Modeling Emotion-Focused Coping as a Decision Process

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***Abstract*—People experience many stressful, emotion-evoking situations in everyday life. How they cope with these situations is crucial to their well-being. Research shows that people may change their beliefs to perceive the situations in a better, less-stressful light. Therefore, understanding how people change their beliefs to cope with stress and emotion is an important research question. Toward that end, we model coping, based on Lazarus's appraisal theory of emotion, as a two-step decision problem. However, people do not hallucinate arbitrary alternative realities in order to reduce stress. So a central challenge here is to model the constraints on belief change. We specifically stipulate two key factors influencing the degree of belief change: the utility of holding the alternative belief and constraints on changing a belief based on its underlying uncertainty. To investigate these factors and the model's assumptions, we applied the model to a simple hurricane situation and conducted an experiment based on this situation, where participants observed hurricane information and reported their beliefs about it. We found that when the hurricane worsens, those who stayed believe the hurricane to be less severe than the most likely outcome from the information and those who evacuated. The results also show that the uncertainty of information and the utility of the beliefs about that information is related and together determine how emotion-focused coping alters the person's beliefs. Overall, the results support the assumptions and predictions of the model. These findings illustrate the relevance of applying a decision-making model analysis to coping.**

***Index Terms*—Coping, Appraisal Theory, Modeling, Hurricane**

I. Introduction

In everyday life, we experience many stressful situations ranging from comparatively mundane ones such as meeting a submission deadline to highly stressful life-threatening events such as natural disasters. How people cope with such stressful situations is crucial to their well-being and is, therefore, an important research question. In this work, we specifically explore this in the context of hurricanes, high-stress situations with significant impact on individuals and society.

Lazarus's appraisal and coping theory provides a framework for modeling how people cope with stressful situations. The theory proposes two broad types of coping: problem-focused and emotion-focused. Problem-focused coping seeks to directly change a stressful situation, while emotion-focused coping seeks to alter one's beliefs and goals, so the situation is perceived as less stressful [1], [2]. Research in natural disasters has applied Lazarus's theory to study coping behavior during hurricanes and has shown that people do use emotion-focused coping to cope with the situation by changing their beliefs about the hurricane [3], [4], [5]. For example, one can choose to believe that the hurricane will miss their area or change how one values the cost of evacuation. Some may discount or ignore the seriousness of the threat, while others may perceive the threat to be severe.

Nonetheless, an important research question remains, that is, what factors govern the extent to which people use emotion-focused coping, specifically how people change their beliefs about a stressful situation. Answering this question would help us better understand coping behaviors and potentially guide people to cope in a more adaptive manner. Toward that end, we study coping from a decision-theoretical perspective. Specifically, we model Lazarus's appraisal and coping theory using a Markov Decision Process framework, where the two types of coping are treated as actions, and how people decide how to cope is based on a cost-benefit analysis. From this formulation, there are two key factors that govern the degree of belief change: the utility of holding an alternative belief and the constraints of changing to that belief.

To investigate these two factors and validate the model approach, we applied the model to a simple hurricane evacuation scenario, where a person receives a hurricane message, makes an evacuation decision, and then receives another update message. We then derived a set of concrete hypotheses regarding beliefs after the second message and the two factors. We conducted a human-subject experiment following this hurricane scenario to test the hypotheses. The results support the hypotheses showing the relationship between the utility and the cost of change and the extent to which people's beliefs deviated from hurricane information.

The paper is organized as follows. In the next section, we first review related work on coping and hurricanes. In Section III, we lay out the decision model for coping. We then apply the model to the hurricane situation and derive the hypothesis in Section IV. In Section V, we detail the experiment and the data collection. Section VI describes the results of the experiment. We end with a discussion of the results, their implication, and limitations in Section VII.

II. Background and Related Work

In this section, we cover three important background works: Lazarus's appraisal theory of emotion, works related to that theory, and the hurricane evacuation decision literature.

A. Lazarus's Appraisal Theory of Emotion

There exists a number of appraisal theories of emotion [2], [6], [7], [8], [9]. In general, appraisal theories posit that emotions arise from an appraisal process, an evaluation of how the situation impacts an individual's goals and concerns. For this work, we chose Lazarus's Appraisal and Coping Theory because it involves not only the appraisal process itself but the connection between the appraisal process, emotions, and how people cope with them [1], [2]. The theory has also been applied to psychological theories of people's behaviors during disasters [3], [4].

The central idea of Lazarus's appraisal and coping theory is the concept of the person-environment relationship, emphasizing both how people appraise their relationship to the situation and how they cope with it [2]. Coping seeks to move the person toward positive situations and away from negative situations by either altering the situation itself or the relation to it. Reflecting this idea, Lazarus proposes two main classes of appraisals: primary appraisals concern whether what is happening is personally relevant, and secondary appraisals concern coping options and future aspects of situations. There are three primary appraisal dimensions: goal relevance, goal congruence/incongruence, and type of ego-involvement (i.e., personal commitments and self-esteem). There are three secondary appraisal dimensions: blame or credit for the situation, coping potential, and future expectancy. Coping potential refers to one's own ability to manage the situation, while future expectancy refers to how things are likely to change for the better or worse by themselves.

A key concept in Lazarus's theory is coping. Lazarus defines coping as "constantly changing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person" [1, pp. 141]. In short, coping refers to what a person thinks and does to try to manage an emotional situation, and it potentially can be effortful, complex, and often a planful process. Lazarus proposes two broad types of coping: problem-focused coping and emotion-focused coping. Problem-focused coping refers to the coping processes that directly change or interact with the situation. Emotion-focused coping refers to the coping processes that mainly involve altering one's beliefs and/or goals in order to change the person-environment relationship. Emotion-focused coping can include wishful thinking (forming beliefs based on what one perceives to be positive), resignation (dropping an intention to achieve a goal), and denial (rejecting beliefs).

Overall, emotion-focused copings change the person-environment relationship. Emotion-focused coping significantly deviates from a standard decision-theoretic model, which typically assumes beliefs and goals (or preferences) to be fixed. For instance, belief-altering coping such as wishful thinking causes a person to wish for some desired outcome to be more likely. Finally, Lazarus's theory argues that appraisal and coping are in a loop, whereby appraisal leads to coping, which subsequently leads to the appraisal of the now modified the person-environment relationship.

There exist other related psychological theories that propose a similar idea to emotion-focused coping in which people alter their beliefs and goals to make them feel better. These include emotion regulation [10], cognitive dissonance [11], optimism bias [12], and motivated reasoning [13]. The closest theory to Lazarus's theory is perhaps Gross's emotion regulation theory [10]. The theory posits that emotion regulation is an attempt to influence which emotions one has, when one has them, and how one experiences them. Gross proposes five regulation strategies, and one of them is reappraisal, changing one's appraisal of a situation to alter its emotional experience, which could be considered the same as emotion-focused coping. The key difference between Lazarus's theory and Gross's emotion regulation theory is that Lazarus's theory provides an explicit link between the appraisal dimensions of situations and coping.

In terms of a computational model, there exist many computational models of appraisal theory of emotion (for reviews, see [14] and [15]). However, only a few models include coping or emotion regulation such as [16], [17], [18], [19], and [20]. These models build upon the psychological theories mentioned above. For example, the models by Bosse et al. (2010) and Martínez-Miranda et al. (2014) are built upon Gross's emotion regulation theory. Gratch and Marsella (2004, 2009) proposed EMA (EMotion and Adaptive), a computational model of emotion based on Lazarus's theory using a plan-based, utility system. Adam and Lorini (2014) proposed a logic system based on Lazarus's theory. Bracha and Brown (2012) proposed Affective Decision-Making (ADM) based on optimism bias theory. ADM is a model of choice under risk, where one process optimizes risk, and another optimizes choice. EMA and ADM are closely related to and influence this work.

Nevertheless, our work differs significantly from existing models in two ways. First, the majority of the existing works have not been applied or evaluated using real data (but see [21], [22]). Second, the objective of this work is to propose a model that could further our understanding of coping and generate testable hypotheses rather than simply being a part of a virtual agent.

B. Hurricane Evacuation Decisions

Huang et al. [23] recently conducted a meta-analysis on hurricane evacuation studies, summarizing forty-nine studies since 1991, including surveys from real and hypothetical hurricane scenarios. Their results identify several important predictors of evacuation decisions, including official notice, mobile home, household location, expectations of impacts on personal concerns, and observations of social and environmental. However, they found that other demographic characteristics such as gender, age, and race have minor effects. Importantly, their analysis indicates that the results from hypothetical hurricanes are comparable to real hurricanes.

The notion of risk perception is closely related to the notion of goals and concerns in appraisal theories. A few studies have looked at risk perception in hurricane contexts and found that perceived risk is associated with the likelihood of evacuation [24], [5], [25]. In particular, our prior work identifies that the probability of being in a life-threatening situation, the expected flood depth, and outage duration are associated with evacuation decisions, and these features can predict evacuation decisions better than standard demographic features [5]. We also find that people change their beliefs about the hurricane's impact after their decision, providing some evidence that people use emotion-focused coping [5] , [25].

There are two leading psychological theories on human behaviors during disasters influenced by Lazarus's theory. The first theory is Protection Motivation Theory (PMT), which proposes that protection motivation, which drives how people cope with a disaster, is influenced by two main cognitive processes: threat appraisal and coping appraisal [26], [4]. Second, Lindell et al. (2012) proposed Protective Action Decision Model (PADM), a three-stage model describing how people decide to adopt protective actions against natural disasters [3]. The three stages are processing of information (environmental and social cues), psychological decision processes, and behavioral response (information search, protective response, and emotion-focused coping).

In sum, existing human evacuation behaviors research found the subjective perception of a hurricane's impact to be a good predictor of evacuation decisions and has emphasized that people may use emotion-focused coping to cope with the perceived threats from hurricanes. Therefore, we seek to study emotion-focused coping in the hurricane context in this work.

III. Coping as Decision-Making Model

In this work, we formulate coping as a decision-making problem, where a person decides the coping strategy that yields the best outcome based on their subjective evaluation. To do so, we make the following assumptions.

First, following Lazarus's theory, we assume that the evaluation of the outcome of coping is based on an appraisal process. Specifically, a person evaluates the outcome of coping using their subjective beliefs about goal-relevant features such as how much flooding the hurricane will cause. Critically, the beliefs could be uncertain because people do not have complete knowledge of the world. For example, in a hurricane situation, people have to rely on the information provided by others, such as the National Hurricane Center[1] (NHC). However, not even NHC can accurately predict a hurricane's path or intensity with certainty [27]. This uncertainty allows people to alter their subjective beliefs about the hurricane in order to reduce stress and negative emotions.

Second, coping, both problem-forced and emotion-focused coping, are modeled as actions. A person can use both strategies to address a situation. Importantly, we assume that there is a cost associated with emotion-focused coping. This cost provides a mechanism to characterize the difficulty of altering a belief. To operationalize this difficulty, we associate it with the cost that depends on the uncertainty. As the uncertainty goes up, the cost goes down and vice versa. In other words, as people become less certain about a belief, it becomes easier to change it, so the cost goes down. This has an additional benefit of capturing the motivated inference since this cost becomes a part of the expected utility calculation in the decision-making framework (more details in the next section).

To capture the above assumptions, we model coping using a simple two-step decision-making framework based on a Belief Markov Decision Process (MDP) framework [28]. The model consists of four elements $< S, R, A, T >$. S is a set of all states, and a state $s = \{s_1, \dots, s_k\}$ is a possible state of the world represented by k independent state's features. Because the decision-maker is uncertain about the state of the world, they maintain a distribution over all possible states, a belief state b. A reward function $R(s)$ describes the utility, how good or bad, of the state is. We assume here that it is a linear reward function $R(s, a, s') = \sum_i^k w_i s'_i$, where w_i is a reward weight associated with state's features s_i, indicating how goal-congruent or important the feature is. A set of actions A contains all available actions in the situation and the transition function $T = P(s'|s, a)$ describes the dynamics of each action. There are two classes of actions in the model, $A = \{A_{pr}, A_{em}\}$. First, A_{pr} is a set of problem-focused coping actions, which depends on the domain. Second, $A_{em} = \{a_{em,1} = s_1, \dots, a_{em,m} = s_m\}$ is a set of emotion-focused coping actions, where the effect of each action a_{em} is to alter the model's assumption as to what the possible state s is. In other words, the dynamic of the a_{em} is simply to accept that the state of the world is s. For example, the a_{em} could be to believe that the maximum wind speed of the hurricane is 120 mph.

In this work, we focus on continuous beliefs, which are modeled using a Gaussian distribution. Therefore, a straightforward cost function for emotion-focused coping, that takes into account the shape of the distribution, is the distance away from the mean of the belief distribution $\mu(b)$ divided by its standard deviation $\sigma(b)$, $C(b, a_{em}) = \alpha|\mu(b) - a_{em}|/\sigma(b)$, where α is a tuning parameter and a_{em} is a specific value (belief) of the distribution. This cost function implies that the cost goes up as the uncertainty goes down. In other words, as people become more certain about a specific belief, it should also become harder to change. Essentially, this cost function is a numerical way to capture the function of how difficult it is to change a belief by basing change on the belief uncertainty.

The coping decision problem can now be stated as follow.

$$\max_{a_{em}} \max_{a_{pr}} \sum_{s'} P(s'|a_{em}, a_{pr}) R(a_{em}, a_{pr}, s') - C(b, a_{em}) \tag{1}$$

Essentially, this decision problem consists of two steps: 1) pick the emotion-focused coping, the state of the world that you want to believe to be true, and then 2) find the best problem-focused coping action given that state. In the case that the agent has already chosen or committed a problem-focused coping a_{pr} that cannot be changed, then the equation

[1] https://www.nhc.noaa.gov/

can be simplified into:

$$\max_{a_{em}} \sum_{s'} P(s'|a_{em}, a_{pr}) R(a_{em}, a_{pr}, s') - C(b, a_{em}) \quad (2)$$

IV. A Simple Hurricane Scenario

In this section, we apply the model to a simple hurricane evacuation scenario to derive the model's predictions regarding the factors governing the use of emotion-focused coping, specifically the change in belief.

In this scenario, there are only two time steps, two days and one day before the hurricane hits the area. In the first time step, a person receives one hurricane message stating the current prediction of the hurricane's intensity and impact, including maximum sustained wind speed and flood depth. Since this is the only information that the person has, this information becomes the belief at the first time step (B1). After receiving the message, the person then has an opportunity to decide whether to evacuate or stay in their home. The state's features in this situation are wind speed, flood depth, and evacuation cost. Evacuating results in a reward equal to evacuation cost time its reward weight, while staying results in a reward equal to the sum of wind speed and flood depth time their weight. These three reward weights are negative as they are incongruent with one's goals. Therefore, as the hurricane becomes worse (flood depth and wind speed go up), it will incur a more negative reward that the person would try to avoid.

In the second time step, the person receives another update message on the hurricane's intensity and impact. This information becomes the belief in the second time step (B2), similar to the first time step. However, this time, there is no option to evacuate or stay as it is too late to evacuate and too dangerous to return from the evacuation. Therefore, in this time step, the person can only use emotion-focused coping, and their problem-focused coping (stay or evacuate) is fixed based on their prior decision.

When the hurricane becomes stronger (i.e., going from a category 3 hurricane[2] in the first time to a category 4 hurricane in the second time step), this will result in a more negative experience and more stress for people who stay, and we expect people to use emotion-focused coping more. In contrast, when the hurricane weakens (i.e., going from a category 3 hurricane to a category 2 hurricane), people who stay will experience less stress and are unlikely to need to use emotion-focused coping. On the other hand, people who have already evacuated will not be affected by the hurricane, so the second hurricane message also should not affect them. Therefore, we only focus on people who stay and when the hurricane worsens.

As a result, we derive the following two hypotheses from the model concerning the beliefs of people who stay at the second time step (B2) when the hurricane worsens. First, the cost of coping is associated with the uncertainty of information. As the information becomes more certain, we expect the change of beliefs to be smaller.

H1: For people who stay and the hurricane worsens, those who receive a high uncertainty message will believe the hurricane at the second time (B2) to be less severe (lower wind speed and flood depth) than those who receive a low uncertainty message.

Second, everything else being equal, people with higher reward weights (less negative) may change their corresponding beliefs more than people with smaller reward weights. To illustrate, let $w_{1,\mathrm{w}}$ and $w_{2,\mathrm{w}}$ be the negative reward weight for wind speed for persons 1 and 2 who decided to stay respectively, and $w_{1,\mathrm{w}} < w_{2,\mathrm{w}} < 0$. Let s_w be the best wind speed for person 1 and b be the current belief. We have $s_\mathrm{w} w_{1,\mathrm{w}} < s_\mathrm{w} w_{2,\mathrm{w}}$. If the cost is low enough (i.e., low sd or high uncertain message), then there exists $s'_\mathrm{w} < s_\mathrm{w}$ such that $s'_\mathrm{w} w_{2,\mathrm{w}} - s_\mathrm{w} w_{2,\mathrm{w}} > C(b, s'_\mathrm{w}) - C(b, s_\mathrm{w})$ so $s'_\mathrm{w} w_{2,\mathrm{w}} - C(b, s'_\mathrm{w}) > s_\mathrm{w} w_{2,\mathrm{w}} - C(b, s_\mathrm{w})$. Thus, person 2 with a higher reward weight could believe the wind speed to be lower than person 1.

In the context of hurricanes, a key characteristic that could influence the reward weights associated with flood depth and wind speed is the resident structure. In particular, people who live on the first floor may concern more about the flood depth than those who are on the third floor. On the other hand, people who live on the third floor may concern more about wind speed than those who are on the first floor. Therefore, we have the following hypothesis.

H2: For people who stay and receive a high uncertain message that the hurricane worsens, those who live on the first floor will believe flood depth to be lower but wind speed to be higher than those who live on the third floor.

V. Hurricane Experiment

Procedure and materials. To test the hypotheses, we conducted the experiment following the structure of the hurricane situation discussed above. The flow of the experiment is as follows.

1) Brief introduction and instruction
2) Hurricane message 1 (2 days before the hurricane)
3) Measure beliefs (B1)
4) Situated in the affected location and a resident structure
5) Make an evacuation decision (evacuate or stay)
6) Hurricane message 2 (1 day before the hurricane)
7) Measure beliefs (B2)
8) Post Survey

There are four conditions in this experiment depending on the second hurricane message (uncertainty level and hurricane category) and the resident structure:

1) High Uncertainty, Category 4, 1st Floor,
2) Low Uncertainty, Category 4, 1st Floor,
3) High Uncertainty, Category 4, 3rd Floor,
4) High Uncertainty, Category 2, 1st Floor.

The first condition is for H1 and H2, the second condition is for H1, the third condition is for H2, and the fourth condition

[2] A category of a hurricane is based on the Saffir-Simpson Hurricane Wind Scale which ranges from 1 to 5, where 1 is the lowest and 5 is the highest. [29]

is for checking the assumption regarding the use of emotion-focused coping when the hurricane becomes stronger but not weaker.

The hurricane messages are based on actual messages and information provided by NHC, a main source of information for hurricanes that people are familiar with. The first message, which is the same for all condition, is as follow.

"This is a hurricane update from National Hurricane Center:

- The storm is expected to be a category 3 hurricane and make landfall on the Florida east coast in 2 days. However, there is still a lot of uncertainty about the hurricane's impacts.
- Our model roughly estimates a maximum sustained wind speed of approximately 120 mph +/- 30 mph (90 - 150 mph).
- Our model roughly estimates the storm is likely to cause approximately 12 inches +/- 8 inches (4 - 20 inches) of flooding."

The second message for high and low uncertainty is as follows (italic indicates the difference):

- High Uncertainty Condition:
  - The storm is now expected to be a category 4 hurricane and make landfall on the Florida east coast in 24 hours. *However, there is still a lot of uncertainty about the hurricane's impacts.*
  - *Our model roughly estimates a maximum sustained wind speed of approximately 140 mph +/- 20 mph (120 - 160 mph).*
  - *Our model roughly estimates the storm is likely to cause approximately 16 inches +/- 8 inches (8 - 24 inches) of flooding.*
  - Authority has warned that it is too late to evacuate and too soon to return."
- Low Uncertainty Condition:
  - The storm is now expected to be a category 4 hurricane and make landfall on the Florida east coast in 24 hours. *As the hurricane gets closer, the predictions of the hurricane's impacts have become more accurate.*
  - *Our model predicts with high confidence that the maximum sustained wind speed will be 140 mph +/- 5 mph (135 - 155 mph).*
  - *Our model predicts with high confidence that the storm will cause 16 inches +/- 2 inches (14 - 18 inches) of flooding.*
  - Authority has warned that it is too late to evacuate and too soon to return.

For the category 2 and high uncertainty message, the range for wind speed is 100 mph +/- 20 mph and for flooding is 8 inches +/- 6 inches. The message also emphasizes that participants cannot change their minds, limiting the use of problem-focused coping and forcing them to only use emotion-focused coping. We situate them by asking them to imagine that they live in the affected area and in a specific resident structure. We also ask participants to rate their distress level that the hurricane will induce to make sure they have appraised the situation.

TABLE I
THE DESCRIPTIVE STATISTICS OF THE DATA.

Condition[a]	High, 4, 1st	Low, 4, 1st	High, 4, 3rd	High, 2, 1st
N	97	98	97	97
Female	61 (62.9%)	61 (62.2%)	47 (48.5%)	55 (56.7%)
Age	36.3 (14.4)	36.3 (14.4)	41.7 (14.4)	35.7 (14.3)
Stay	65 (67.0%)	76 (77.6%)	63 (64.9%)	60 (61.9%)

[a]Format = Uncertainty, Category, Floor.

For the measurement, we use a sliding scale to measure two beliefs, maximum sustained wind speed (80 - 160 miles per hour) and flood depth (0 - 30 inches). The complete experiment materials, data, and analysis can be found at https://github.com/yongsa-nut/CopingCostHurricane.

Participants. We recruit participants who currently live in Florida (FL) from Prolific[3], 100 for each condition in a total of 400. Nonetheless, there are still a few participants who do not currently live in Florida based on their self-report zip code, and we exclude them from the analysis, leaving us with 389 participants. The reason for recruiting participants only from FL is because they are familiar with hurricanes and the NHC, and the framing of the message is the hurricane approaching FL. Table I shows the descriptive stats for the data.

Ethics statement. This research was approved by the institutional review board of Northeastern University.

VI. RESULTS

Before looking at the main hypotheses, we first confirm that people use emotion-focused coping and check the assumption that when the hurricane becomes worse, going from category 3 to category 4 and not 2, people are more likely to use emotion-focused coping. The data analysis in this section is done using brms, a Bayesian Data Analysis R Package [30].

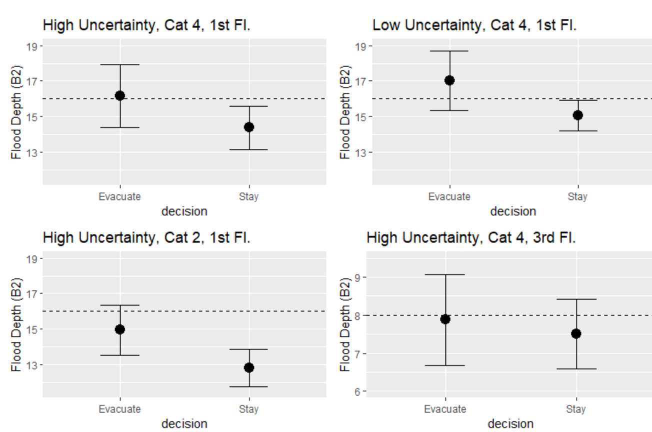

Fig. 1. The estimated mean of the flood depth at the second time (B2) for all four conditions and for people who evacuate and stay. The dot lines indicate the mean value from the hurricane message.

[3]https://www.prolific.co

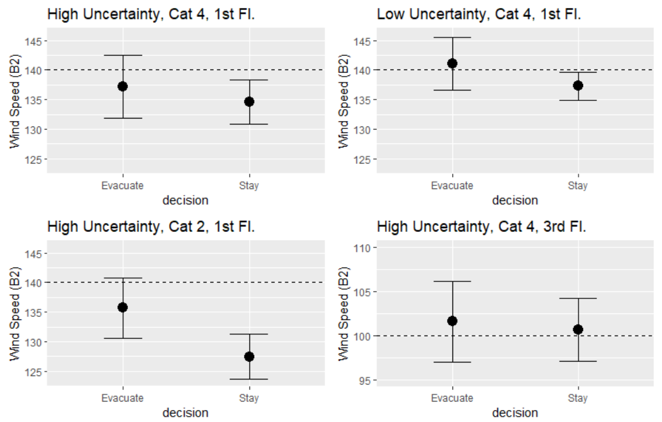

Fig. 2. The estimated mean of the wind speed at the second time (B2) for all four conditions and for people who evacuate and stay. The dot lines indicate the mean value from the hurricane message.

TABLE II
THE ESTIMATED MEAN DIFFERENCE IN BELIEFS BETWEEN PEOPLE WHO STAY AND EVACUATE ACROSS THE FOUR CONDITIONS.

Belief	Est.[a,c]	SE[a]	90% CI[b]	Prob.[b]
Condition 1: High Uncertainty, Cat 4, 1st. Fl.				
Flood	-1.81	1.10	[-3.60, 0.02]	.95
Wind	-2.58	3.31	[-8.07, 2.85]	.78
Condition 2: Low Uncertainty, Cat 4, 1st. Fl.				
Flood	-1.95	0.96	[-3.53, -0.36]	.98
Wind	-3.80	2.63	[-8.07, 0.59]	.92
Condition 3: High Uncertainty, Cat 4, 3rd. Fl.				
Flood	-2.14	0.89	[-3.59, -0.69]	.99
Wind	-8.24	3.22	[-13.46, -2.93]	.99
Condition 4: High Uncertainty, Cat 2, 1st. Fl.				
Flood	-0.38	0.76	[-1.64, 0.88]	.69
Wind	-0.90	2.94	[-5.71, 3.94]	.63

[a]Est.= Estimated difference. SE = Standard Error.
[b]CI = Credible Interval. Prob. = Probability.
[c]Negative value indicates lower value for stay.

Fig. 1 and 2 show the estimated mean for flood depth and wind speed at the second time (B2) for all four conditions and for people who decided to stay and evacuate. For the three category 4 hurricane conditions, we see that participants who stay believe the hurricane's flood depth and wind speed to be lower than the mean point (95% Credible Intervals (CI)s do not include 140 mph for wind speed and 16 inches for flood depth). However, in the case of the category 2 hurricane, the estimated mean beliefs are not different from the mean point (100 mph for wind speed and 8 inches for flood depth).

Table II shows the estimated difference in the mean between participants who stay and evacuate and the posterior probability for the one-tailed t-test that the stay group is less than evacuate group. We again see similar results that there is a clear difference for the three category 4 hurricane conditions except for wind speed for the first condition, but there is no difference for the category 2 hurricane condition. Overall, the results confirm our assumption regarding the use of emotion-focused coping. We now turn to the results of the two hypotheses.

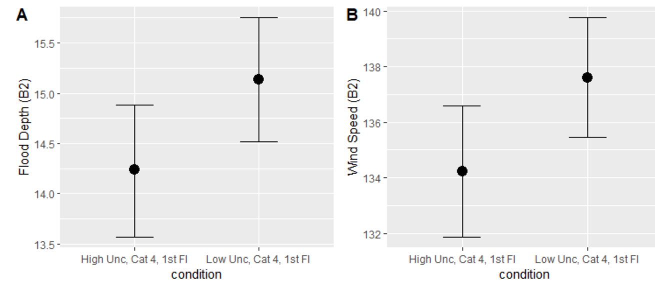

Fig. 3. The estimated mean of the second beliefs adjusted for the first belief between high and low uncertainty conditions among participants who stay. A is flood depth, and B is wind speed. The dot indicates the mean, and the error bar is 95% CI.

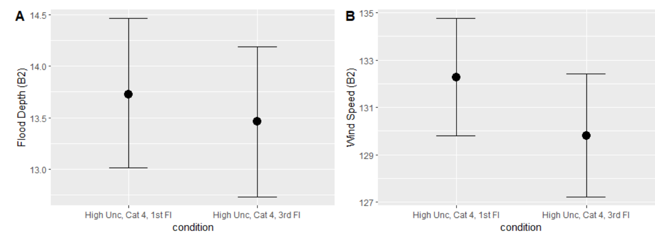

Fig. 4. The estimated mean of the second beliefs adjusted for the first belief between 1st floor and 3rd floor conditions. A is flood depth, and B is wind speed.

Fig. 3 shows the estimated mean of the second beliefs (the beliefs reported after the second message) between high and low uncertainty conditions adjusted for their first belief, and Table III shows the estimated difference in the mean between the two conditions for the one-tailed t-test and the probability that high uncertainty condition is less than low uncertainty condition. We see that, for both flood depth and wind speed, participants in the low uncertainty conditions believe them to be higher than those in the high uncertainty conditions (Flood: Est. = 0.89, SE = 0.47, and Prob = .97, and Wind speed: Est. = 3.36, SE = 1.62, and Prob = .98). These results support H1.

Similarly, Fig. 4 shows the estimated mean difference of the second beliefs between the 1st floor and 3rd floor conditions controlled for their first belief, and Table III shows the estimated difference in the mean between the two conditions for the one-tailed t-test and the probability that the 3rd floor condition is less than the 1st floor condition. The result shows that participants in the 3rd floor condition believe the wind speed to be lower than those in the 1st floor condition (Est. = -2.46, SE = 1.85, and Prob = .91). However, there is no clear difference between the two groups for the flood depth (Est. = -0.28, SE = 0.53, and Prob = .7). These results partially support H2.

VII. DISCUSSION

In this work, we seek to understand the factors that influence the degree of emotion-focused coping, specifically change of belief, in a stressful situation. We model coping as a decision process and identify two key factors that could influence coping: the utility gained from changing to an alternative belief

TABLE III
THE ESTIMATED MEAN DIFFERENCE IN THE SECOND BELIEFS ADJUSTED FOR THEIR FIRST BELIEF FOR THE TWO HYPOTHESES AMONG PARTICIPANTS WHO STAY.

Belief	Est.[a,b]	SE	90% CI	Prob.
High vs Low Uncertainty				
Flood	0.89	0.47	[0.13, 1.66]	.97
Wind	3.36	1.62	[0.70, 6.04]	.98
1st floor vs 3rd floor				
Flood	-0.28	0.53	[-1.14, 0.60]	.70
Wind	-2.46	1.85	[-5.55, 0.59]	.91

[a]Positive indicates higher value for low uncertainty.
[b]Negative indicates lower value for 3rd floor.

and the cost of changing to the new belief. To study these factors, we consider a specific stressful situation, hurricane evacuation, where people first have to decide whether to evacuate or not, and then the situation changes, but they cannot change their decision leading them to rely on emotion-focused coping to cope with the situation.

First, the results from the hurricane experiment show that, in the situation where the hurricane became worse (but not better), people who stayed consistently believed the hurricane's impact to be less than the mean or most likely outcomes from the hurricane information. This result support that people use emotion-focused coping in high-intensity situations and aligns with existing work [31], [5].

More importantly, among people who stayed, those who presented with high uncertainty information believed the hurricane to be even less severe than those who presented with low uncertainty information. This suggests that uncertainty of the information is associated with the degree of emotion-focused coping, supporting H1. Additionally, the results show that people who are situated on the 3rd-floor apartment believe the hurricane wind speed to be lower than people who are situated in the 1st-floor house, but there is no clear difference in the belief about flood depth. This result partially supports H2, showing the association between the utility in the change of belief and the belief change in the case of wind speed.

A potential explanation for the flood depth case is that wind speed is much more salient for people on the 3rd floor, and the flooding still has some impacts on them as they cannot get out of the building. Another explanation is that people may perceive the flood depth and wind speed to be highly correlated as they both are the impact of the same hurricane, resulting in enforcing them to change in a similar direction. Future work is needed to extend the simple, isolated belief representation in the current model to a network of beliefs to capture the relationship/influences between beliefs (e.g., coherence models of beliefs [32]). This would allow us to model how a change of beliefs could impact other beliefs in the network, which could also incur additional costs in changing them.

This work and the results are related to a recent work by Milyavsky et al. (2019), in which they employed Cognitive Energetics Theory (CET) to study the use of emotion regulation under a function of two opposing forces: the driving force (i.e., the motivation to use a specific strategy) and the restraining force (i.e., the difficulty of the strategy) [31]. They use emotional-evoking images to study the use of the reappraisal strategy across different difficulty levels. They found that when the difficulty is low (predicting other's use or predicting their choice vs. implementing it and rethinking it as fake vs. as positive), participants choose reappraisal more for high (but not low) intensity images. These results are quite similar to our results here, in which the use of emotion-focused coping or reappraisal is more when the intensity is high and the cost or difficulty is low. Nevertheless, this study differs from our work in two significant ways. First, we use a decision-making framework instead of CET to study the use of emotion-focused coping (reappraisal). Second, we situate participants in a stressful, negative situation rather than asking them to reappraise negative images unrelated to them.

One important limitation of this work is that the situation is only hypothetical. However, existing literature suggests that the results from hypothetical situations are similar to the results from real hurricanes [23]. Still, hypothetical situations will never be as intense and stressful as real situations. Therefore, it is likely that the results here may underestimate the effect of coping in real situations.

In summary, the results support the idea that the extent to which people use emotion-focused coping depends on their own utility and the uncertainty of their beliefs. These findings have an implication for understanding the use of emotion-focused coping and what could influence that coping. For instance, these findings could help design hurricane messages to guide people's beliefs and decisions. In particular, the work shows that the uncertainty of information and people's situation would influence what they believe about the information. Nonetheless, this is just one way of presenting uncertainty. Communication of uncertainty is an open research area and future work is needed to further explore different ways of presenting uncertainty and its impact [33], [34], [35].

To conclude, this work highlights the potential of the decision-making framework for modeling coping and generating testable hypotheses that could advance our understanding of emotion-focused coping during hurricanes and coping in stressful situations generally.

ETHICAL IMPACT STATEMENT

The objective of this work is to understand how people cope with stressful situations. With a better understanding, we could help people to cope in a more adaptive way. Nonetheless, there are potentially harmful uses of this understanding. In particular, the knowledge could be used in a harmful way by guiding people to believe in false information or bias their decision to suit one's own interest instead of the user's or public's interest. This also highlights the importance of considering users' values in suggesting how people should cope. Future work is needed to better understand the adaptiveness of different coping strategies while considering individual differences, including their situations, background, race, and gender.

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