjective attribution; more negative experience with major hurricanes may be positively associated with greater hurricane subjective attribution.

Emerging evidence suggests that climate change beliefs are positively associated with perceptions about the severity of weather-related extremes, with perceptions of severity a key component of overall hazard risk appraisal [31]. Hoogendoorn et al. (2020) found the belief in anthropogenic climate change was positively associated with the perception that the impacts of the 2017 hurricane season in the United States to be worse and to have caused more suffering than they would have in the absence of climate change [32]. As subjective attribution of extreme weather events to climate change reflects beliefs about climate change, it is likely that greater hurricane subjective attribution agreement will be associated with greater hurricane risk appraisal. In the context of flooding, Ogunbode et al. (2019) found subjective attribution modulated the association between personal flooding experience and risk appraisal [4]. Those who expressed high or moderate levels of flooding subjective attribution held greater climate risk perceptions than those who expressed low levels of subjective attribution. Thus, hurricane subjective attribution may moderate the association between hurricane negative personal experience and hurricane risk appraisal.

Evidence suggests that negative personal experience with climate change-related hazards is associated with adaptive behavior, such as household protection. For example, Bradford et al. (2012) found greater flood experience was associated with more self-reported flood preparedness [33]. Osberghaus (2015) found self-reported flood-related household protections such as moving valuables or installing water barriers increased with previous flood damage experience [34]. In the context of landscape planning, Blennow et al. (2021) observed that negative, as well as positive, experience with climate change-related hazards was associated with climate adaptation [35]. Growing evidence also suggests that stronger risk appraisals (e.g., perceptions regarding the probability and severity [7], [31], [36] of a threat) and adaptation appraisals (e.g., perceptions

regarding the efficacy of adaptation measures and self-efficacy [35], [37]–[39] to deal with a threat) are associated with stronger adaptation intentions and behaviors, especially those related to household protection across a range of environmental threats. As such, hurricane negative personal experience, hurricane risk appraisal, and hurricane adaptation appraisal may be positively associated with hurricane personal household adaptation. While subjective attribution has been previously associated with environmental views such as support for climate policy [40], less is known about its relationship to personal household adaptation behaviors. Given the possible positive association between hurricane subjective attribution agreement and hurricane risk appraisal [8], [32], it is likely that greater subjective attribution agreement will be associated with greater self-reported hurricane personal household adaptation.

3. Research aims and hypotheses

This study aims to understand how hurricane negative personal experience relates to hurricane subjective attribution agreement and hurricane risk appraisal, and how these factors, along with hurricane adaptation appraisal, are associated with self-reported hurricane personal household adaptation. As shown in Figure 1, we hypothesize:

H1: Greater hurricane negative personal experience will be associated with greater hurricane subjective attribution agreement.

H2: Greater hurricane subjective attribution agreement will be associated with greater hurricane risk appraisal.

H3: (a) Greater hurricane negative personal experience will be associated with greater hurricane risk appraisal. **(b)** Hurricane subjective attribution will moderate the positive relationship between negative hurricane personal experience and hurricane risk appraisal.

H4: Greater hurricane **(a)** negative personal experience, **(b)** subjective attribution agreement, **(c)** risk appraisal, and **(d)** adaptation appraisal will be associated with more self-reported hurricane personal household adaptation.

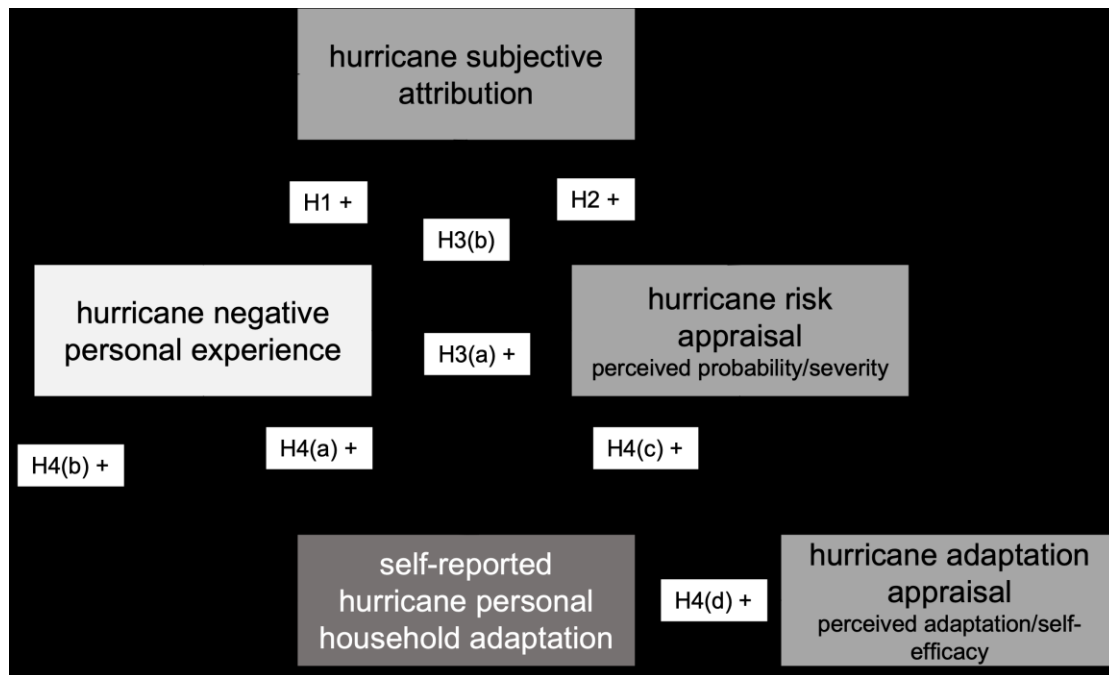


Figure 1. Simplified conceptual model based on Grothmann and Patt's (2005) process model of private proactive adaptation to climate change (MMPACC) demonstrating the hypothesized relationships and made specific to hurricanes.

4. Methods

4.1 Sampling

Data were collected as part of an ongoing longitudinal study of Texas and Florida residents' responses to hurricanes and other extreme events. Individuals were recruited from the Ipsos KnowledgePanel, a nationally representative panel of adults in the United States that employs address-based sampling methods. A total of 2,507 current and former panelists who we surveyed in tandem to major extreme weather events (e.g., Hurricanes Harvey, Irma, and

Michael) since 2017 were invited to participate; 1,846 completed the survey between May 14-27, 2020 (pre-2020 Atlantic Hurricane season) for a response rate of 73.6%. The median completion time of the survey was 17 minutes. Qualified active panelists received a cash-equivalent incentive of \$15 ($n=1,760$) and qualified withdrawn panelists received a cash-equivalent incentive of \$20 ($n=86$).

4.2 Protection of Human Subjects

The Institutional Review Boards of Stanford University and the University of California - Irvine approved all procedures.

4.3 Variables

Self-reported hurricane personal household adaptation. Two types of self-reported personal household adaptation behaviors were assessed using an 11-item checklist adapted from Wong-Parodi and Feygina (2018) [41]: anticipatory learning and household protection. *Learning* was assessed through one option: “Learn about the risks from hurricanes and how to prepare for them.” *Household protection* was assessed through nine options: “make a plan for safe places to move vehicle(s) in the event of a hurricane,” “put together an emergency kit (e.g., food, medical supplies, flashlight),” “develop and practice an emergency plan,” “identify shelter locations in the event of an evacuation,” “copy important documents,” “consider hurricane forecasts when making travel plans,” “get a row boat or inflatable raft,” “make my home more hurricane proof (e.g., install hurricane shutters, sand bags),” “have flood insurance”, and “other, please specify.” For each item, participants indicated whether they had taken that action to prepare for the 2020 Atlantic hurricane season. Responses were summed to create an overall count measure of *self-reported hurricane personal household adaptation* behaviors.

Hurricane negative personal experience. Prior to May 2020, hurricane negative experiences were assessed using a 6-item checklist, which included: “I lost property in a hurricane or its aftermath,” “My home was totally destroyed in the hurricane or its aftermath,” “I was injured in the hurricane or its aftermath,” “I lost a pet in the hurricane or its aftermath,” and “I knew someone who was injured in a hurricane or its aftermath” (0=did not happen, 1=occurred). Responses were summed.

Subjective attribution. Hurricane subjective attribution was assessed by asking respondents to rate their agreement with the statement: “climate change will make the 2020 hurricane season worse.”

Hurricane risk appraisal. Respondents reported 1) how likely they think it is that their well-being (health, financial, emotional, social, etc.) will be impacted by a major hurricane this year (perceived probability) (endpoints were 1=*not at all likely*, 5=*extremely likely*) and 2) how much they think their well-being would be harmed if a major hurricane were to occur in their community (perceived severity) (endpoints were 1=*not at all*, 5=*a great deal*). Items 1 and 2 were averaged following the conceptualization of the construct of ‘risk appraisal’ as described by the Extended Parallel Process Model [38], [39], [42], internal consistency was ‘moderate’ (Cronbach’s $\alpha = .75$) [43].

Hurricane adaptation appraisal. To assess *self-efficacy*, respondents reported how well they think they could perform actions to prepare for the 2020 Atlantic hurricane season (endpoints: 1=*not well at all*, 5=*extremely well*). To assess *response efficacy*, respondents reported how much they think adopting hurricane mitigation behaviors will prepare them for the 2020 Atlantic hurricane season (endpoints: 1=*Not at all*, 5=*Completely*). Items 1 and 2 were averaged following the conceptualization of the construct of ‘adaptation appraisal’ as described

by the Extended Parallel Process Model [38], [39], [42] and internal consistency was marginal (Cronbach's $\alpha = .68$) [43]. Higher Cronbach's α indicates that participants' individual responses were correlated, signaling items measure an overarching construct (e.g., adaptation appraisal), although not necessarily an identical component of that construct (e.g., self- and response efficacy) [44]. Despite the lower than ideal alpha, based on theory and for parsimony, we combine these two items into a single measure.

Demographics. Prior to the start of the study, upon entry into the KnowledgePanel, respondents provided information about their demographics including age, education, gender, income, ethnicity, and political party identification. These demographics are updated by Ipsos regularly.

See the Supplemental Materials section for the exact wording of the survey questions.

4.4 Weighting

Post-stratification weights were constructed iteratively, adjusting for factors from Ipsos's initial sampling strategy, forms of non-response and non-coverage, and panel attrition, using probability estimates based on location of residence, demographic characteristics (gender, age, race/ethnicity, household income, metro/non-metro area, and education), and access to Internet. Weights were constructed in several steps. First, panel *design weights* were computed that reflect unequal selection probabilities for different respondents (e.g., some demographic groups are more likely to agree to be on the KnowledgePanel than others). These design weights were then calculated for the panel according to active panel members. Every panel member was assigned a *design weight* reflecting in part the sampling procedures used to recruit that individual onto the panel. In the second phase of weighting, *study design weights* were constructed for use in study-specific datasets such as the one used in our analyses; these *study design weights* include

information from the initial weighting procedure, sample attrition, and discrepancies between the final obtained sample and U.S. Census Bureau's March 2020 Current Population Survey (CPS) [45] benchmarks for Florida and Texas, allowing for population-based inferences. Thus, the weighted sample used for this study closely matches the U.S. Census Bureau's CPS for Florida and Texas. Unless otherwise indicated, all descriptive and inferential statistics were weighted using study-specific post-stratification weights.

4.5 Data Analytic Plan

Analyses were conducted using Stata (version 15.1; StataCorp). Descriptive statistics for key study variables were conducted. To test H1 we conducted an ordinary least squares (OLS) regression with hurricane negative personal experience predicting hurricane subjective attribution. To test H2 we conducted an OLS regression with hurricane subjective attribution predicting hurricane risk appraisal. To test H3(a) we conducted an OLS regression with hurricane subjective attribution predicting hurricane risk appraisal, and to test H3(b) we conducted an OLS regression with hurricane negative personal experience interacted with hurricane subjective attribution predicting hurricane risk appraisal. To test H4 we conducted a Poisson regression with hurricane (a) negative personal experience, (b) subjective attribution, (c) risk appraisal, and (d) adaptation appraisal predicting hurricane personal household adaptation. All models were estimated using multiple imputation by chained equations to account for missing data. Missing data was extremely low in the sample. The following measures had some missing responses: negative personal experience ($n = 4$, 0.22%), risk appraisal ($n = 2$, 0.11%), adaptation appraisal ($n = 13$, 0.70%), subjective attribution ($n = 6$, 0.33%), political party identification ($n = 120$, 6.50%), with no other measures having missing responses. All analyses controlled for gender, age, income, education, and ethnicity, and political party identification.

Analyses for H2 and H4(b) were preregistered at the Center for Open Science, and the rest were not explicitly stated in our pre-registration plan.

4.6 Participants

Our respondents were 53.2% female, with a median age of 51.0 years old; 56.9% of households reported annual incomes less than \$75,000. About one-third reported having earned a Bachelor's degree or higher (29.5%). Of our sample, 54.8% were White/non-Hispanic, 28.1% were Hispanic, 11.9% were Black/non-Hispanic, and 5.2% were Other, non-Hispanic, or 2+ races. A little less than half of our participants reported leaning towards to being strong Republicans (48.1%), 47.1% reported leaning towards to being strong Democrats, and 4.9% reported being undecided/independent. For more details on demographics by state and comparison to U.S. Census and Pew Research Center data, see Supplemental Material Table 1.

5. Results

5.1 Descriptive statistics

As shown in Figure 2A, the top five most common self-reported adaptation behaviors were using hurricane forecasts when making travel plans ($n = 713$, 38.60%), followed by having flood insurance ($n = 108$, 5.90%), copying important documents ($n = 101$, 5.50%), putting together an emergency kit ($n = 98$, 5.30%), and identifying shelters ($n = 53$, 2.90%). As shown in Figure 2B, the majority ($n = 1347$, 73.00%) of our participants self-reported having performed at least one adaptation behavior to prepare for the 2020 Atlantic hurricane season. Close to one-third (29.00%) of our participants reported having had at least one hurricane negative personal experience. On average, participants expressed a moderate level of hurricane subjective attribution agreement ($M = 3.09$, $SD = 1.10$). They also expressed a small-to-moderate level of hurricane risk appraisal ($M = 2.49$, $SD = .98$) and moderate level of hurricane adaptation

appraisal ($M = 3.31$, $SD = .95$). For more details on differences in key measures by self-reported adaptation behaviors (no adaptation versus at least one adaptation behavior), see Supplemental Material Figures 1-6 and Table 2.

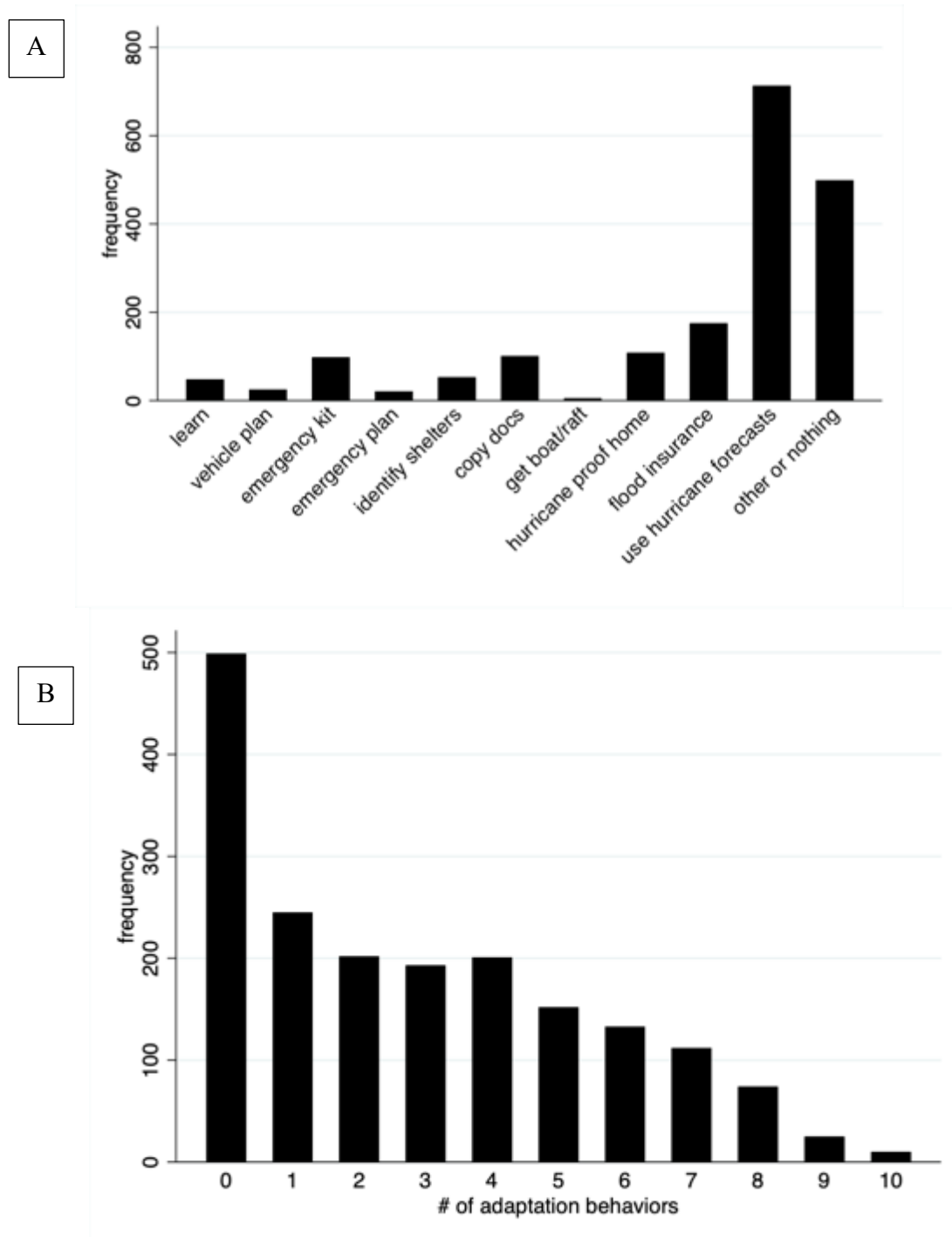


Figure 2. Panel A shows the frequency of each of the self-reported adoption of personal

household protection adaptation behavior. Panel B shows the frequency of the number of total self-reported adopted personal household adaptation behaviors.

5.2 Hurricane personal negative experience, subjective attribution, and risk appraisal

Support was observed for H2 and H3(a-b). As shown in Table 1 and Figure 3, greater hurricane negative personal experience and hurricane subjective attribution agreement was associated with greater hurricane risk appraisal. The positive relationship between hurricane negative personal experience and hurricane risk appraisal was moderated by hurricane subjective attribution. More specifically, hurricane subjective attribution agreement was associated with increasing levels of hurricane risk appraisal among those with no hurricane negative personal experience (Figure 4). However, no support was found for H1, as no association between hurricane negative personal experience and hurricane subjective attribution agreement was observed (Table 1 and Figure 3).

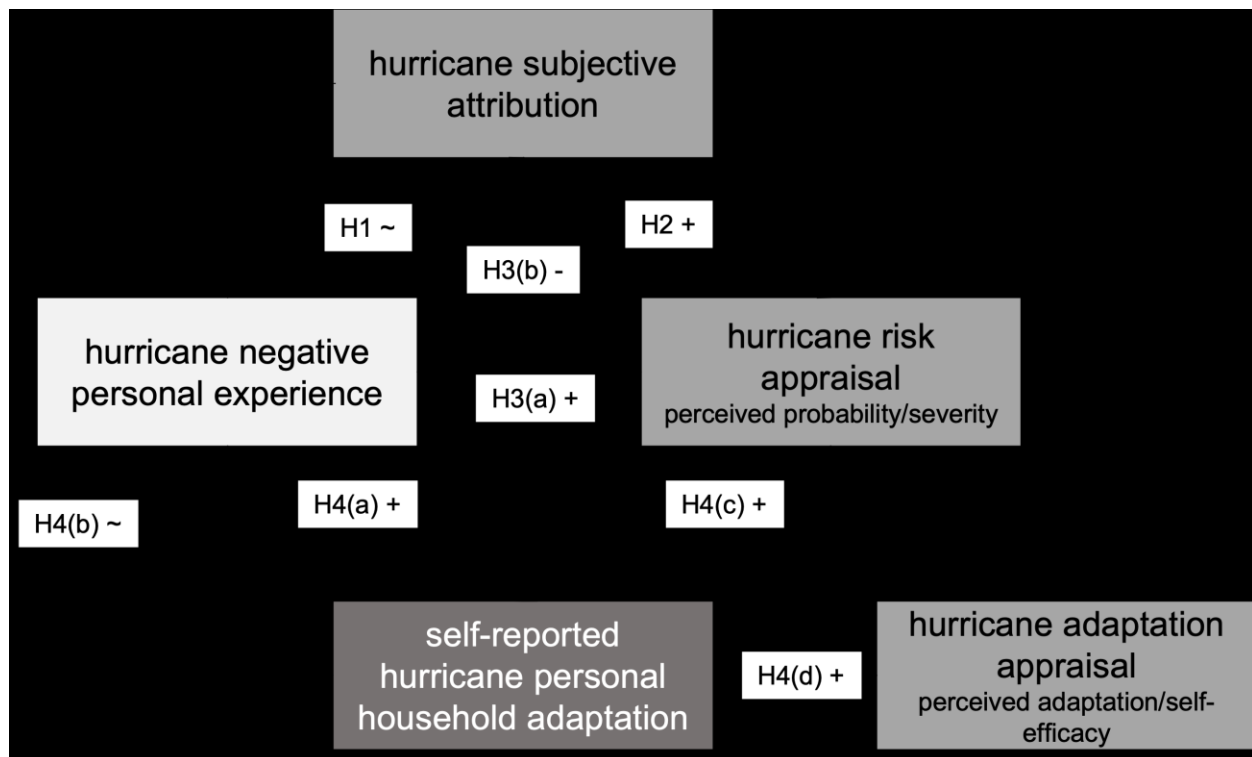


Figure 3. Conceptual model showing the observed relationships for each hypothesis (~ indicates no association, + indicates a positive association, and - indicates a negative association).

Table 1. OLS regressions with hurricane negative personal experience predicting hurricane subjective attribution, and hurricane negative experience and subjective attribution and their interaction predicting hurricane risk appraisal ($N = 1,486$)

Variables	Hurricane subjective attribution				Hurricane risk appraisal							
					(1)				(2)			
	<i>B</i>	<i>p</i>	95% <i>CI</i>		<i>B</i>	<i>p</i>	95% <i>CI</i>		<i>B</i>	<i>p</i>	95% <i>CI</i>	
Hurricane negative personal experience	.04	.28	-.03	.11	.23	<.001	.12	.34	.62	.00	.30	.94
Hurricane subjective attribution					.10	.02	.01	.18	.15	<.001	.06	.25
Experience x attribution									-.12	.01	-.20	-.03
Gender (ref = female)	-.09	.15	-.22	.03	.08	.02	-.34	-.03	-.17	.02	-.32	-.02
Age	-.01	.01	-.01	.00	.00	.11	.00	.01	.00	.12	.00	.01
Income	.00	.97	-.04	.04	.02	.36	-.06	.02	-.02	.29	-.07	.02
Education (ref = no college)	.16	.04	.01	.30	.08	.17	-.27	.05	-.11	.16	-.27	.04
Ethnicity (ref=White)												
Black, Non-Hispanic	-.28	.03	-.54	-.03	.10	.45	-.16	.35	.11	.41	-.14	.36
Other, Non-Hispanic, 2+ races	.30	.04	.01	.59	.38	.03	.04	.72	.40	.02	.05	.74
Hispanic	.05	.58	-.13	.23	.04	.71	-.16	.23	.03	.73	-.16	.23
Political party (1=strong Republican, 7=strong Democrat)	.23	<.001	.19	.26	.00	.90	-.04	.05	.00	.91	-.04	.05
Constant	2.48	<.001	2.14	2.83	2.05	<.001	1.59	2.50	1.88	<.001	1.42	2.35
Model statistics	$F(9,1780.7)=29.30; p<.001$				$F(10,1811.9)=5.93; p<.001$				$F(11,1816.1)=6.34; p<.001$			
R-square	.24				.08				.09			

Note. Model (1) shows the main effect of hurricane negative personal experience and subjective attribution on hurricane risk appraisal, and model (2) shows the interaction between hurricane negative personal experience and subjective attribution on hurricane risk appraisal. Bolded values are significant at $p<.05$ and are thus interpreted. The variance inflation factor for each model was under 2, suggesting no meaningful collinearity among the independent variables.

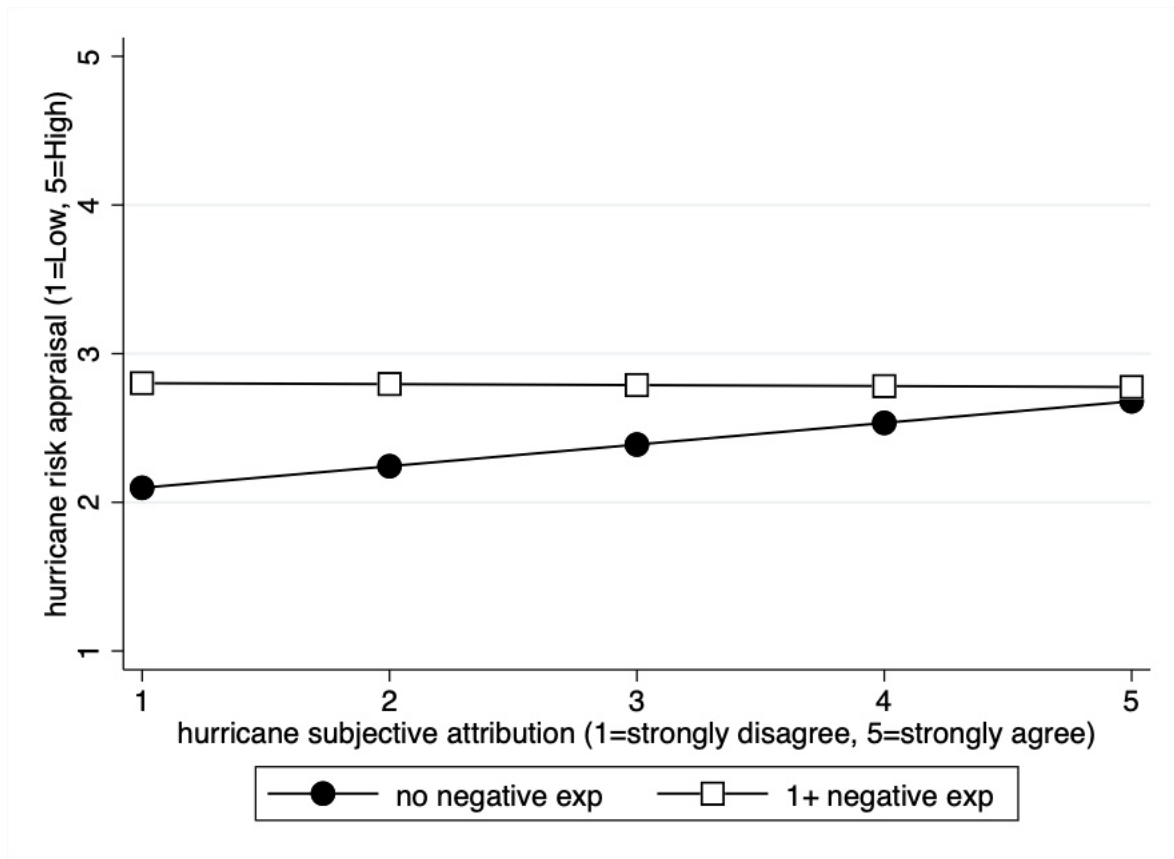


Figure 4. Hurricane subjective attribution moderates negative personal experience on hurricane risk appraisal. 1+ negative experience means having had one or more previous negative hurricane experience.

5.3 Hurricane personal household adaptation

Support was observed for H4(a and c-d). As shown in Table 2 and Figure 3, greater hurricane negative personal experience, hurricane risk appraisal, and hurricane adaptation appraisal were associated with more hurricane personal household adaptation. However, when controlling for hurricane negative personal experience, risk appraisal and adaptation appraisal, no association between hurricane subjective attribution and hurricane personal household adaptation was observed.

Table 2. Poisson regression with hurricane negative personal experience, subjective attribution, risk appraisal, and adaptation appraisal predicting hurricane personal household adaptation ($N = 1,486$)

Variables	<i>B</i>	<i>p</i>	<i>95% CI</i>	
Hurricane negative personal experience	.17	<.001	.12	.21
Hurricane subjective attribution	.03	.27	-.02	.08
Hurricane risk appraisal	.16	<.001	.11	.22
Hurricane adaptation appraisal	.49	<.001	.43	.55
Gender (ref = female)	-.01	.87	-.13	.11
Age	.01	<.001	.01	.01
Income	.04	.03	.00	.07
Education (ref = no college)	-.04	.48	-.17	.08
Ethnicity (ref=White)				
Black, Non-Hispanic	.09	.38	-.11	.30
Other, Non-Hispanic, 2+ races	.16	.23	-.10	.41
Hispanic	-.05	.53	-.20	.11
Political party (1=strong Republican, 7=strong Democrat)	.00	.84	-.03	.03
Constant	-2.10	<.001	-2.50	-1.70
Model statistics	$F(12,1200000.0)=50.96; p<.001$			
Pseudo R-square	.15			

Note. Bolded values are significant at $p<.05$ and are thus interpreted. The variance inflation factor for the model was under 2, suggesting no meaningful collinearity among the independent variables. The pseudo r-square was calculated with the original data.

6. Discussion

Overall, our results indicate that, in a sample exposed to repeated hurricanes, prior hurricane negative personal experience and hurricane subjective attribution agreement were associated with greater hurricane risk appraisal prior to an impending above normal hurricane season. Hurricane subjective attribution agreement moderated the relationship between hurricane negative personal experiences and hurricane risk appraisal. In turn, hurricane negative experience, hurricane risk appraisal, and hurricane adaptation appraisal were positively associated with self-reported hurricane personal household adaptation behaviors.

In support of H3(a) and H2 (section 5.2), higher levels of hurricane negative personal experience and hurricane subjective attribution agreement were associated with higher levels of hurricane risk appraisal. This aligns with mounting evidence that negative personal experience with extreme weather (e.g., hurricanes, flooding) is associated with greater risk perceptions [7], [17]–[20]. This phenomenon was also demonstrated in the context of the COVID-19 pandemic, where greater exposure to secondary stressors associated with the disaster were associated with greater perceptions of risk [46]. Prior research shows even for those repeatedly exposed to hurricanes, nearly half of homeowners have never engaged in any protective action against future storms [47]. Our findings suggest subjective attribution and perceptions of risk are explanatory mechanisms that help explain variability in preparation behavior. Importantly, these findings support Ogunbode et al. [4], [46] suggesting that subjective attribution agreement is also associated with greater risk perceptions in the context of hurricanes. In contradiction to H1 (section 5.2), we did not observe a relationship between hurricane negative personal experience and hurricane subjective attribution agreement. Taken together, these results suggest that

hurricane negative personal experience and hurricane subjective attribution agreement are independently associated with hurricane risk appraisal.

In support of H3(b) (section 5.2), hurricane subjective attribution moderated the relationship between hurricane negative experience and hurricane risk appraisal. Among those who strongly disagree that hurricanes are attributable to climate change, having no hurricane negative personal experience was associated with lower levels of hurricane risk appraisal compared to those with at least one prior hurricane negative personal experience. However, among those who strongly agree that hurricanes are attributable to climate change, no differences in hurricane risk appraisal between those with or without at least one prior hurricane negative personal experience were observed. This aligns with Ogunbode et al., who found that flood subjective attribution moderated an observed positive association between personal experience with flooding and perceived threat from climate change [4], with higher levels of subjective attribution being associated greater perceived threat. Our findings build upon and extend Ogunbode et al.'s [4] work on flooding by demonstrating subjective attributions may modulate positive relationships between negative personal experiences and risk appraisal in the context of hurricanes. These results reinforce the hypothesis that subjective attributions may be an important precursor for perceptions about climate change, but also about the impacts from climate change such weather extremes. Future study may examine subjective attribution for other hazards such as climate-related infectious disease spread and hazard-specific risk appraisals, as well as with respect to climate change more generally.

We also found support for H4(a and c-d) (section 5.3), where more hurricane negative personal experience, hurricane risk appraisal, and hurricane adaptation appraisal were associated with the self-reported adoption of more hurricane personal household adaptation behaviors. Our

results align with previous work finding greater flood experience is associated with more self-reported household protective adaptation behavior [33], [34]; having had greater reported experience with the impacts of climate change predicts greater adaptation to climate change in forest management [25]; and further support previous work finding that negative experience such as severe loss during a flood may motivate the adoption of measures such as obtaining more information or making structural changes, and may be mediated by factors such as fear [47]. Our results also expand previous findings regarding positive associations between risk appraisal [7], [31], [36] and adaptation appraisal [37]–[39] with self-reported or observed adaptation behaviors. Similarly, we expand work suggesting that subjective attributions may be associated with how risks are appraised [4], [46]. One possible explanation for a lack of association between subjective attribution and personal household adaptation (Hb(4)) could have to do with ‘decision-maker tipping point behavior’ [35]. Blennow and Persson (2021) describes ‘tipping point behavior’ as the belief that any adaptation behavior adopted would not make a difference, resulting in behavioral abstinence. Future study may further examine the relationships of adaptation appraisals (i.e., response efficacy) [31], [38], [39], in the context of personal household adaptation to hurricanes.

Overall, these results provide support for Grothmann and Patt’s process model of private proactive adaptation to climate change [31], with our findings that show a positive association of risk and adaptation appraisal with self-reported adaptation behaviors. They also underscore the potential for including key factors such as negative personal experience and subjective attribution in conceptual models of climate adaptation behaviors (e.g., MPPACC) to better understand processes of individual decision making, informing potential interventions to promote adaptation.

6.1 Limitations

There are several strengths of this study including its large sample size ($N = 1,846$), representative sample of Gulf Coast residents, fielding in the weeks leading up to the start of the 2020 Atlantic hurricane season, and prior hurricane negative experience data. We acknowledge some limitations. First, we focused only on a subset of self-reported adaptation behaviors (learning and household protection). While not the focus of the study, it would have been informative to assess whether in the context of hurricanes, subjective attribution modulates the relationship between negative personal experience and other self-reported adaptation behavior or civic engagement. Second, previous studies find that subjective attributions may be important for how people perceive climate change risks more generally. Again, while not the focus of this study, it would have been informative to assess whether in the context of hurricanes, subjective attribution modulates the association between negative personal experience and climate change risk appraisal. Future study should examine the relationships of subjective attribution across domain areas with risk appraisals and self-reported or observed adaptation behaviors to specific hazards and to climate change more broadly. Third, internal consistency for the two questions comprising ‘hurricane adaptation appraisal’ was marginal (Cronbach’s $\alpha = .68$). While lower than ideal alpha, we combined these questions based on theory and parsimony; however, future study should include revising and/or adding questions to assess the overall construct of adaptation appraisal.

7. Conclusions

Our findings demonstrate that hurricane subjective attribution and hurricane negative personal experience are positively associated with hurricane risk appraisal. Importantly, hurricane subjective attribution moderated the positive relationship between hurricane negative

personal experience and hurricane risk appraisal. Our findings suggest that connecting personal experiences with climate-related events like hurricanes to climate change, and communications that enhance understanding of climate change impacts [35], may help promote personal household adaptation behaviors. Such messaging may be useful for science communicators and practitioners engaging with the public.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Ethics Statement

The authors confirm that this original manuscript has not been previously published and is not currently under consideration by any other journal. Additionally, the authors have approved the contents of this paper and have agreed to Environmental Research Letters' submission policies. The Institutional Review Boards of Stanford University (IRB-52533) and the University of California, Irvine (IRB-2016-2827) approved all procedures, and informed consent was obtained.

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Contributions

Gabrielle Wong-Parodi: Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, visualization, writing-original draft, and writing-review and editing. Dana Rose Garfin: Conceptualization, funding acquisition, investigation, methodology, project administration, resources, and writing-review and editing.

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