How Near-Miss Events Can Embolden or Mitigate Risky Decision Making

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Abstract

Decades of research have sought to understand how individuals and organizations prepare for both natural and man-made disasters. We believe one understudied factor is the impact of prior near-miss events. A near-miss occurs when an event (such as a hurricane or tornado), which had some non-trivial probability of ending in disaster (loss of life, property damage), does not because of good fortune. If the near-miss has no salient cues of a possible bad outcome, people appear to mistake such good fortune as an indicator of system resiliency. In the first of two experiments, we study people's reactions to hurricane warnings and find that people with prior near-miss information that have no cues about bad outcomes were less likely to take protective measures to avoid a forecasted hurricane. In this study, we also examined the role of an individual's risk propensity and general optimism. We find risk propensity to be stable across conditions, whereas general optimism can be influenced by the type of prior near-miss information and this influence mediates the impact of near-miss information. In our second study, we examine a specific type of near-miss – the false alarm. We show that over a series of false alarms, people's perception of the risk of a tornado warning decrease and that people are less likely to cancel plans. Our findings indicate that people who experience a hazard but escape without obvious cues of damage will make decisions consistent with a perception that the situation is less risky. We end by discussing the implications for risk communication.

Key words: Near-misses, risk perception, hazard warnings

1.0 Introduction

Disasters are commonly preceded by prior related events with lesser consequences, and more often by an even larger number of related events that had no adverse consequences at all. While there is not a single, agreed-upon definition of a 'near-miss,' there is agreement that recognizing these prior events and understanding people's response to such near-misses is critical for reducing future catastrophes.

We define a near-miss as some event where a negative outcome could have happened because of hazardous conditions but did not (Dillon and Tinsley, 2008). These events are interpreted by observers who are influenced by the saliency of the hazardous conditions. Tinsley, Dillon, and Cronin (2012) demonstrate that some near-misses have cues that highlight resilience (a disaster was successfully avoided and hence it did not feel like a disaster almost happened). People experiencing these "resilient near-misses" can reason that the negative outcome did not impact them and then illegitimately underestimate the danger of subsequent hazardous situations. Thus, false alarms would be one type of resilient near-miss where events forecasted to happen do not occur because of the fortunate improvement in weather conditions. Other resilient near-misses could include events that do occur but with no obvious damage such as a forecasted tornado that occurs far from any populated area or a strong hurricane whose path turns away from any land masses. Dillon and Tinsley (2008), Dillon, Tinsley and Cronin (2011), and Tinsley et al. (2012) demonstrate that individuals who experience resilient near-misses are likely to ignore or discount future hazard warnings.

Other near-misses have cues that highlight danger (a disaster almost happened). People experiencing these "vulnerable near-misses" reason that a disaster came close to occurring,

which encourages them to attend to future hazard warnings and engage in mitigation behavior (Tinsley et al., 2012).

In this research, we explore individual's perceptions of prior events that are near-misses, how individual differences in risk attitudes and optimism may influence these perceptions, and how these perceptions change over repeated events, in particular, for repeated false alarms.

2.0 Recognizing and Responding to a Near-Miss

Investigations that follow catastrophes often identify prior near-misses, and in many cases the difference between these near-misses and the disaster is simply a good versus bad draw from a complex stochastic process. This research builds on the framework developed in Tinsley, Dillon, & Cronin (2012) that examines two types of near-misses: vulnerable near-misses and resilient near-misses. Near-miss events that highlight resiliency, as when people escape harm, can lead to riskier behavior because decision makers frequently interpret these prior near-misses as successes rather than as failures. Consequently, people fail to examine these warning signals for possible valuable information. Thus resilient near-misses could help identify situations in which individuals are likely to take riskier actions. Alternatively, if people experience the near-miss as a disaster that almost happened rather than a disaster that was avoided, then the near-miss highlights one's vulnerability in terms of the harm that could have occurred and should inspire avoidance actions (Tinsley et al. 2012).

Hypothesis 1: People with "resilient" near-miss information will be less likely to take mitigation actions for an impending hazard than people without this information.

In addition to demonstrating that people who experience resilient near-misses are less likely to take mitigation actions, we explore several explanations for why this behavior may occur. One

possibility is that people may be legitimately updating their beliefs about the likelihood of an event using Bayesian logic. That is, perhaps people are processing the near-miss experience as data to re-calculate the likelihood of the impending hazard's impact, and since nothing bad happened before, the likelihood of a future problem should be updated in the downward direction. Past research has demonstrated that this is not a particularly good explanation for people's riskier behavior following near-miss events (Dillon & Tinsley, 2008; Tinsley et al., 2012), and forecasting research has shown that likelihood estimates are less subject to distortion than discrete choices (Krizan & Windschill, 2009). Yet, if people are motivated to choose a particular option they may update (lower) their likelihood of a hazard's occurrence as a way of justifying their choice. Thus we continue to explore this option.

Hypothesis 2: People with near-miss information will revise their estimate of how likely the hazard is in ways that are consistent with their choice to take mitigation actions or not.

Another possible reason why people who experience resilient near-misses are less likely to take mitigation actions is that a near-miss event may change people's risk propensity. Sitkin and Weingart (1995) define risk propensity as an individual's current tendency to take or avoid risks. It is conceptualized as an individual trait that can change over time and thus is described as an emergent property of the decision maker (Sitkin and Weingart, 1995). Thus it is possible that near-misses could change people's risk propensity which would explain their decision to take mitigation actions. We do not expect this to be a good explanation either. Although people's risk propensity can evolve, we suspect this change requires greater saliency of risk information than that typically embedded in a resilient near miss. With a vulnerable near-miss, feelings of danger

and risk are consciously activated, thus vulnerable near-misses may decrease someone's risk propensity. But people are less likely to consciously recognize the absence of risk feelings, therefore we expect little change (increase) in people's risk propensity after a resilient near-miss.

Hypothesis 3: Higher risk propensity individuals will choose riskier action but that risk propensity will not be influenced by prior near-miss information.

Another possible reason to explain why people who experience resilient near-misses are less likely to take mitigation actions is that a near-miss event changes people's general optimism about the situation. We focus on a person's dispositional optimism as defined by Radcliffe and Klein (2002). Dispositional optimism is considered to be the general positive expectancy that one will experience good outcomes. Other types of optimism that are often considered in the hazards literature are comparative optimism (that one is less likely than others to experience a specified risk compared to others) or unrealistic optimism (an erroneous perception of comparative risk for a specific hazard). These later two definitions of optimism are often components of the "optimism bias" (e.g., Weinstein, 1989b) that has been found in relation to risks in extreme sports (Middleton, 1996), motor vehicle driving (Lee and Jobs, 1995; Jobs, Hamem, and Walker, 1995), earthquakes (Spittal, McClure, Siegert, Walkey, 2005), and experiencing work place hazards (Caponecchia, 2010). We test here whether dispositional optimism may also play a role in understanding reactions to hazard warnings. Recall that a resilient near-miss does highlight that a good outcome occurred. This positive information could therefore impact someone's general level of optimism. If so, it suggests that dispositional optimism is another individual-level emergent trait.

Hypothesis 4: Resilient near-miss information will trigger higher dispositional optimism, and this higher optimism will mediate the relation between the near-miss experience and the intention to choose a riskier action.

The challenge of recognizing near-misses becomes even more difficult over time because of a strong tendency for "normalizing deviance" (Vaughan, 1996; Vaughan, 2005). When anomalies occur repeatedly, decision makers tend to dismiss underlying risk as the anomalies come to feel normal and routine over time. Thus, near-misses may no longer appear to be signals of danger but instead become a sign that the system is operating as predicted. Specifically, "what was originally defined as deviant becomes normal and acceptable as decisions that build upon the precedent accumulate" (Vaughan, 2005: 55). March and Shapira (1987) and Thaler and Johnson (1990) argue that successful or unsuccessful outcome histories affect how decision makers perceived risky situations and that decision makers would be prone to persist in pursuing what worked in the past and to abandon what did not. Thus, as individuals are exposed to false alarms and fail to take mitigation actions, this risky behavior will continue to persist. Additionally, those who do take mitigation actions that prove to be unnecessary because of the false alarm should, over time, decide to not take future mitigation actions.

Hypothesis 5: Multiple false alarms will reduce perceptions of risk over time, and individuals who are exposed to multiple false alarms will be less likely to take mitigation actions for an impending hazard.

3.0 Overview of Studies

We test these hypothesis with two experimental studies. The first study presents decision makers with a warning in the hurricane context. The second study presents decision makers with a series of three tornado warnings that all turn out to be false alarms.

3.1 Study 1: Cruise Ships and Hurricanes

In the first study, participants read a vignette about a planned cruise that could be impacted by a forecasted hurricane. Participants were 875 participants who were recruited by Qualtrics, Inc. to complete the exercise on-line and who passed two attention filters in the survey. All participants read the following vignette:

> *Imagine that last April, you purchased non-refundable tickets to take your best friend on a Caribbean cruise for your friend's birthday. You are supposed to leave tomorrow, but the National Weather Service is currently tracking a hurricane in the Caribbean that they estimate has a 30% chance of hitting where you will be on cruise. You need to decide whether or not to go on the trip.*
>
> *If you do not go, you will lose the $2,000 cost of the tickets.*
>
> *If you decide to go, and the hurricane does cross your ship's planned route, you will encounter rough seas and the ship will be diverted. Rough seas commonly cause motion sickness but can cause significant injuries from accidents. You calculated the collateral costs from diversions/delays and sickness/accidents to be roughly $10,000. Thus if you go on the trip, you have a 30% chance of losing $10,000.*

Participants were randomly assigned to one of three conditions: the control condition (N=302), the "resilient" near-miss condition (N=290), and the "vulnerable" near-miss condition (N=283). In the control condition, participants read:

> *You do know that cruise ships can be diverted by bad weather, but you have no information about past hurricanes impacting cruises in this region.*

In the resilient near-miss condition (prior near-miss events without any cues of potential problems), participants read:

> *You do know that cruise ships can be diverted by bad weather, but you have been on three prior cruises this time of year while there were hurricanes, and your ship has never been diverted or had passengers injured.*

In the vulnerable near-miss condition (prior near-miss events with salient possible bad outcomes), participants read:

> *You do know that cruise ships can be diverted by bad weather, but you have been on three prior cruises this time of year while there were hurricanes, and your ship has never been diverted or had passengers injured. On the other hand, last year, a close friend of yours was on a ship that was diverted because of a storm and incurred $10,000 in collateral costs trying to get home.*

After reading each scenario, participants were asked a series of questions. Participants were asked about the situation:

- "What is the probability that you would still go on the trip? (definitely not go = 0%, definitely go = 100%).
- "What do you believe is the likelihood of your cruise ship having a problem with the hurricane if you continue with your plans? (1 = very unlikely, 7 = very likely)

The first question assesses the participant's preference for continuing on the trip using a scaled format item as an indirect measure of decision making to capture the subject's intentions. The second assesses the participant's beliefs regarding the likelihood of the hurricane impacting the trip.

Participants were also asked about their general approach to risk:

- "In facing this type of decision, how would you rate your tendency to choose a more risky or less risky alternative?" (1 = very unlikely to choose risky alternatives, 7 = very likely to choose risky alternatives)
- "How would you rate your tendency to choose an action which has the potential to backfire?" (1 – very unlikely to initiate risky action, 7 – very likely to initiate risky action)

Finally, participants were asked about their general optimism (Schier, Carver, and Bridges, 1994):

- "In general, how much do you agree with the statement: overall, I expect more good things to happen to me than bad." (1 – strongly disagree, 7 – strongly agree)
- "In general, how much do you agree with the statement: I tend to focus on the possible bad outcomes that could occur in a situation." (1 – strongly disagree, 7 – strongly agree)
- "Are you more likely to think about the possible good outcomes that could happen or the possible bad outcomes that could happen?" (1- strongly disagree, 7 – strongly agree)

The two general propensity toward risk questions were used to create a scale for risk propensity ($\alpha = .79$), and the three general optimism questions (with the second one reverse coded) were used to create a scale for dispositional optimism ($\alpha = .77$).

3.1.1 Results and Analysis

Bivariate correlation showed that the variables (probability still go, likelihood of problems, risk propensity scale, and dispositional optimism scale) are significantly correlated with each other (see Table 1), thus MANOVA is used (Devore 1987). Because our hypotheses are interested in whether or not the resilient near-miss is perceived differently than the control or the vulnerable near-miss, we dummy coded the resilient condition =1 and the two non-resilient conditions (i.e., control and vulnerable near-miss) = 0. The MANOVA shows that condition has a significant effect on participants' assessments ($F_{(4, 870)} = 2.76$, $p = .03$). Participants were more likely to state a higher probability to continue with the trip in the resilient near-miss condition than the non-resilient condition (resilient mean = 63.6, s.d. = 31.3; non-resilient mean = 58.1, s.d. = 31.4, $F_{(1,873)} = 5.77$, $p = .02$), supporting Hypothesis 1.

Table I. Matrix of Correlations for Study 1 Variables

	Likelihood Problems	Risk Propensity	Dispositional Optimism
Probability Will Go	-.42**	.53**	.43**
Likelihood Problems		-.26**	-.32**
Risk Propensity			.37**

** p < 0.05; ** p < 0.01. Two-tailed tests*

To test Hypothesis 2, we examined if the belief regarding the likelihood of the cruise ship having a problem with the hurricane was different by condition again with the resilient condition dummy coded = 1 and the two non-resilient conditions = 0. Participants in the two conditions did not have significantly different perceptions of the likelihood of problems if they were to continue with the trip (resilient mean = 4.0, s.d. = 1.5; non-resilient mean = 4.2, s.d. = 1.4, $F_{(1,873)} = 1.34$, $p = .25$), thus providing no support for Hypothesis 2.

Risk propensity showed no differences across conditions (resilient mean = 3.64, s.d. = 1.42; non-resilient mean = 3.62, s.d. = 1.41, $F_{(1,873)} < 1.0$, p = n.s.), but dispositional optimism did (resilient mean = 4.95, s.d. = .08; non-resilient mean = 4.72, s.d. = .05, $F_{(1,873)} < 6.47$, p = .01).

We next examined the data with a regression analysis where we Helmert coded (Judd and McClelland, 1989) the differing levels of near-miss experience to compare: 1) resilient near-miss to the other conditions (Contrast 1 = 2 if resilient near-miss; Contrast 1 = -1 if vulnerable near miss, and Contrast 1 = -1 if control) and then 2) control to vulnerable near-miss(Contrast 2 = 0 if resilient near miss; Contrast 2 = 1 if vulnerable near miss; Contrast 2 = -1 if control).

The first regression model examined the effect of near-miss information (contrasts 1 and 2) on stated probability that the individual would still go on the trip (Table II, model 1). The first contrast was significant demonstrating that participants were more likely to state a higher probability to continue with the trip if they had the resilient near-miss condition than the other conditions confirming the MANOVA results and supporting Hypothesis 1. The second contrast was not significant demonstrating that participants' probabilities to continue with the trip in the control and vulnerable condition were not different than each other.

The second regression model examined the effect of near-miss information (contrasts 1 and 2) on stated probability that the individual would still go on the trip with risk propensity included in the model (Table II, model 2). The first contrast was still significant demonstrating that participants were more likely to state a higher probability to continue with the trip if they had the resilient near-miss condition than the other conditions, and the second contrast was not significant demonstrating that participants' probabilities to continue with the trip in the control and vulnerable condition were not different than each other. Additionally, risk propensity is

significant such that those who stated they were more likely to choose riskier options also stated a higher probability to continue with the trip plans, supporting Hypothesis 3.

Table II. Probability that participant would still go on the trip

	Model		
	1	2	3
Contrast 1: resilient near-miss vs. control & vulnerable near-miss	.082*	.078**	.045
Contrast 2: control vs. vulnerable near-miss	-0.042	-.043	-.029
Risk propensity		.528**	
Dispositional optimism			.422**
R square	.008	.28	.18
Significant R-squared change	p=.026	p=.000	p=.000

Note ** p≤ .01 * p≤ .05 †p≤ .10

The third regression model examined the effect of near-miss information (contrasts 1 and 2) on stated probability that the individual would still go on the trip with dispositional optimism included in the model (Table III, model 2). With dispositional optimism included, neither the first nor second contrasts are significant suggesting that dispositional optimism is a mediator of resilient near-miss information. To confirm this, we performed a mediation analysis as described in Baron and Kenny (1986).

(1) Regression analysis showed that our exogenous condition variable predicted intention to go on cruise. Receiving resilient near-miss information (contrast 1) was correlated with probability to continue with the trip ($\rho = .08$, $p = .02$).

(2) Regression analysis showed that our mediator variable predicted intention to go on the cruise. The more optimistic someone was the more likely they were to go on the cruise ($\beta = .43$, $p < .001$)

(3) When both the resilient near-miss information (contrast 1) and dispositional optimism are simultaneously included in a regression predicting probability to still go, dispositional optimism is a significant predictor ($\beta = .42$, $p < .001$) but near-miss was not ($\beta = .045$, $p = .14$) (Table 1, Model 3).

(4) A Sobel test (Sobel, 1982) revealed a significant effect ($z = 2.56$, $p = .01$) indicating that the effect of the resilient near-miss information on individual choice to continue with the trip was fully mediated by dispositional optimism.

3.1.2 Discussion

When participants had near-miss information where the outcome was fine and there was no salient information about problems that almost occurred, they chose the riskier option to continue with the cruise as planned, compared to people with no information about past near-misses or those with salient information about vulnerabilities in past near-misses. We do not find evidence that people are intuitively updating likelihood estimates in a Bayesian calculation, but instead find that people across all three conditions saw the likelihood of problems if they continue with the cruise to be about the same. We did find that those who describe themselves as generally more risk seeking using our risk propensity scale were more likely to choose the riskier option and continue with the cruise, but this was independent of the near-miss information provided. In terms of impact of near-miss information, we find that if a person experiences a resilient near-miss, he or she is more optimistic in general, and this general optimism makes that

individual more likely to continue with the riskier choice. We also tested and found that the effect of resilient near-miss information on individual choice was mediated by dispositional optimism. In future work, we will examine if this dispositional optimism will transfer between categories of hazards. Specifically, if you had prior resilient near-miss experience with wild fires, are you more optimistic about successfully surviving future wildfires, and are you also more optimistic regarding future flooding events (since flooding commonly follows wildfires)?

Given the impact of resilient near-miss information on people's future risky choices shown in the first study, we further examine a specific type of resilient near-miss: the false alarm in the second study.

3.2 Study 2: Tornados and False Alarms

In the second study, we looked at one particular type of resilient near-miss: the false alarm. A high false alarm ratio (FAR) (or repeated overwarnings) is considered by many emergency managers and researchers to be problematic because of the perceived complacency among the population that will occur when the public is continuously warned but not impacted by an event (Simmons and Sutter, 2009). False alarms represent a specific type of resilient near-miss, because the person of interest is warned of a potentially hazardous event and when the hazardous event does not impact the individual, there are no signals that a bad event almost occurred.

In this study, participants were 157 undergraduate students who completed on-line exercises for class credit, one of which was this study. The design was a 2×2 where participants were presented with scenarios over three simulated time periods. In each time period, participants encountered either a large or small storm and after rating their risk and their personal

decision about mitigating actions to take, they are told they have been convinced to either cancel plans and seek shelter or continue with plans.

Specifically, in the first time period, half the participants were presented with a tornado warning for either a large or small event:

> Version 1 (small – time 1):
> *You are visiting relatives in Norman, Oklahoma for two weeks over the summer when the following warning is broadcast on the television:*
>
> *"Doppler radar is detecting severe weather conditions likely to produce a small tornado. Winds of 50-85 mph are possible within the warned area. Seek shelter in a bathroom or basement away from windows."*

> Version 2 (large – time 1):
> *You are visiting relatives in Norman, Oklahoma for two weeks over the summer when the following warning is broadcast on the television:*
>
> *"Doppler radar is detecting severe weather conditions likely to produce a DANGEROUS tornado. Winds exceeding 85 mph and producing major damage are possible within the warned area. Seek shelter in a bathroom or basement away from windows."*

All participants were then asked:

"What do you believe the risk is to your personal safety from this reported severe weather event?" (0 = not at all risky, 10 = very risky). And then each participant is told what his or her response was to the forecasted storm for time period 1: cancel plans and seek shelter or continue with plans based on the random assignment to one of the two conditions. The cancel plans and seek shelter condition read:

> (Response 1): *Your aunt who has spent her whole life in Oklahoma is inclined to ignore the warning and continue watching the television. Your other relatives convince everyone to seek shelter for about two hours in the unfinished basement until the weather alert is removed. Upon further research, you learn that no tornadoes were spotted in the warning area during the alert and that 70% of all tornado warnings are false alarms.*

The continue with plans condition read:

> (Response 2): *Your aunt who has spent her whole life in Oklahoma is inclined to ignore the warning and continue watching the television. She persuades the rest of your relatives*

to continuing with plans and to not seek shelter from the tornado. After the alert is removed, upon further research, you learn that no tornadoes were spotted in the warning area during the alert and that 70% of all tornado warnings are false alarms.

If participants read about a small storm in time period 1, they also read about a small storm forecast in time period 2 (and the same for the large storm condition).

Version 1 (small – time 2):
Three days later, you are still visiting your relatives in Norman, Oklahoma, when the same warning is broadcast on the television:

"Doppler radar is detecting severe weather conditions likely to produce a small tornado. Winds of 50-85 mph are possible within the warned area. Seek shelter in a bathroom or basement away from windows."

Version 2 (large – time 2):
Three days later, you are still visiting your relatives in Norman, Oklahoma, when the same warning is broadcast on the television:

"Doppler radar is detecting severe weather conditions likely to produce a DANGEROUS tornado. Winds exceeding 85 mph and producing major damage are possible within the warned area. Seek shelter in a bathroom or basement away from windows."

All participants were then again asked:

"What do you believe the risk is to your personal safety from this reported severe weather event?" (0 = not at all risky, 10 = very risky). In time period 2, unlike in time period 1, before participants were told their response, all participants are asked:

You already have plans to go to the birthday party of your cousin at a local restaurant. You and your cousin have celebrated each other's birthday together since you were five years old. You call ahead to the restaurant and the party has not been canceled.

Would you continue with your plans as scheduled or postpone them? (1 = continue with plans as scheduled, 2 = postpone planes)

Then based on the participant's randomly assigned condition from time period 1 (cancel plans and seek shelter or continue with plans), participants are told the same information in time 2,

either that their relatives reinforce their plan or over-ride their plan. Then the "cancel plans and seek shelter" condition read:

> *Your relatives convince you that it is not safe to go to the birthday party, and instead seek shelter for about two hours in the unfinished basement until the weather alert is removed. Later you again learn that no tornadoes were spotted in the warning area during the alert.*

The "continue plans" condition read: :

> *Your relatives convince you to go to the birthday party, and not seek shelter from the tornado. After the weather alert is removed, you again learn that no tornadoes were spotted in the warning area during the alert.*

Time period 3 is similar to time period 2. Those participants in the small event condition read:

> *Seven days later, you are still visiting your relatives in Norman, Oklahoma, when the same warning is broadcast on the television:*
> *"Doppler radar is detecting severe weather conditions likely to produce a small tornado. Winds of 50-85 mph are possible within the warned area. Seek shelter in a bathroom or basement away from windows."*

Participants in the large event condition read:

> *Seven days later, you are still visiting your relatives in Norman, Oklahoma, when the same warning is broadcast on the television:*
> *"Doppler radar is detecting severe weather conditions likely to produce a DANGEROUS tornado. Winds exceeding 85 mph and producing major damage are possible within the warned area. Seek shelter in a bathroom or basement away from windows."*

All participants were again asked "What do you believe the risk is to your personal safety from this reported severe weather event?" (0 = not at all risky, 10 = very risky). And then finally, all participants read and were asked regarding the time period 3 forecasted storm:

> *You have plans for a very important meeting that is related to some research that you are doing for school. You are leaving tomorrow so the meeting will not be able to be rescheduled. You have called ahead and the meeting has not been canceled.*
>
> *Would you continue with your plans as scheduled or postpone them? (1 = continue with plans as scheduled, 2 = postpone planes)*

3.2.1 Results and Analysis

When asked about the risk to your personal safety, in all three time periods, those who saw the large forecasted storm thought the storm was a higher risk, but over time, everyone's perception of the risk declined with the repeated false alarms. The perception of risk by storm condition is shown in Figure 1.

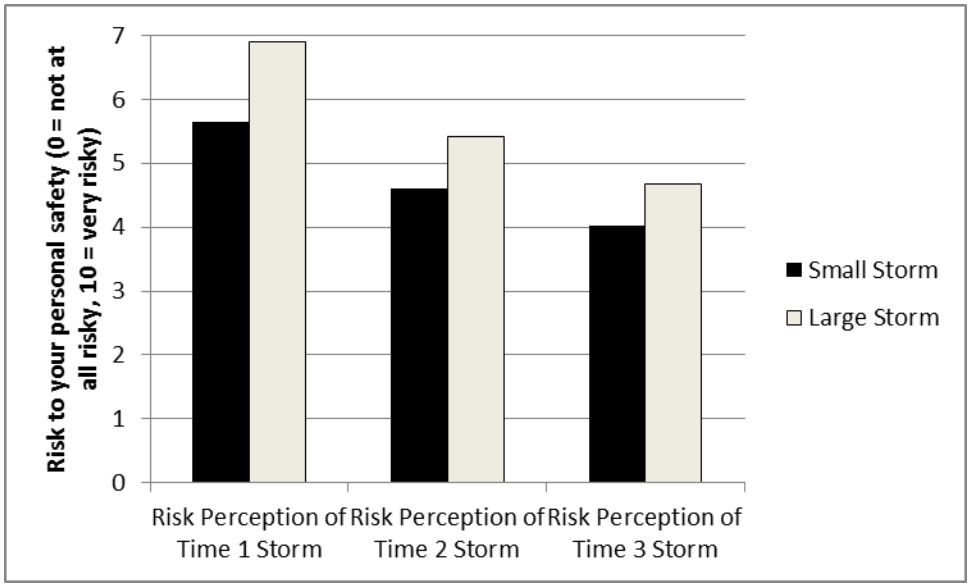

Figure 1 – Risk Perception of Possible Storm over Three Storm Forecasts

Using 2 (storm size) × 3 (time period) mixed model ANOVA, the perception of risk has a significant main effect for the severity of the storm (small storm mean = 4.75, s.d. = 1.9; large storm mean = 5.68, s.d. = 1.9; $F_{(1,155)} = 9.4$, p=.003) and for time (risk time 1 mean = 6.22, s.d. = 2.2; risk time 2 mean = 4.97, s.d. = 2.1; risk time 3 mean = 4.32, s.d. = 2.3; $F_{(2,310)} = 113.9$, $p < .001$). As the plot in Figure 1 demonstrates, while the risks are decreasing over time, the gap between large and small storm is also decreasing. This is reflected in a significant interaction effect, $F_{(2,319)} = 2.96$, p=.05.

Using a second mixed model ANOVA, we examine the impact of informing the participant of their response action (either cancel plans and seek shelter or continue with plans). Again, remember this was an assigned condition as participants were told the response to the first

storm forecast after the assessment of risk in time period 1 and were told the response to the second forecast after the assessment of risk and after they said what they would do in time period 2. Using 2 (response condition) × 3 (time period) mixed model ANOVAs, the perception of risk still has a significant main effect for time ($F_{(2,310)} = 109.6$, $p < .001$), but does not have a main effect for what response was performed ($F_{(1,155)} = 1.65$, $p = .2$). In other words, the assigned response condition (their being told that they were convinced to either cancel plans and seek shelter or continue with plans) did not have an influence on the participant's perceived risk of the situation.

We then examined participants' individual response as to whether their reaction had been to cancel plans and seek shelter or continue with plans in time periods 2 and 3. Figure 3 shows the percentage of respondents by condition that stated they would continue with their plans in time period 2 and time period 3.

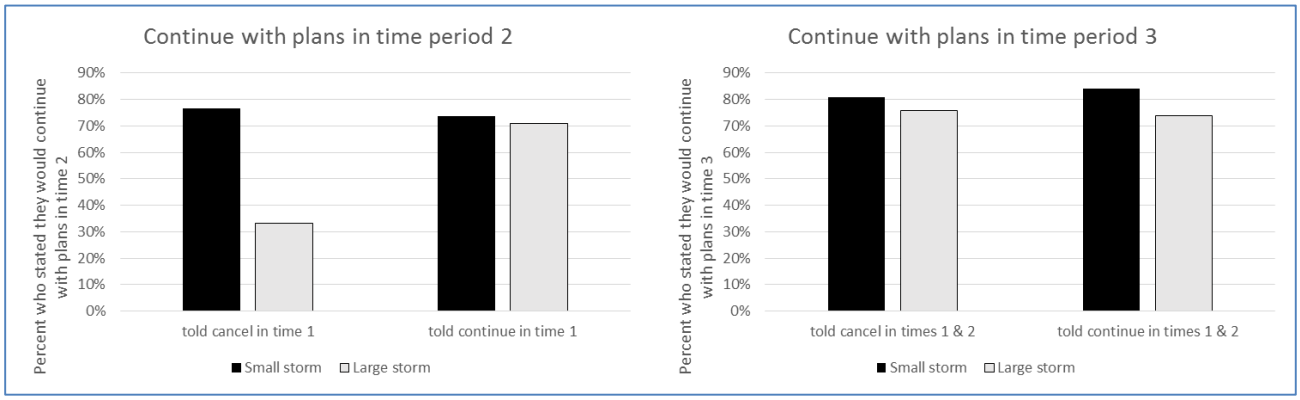

Figure 3 – Percentage of participants who would continue with plans after tornado warnings in time periods 2 and 3

The only group to cancel plans and seek shelter in a significant percentage were those in the second storm time period in the condition where the storm was large and the participants had been told that they had been convinced to cancel plans and seek shelter in time period 1. In that condition, 33% of participants would continue with plans, compared to 76% in the small storm

condition ($\chi 2$ (1) = 14.9, $p<.001$) and 71%-84% in all the other conditions. Yet, by the third storm time period (after two false alarms), the majority of participants in all conditions continue with their plans with no significant difference between conditions. In other words, even when participants are told that they had been convinced to seek shelter (at times 1 and 2) and that the storm is large, after two false alarms, people no longer seek shelter.

3.2. Discussion

Results of Study 2 suggest that people can be nudged to seek shelter by cues that suggest this is appropriate behavior. When participants were told that their family had convinced them to seek shelter at time 1 they were more inclined to seek shelter for the same hazard at time 2 (than those who had been told their family had convinced them to continue with their plans). However, this window of opportunity to influence people's reaction seems to be open for only a limited time. After two false alarms, the vast majority of participants ignored the tornado warning—regardless of whether or not they had been nudged to heed this warning in the past. Additionally (and unfortunately), the size of impending storm did not matter—after two false alarms even those facing a large storm warning were not likely to cancel their plans. A possible influencing factor is that storms size did not change across participants' warnings. Perhaps if people encountered a small storm false alarm followed by a large storm warning they might be more inclined to heed this warning than those who first encountered a large storm false alarm followed by a second storm warning.

4.0 General Discussion

A better understanding of people's responses to prior near-misses is critically important if emergency managers are going to successfully communicate risks of hazardous situations to the public. This is because in most hazardous areas, people are repeatedly exposed to similar hazards year after year (e.g., hurricanes in the southeastern United States, tornados in the mid-western United States, etc.). Yet, most people's prior experience with a particular hazard is that they did not experience severe damage. For example, most "hurricane-experienced" people are actually on the fringe of the storm (Weinstein, 1989a), and thus many prior experiences with a hazard are resilient near-misses, and many of these resilient near-misses are specifically false alarms.

In study 1, we show that those who have prior near-miss information that highlights resiliency are more likely to make the riskier choice and not choose the mitigation actions. The reason for this behavior was a general improvement in dispositional optimism and not a critical updating of prior estimates of the likelihood of potential problems. This finding is consistent with research that shows that people have two general information-processing systems that involve thinking either "fast or slow" (Kahneman, 2011). Although there are several labels for these systems, one is generally rule-based (also called system 2), which operates according to formal rules of logic and evidence. The other is associative (system 1), which operates by principles of similarity so that the situational context has a direct and powerful influence on responses. Responses that require more cognitive effort such as updating the likelihood of potential problems based on prior events is an analytic processing that may not be activated when processing near-miss information. Affective responses, such as feeling more optimistic about the situation, tend to be the product of system 1 processing (Kahneman, 2011) and may be more activated by near-miss

information. Thus near-misses may provoke choices that are riskier simply because people feel more optimistic and they react to this affective response to continue with their plans

Thus, for emergency managers to overcome the impact of prior resilient near-miss information, we show that highlighting the vulnerability of the hazard is a promising idea. For example, risk communication messages could emphasize how the event was almost a bad event for those who did not experience damage. This should prompt more risk averse behaviors and more mitigating actions. The strategy to emphasize vulnerability was evident in April 2012 for a series of severe weather events (specifically tornadoes) that impacted several Plains states including Iowa, Kansas, and Oklahoma. Days ahead of the storms, warnings for residents across five states emphasized the threat of "extremely dangerous" and "catastrophic" weather. In Kansas, the warning stated, "This is a life-threatening situation. You could be killed if not underground or in a shelter" (Fernandez & Flegenheimer, 2012). The warnings may have helped in Thurman, Iowa, where severe weather battered the small town damaging or destroying 75 to 90 percent of its homes, and yet none of the 200 residents were seriously injured or killed. But how sustainable is this type of warning? Of course this strategy is not without some risk. A strategy that emphasizes communicating vulnerability needs to be adopted carefully because as shown in study 2, after repeated false alarms, people worry less regardless of prior concerns, and as shown in study 2, the severity of the storm.

In future research, we will explore the possible impact of an inoculation or two-sided persuasion message. For example, a test message could be something like, "We realize that your community [insert community name] has averted [insert relevant major catastrophe/crisis/ hazard]. This is commendable, however, in many cases, success of this nature can conceal opportunities for further reducing risk." Future research will test a two-sided risk communication

message to identify how the influence of the message on behavior would depend on participant's perception of prior near-miss events and how the inoculation message is described.

5.0 Conclusions

A primary assumption in our research is that false positives (assuming a situation to be safe when it is truly risky) are far more dangerous than false negatives (assuming a situation to be risky when actually it is not), and that false positives commonly occur after near-misses with no salience of near-failure. With two studies, we demonstrated how people who have experienced a similar situation but escape damage without obvious cues of a bad event will make decisions consistent with a perception that the situation is less risky than those without the past experience. Future research will test communication messages that can help emergency managers effectively warn the public to the dangers of repeated hazards where most past experiences are resilient near-misses.

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