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How Near-Miss Events Amplify or Attenuate Risky Decision Making

Catherine H. Tinsley, Robin L. Dillon
McDonough School of Business, Georgetown University, Washington, DC 20057
{tinsleyc@georgetown.edu, rld9@georgetown.edu}

Matthew A. Cronin
School of Management, George Mason University, Fairfax, Virginia 22030, mcronin@gmu.edu

In the aftermath of many natural and man-made disasters, people often wonder why those affected were underprepared, especially when the disaster was the result of known or regularly occurring hazards (e.g., hurricanes). We study one contributing factor: prior near-miss experiences. Near misses are events that have some nontrivial expectation of ending in disaster but, by chance, do not. We demonstrate that when near misses are interpreted as disasters that *did not occur*, people illegitimately underestimate the danger of subsequent hazardous situations and make riskier decisions (e.g., choosing not to engage in mitigation activities for the potential hazard). On the other hand, if near misses can be recognized and interpreted as disasters that *almost happened*, this will counter the basic "near-miss" effect and encourage more mitigation. We illustrate the robustness of this pattern across populations with varying levels of real expertise with hazards and different hazard contexts (household evacuation for a hurricane, Caribbean cruises during hurricane season, and deep-water oil drilling). We conclude with ideas to help people manage and communicate about risk.

Key words: near miss; risk; decision making; natural disasters; organizational hazards; hurricanes; oil spills
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Introduction

In the aftermath of Hurricane Katrina, the public and media alike questioned why so many people failed to evacuate the Gulf Coast and why the government and first-responder organizations were so appallingly underprepared (Glasser and Grunwald 2005). The reasons for these failures are often rooted in experiences with previous hurricanes. In the lead-up to the storm, Governor Haley Barbour of Mississippi warned of "hurricane fatigue"—the possibility that his constituents would not evacuate because they had successfully weathered earlier storms; similarly, one former Federal Emergency Management Agency official said people in the agency unfortunately approached the Katrina response as it had other responses, though the aftermath of Katrina was clearly "unusual" (Glasser and Grunwald 2005). Such complacency is not exclusive to hurricanes. Citizens who survive natural disasters in one season often fail to take actions that would mitigate their risk in future seasons (e.g., moving off a Midwestern flood plain or clearing brush to prevent wildfires in the West; see Lindell and Perry 2000). Our research demonstrates that people may be complacent because prior experience with a hazard can subconsciously bias their mental representation of the hazard in a way that often (but not always) promotes unrealistic reassurance.

When people escape an impending disaster by chance, they have experienced a "near miss." More precisely, a near miss is an event that has some nontrivial expectation of ending in disaster but because of luck did not (Reason 1997, Dillon and Tinsley 2008).[1] Our natural environment produces many examples of near misses: a random tree pattern saves a house from a mud slide or a hurricane weakens right before it hits a city. Organizations experience near misses as well. For example, in the deep-sea oil drilling industry, dozens of Gulf of Mexico wells in the past two decades suffered minor blowouts during cementing; however, in each case chance factors (e.g., favorable wind direction, no one welding near the leak at the time, etc.) helped prevent an explosion (Tinsley et al. 2011).

We study how prior near misses influence peoples' interpretation of similar hazards and thus influence future mitigation decisions. We do this in multiple contexts: a single household threatened by a hurricane, a planned Caribbean cruise threatened by

[1] Other events have been labeled "near misses" such as last minute heroic efforts to avert crisis or interventions of chance that cause bad rather than good outcomes (e.g., narrowly missing an airplane departure). Thus, we specify our focus here on near misses as chance-dependent good outcomes.

a hurricane, and oil-rig operations threatened by a dangerous storm. We explain why and when a near miss produces complacency versus action and offer prescriptions for risk communication strategies based on how different types of near misses operate.

How Near Misses Influence Cognitive Processes

When facing an imminent hazard, people should assess the risk, which is technically a function of the probability of the event occurring and the harm that results from the event if it occurs (Kaplan and Garrick 1981, von Neumann and Morgenstern 1944). This is the classic subjective expected utility (SEU) model. For example, to decide whether or not to evacuate for an impending hurricane, people should combine assessments of the likelihood of their location being hit by the hurricane and how bad the damage could be. Such assessments make use of the information at hand, but people also bring past personal experiences into their evaluation of the risk (Fishbein and Azjen 2010, Tierney et al. 2001). We show that a particular type of personal experience, near misses, have an undue influence on how people evaluate risk and can lead to questionable choices when people face an impending hazard with which they have had prior near-miss experience. We show that this near-miss effect is robust because it seems to implicitly influence the thoughts people use as inputs to their decision making. This near-miss effect can be countered, but doing so needs to use the same kind of implicit mechanism.

Although an SEU model provides a strong basis for characterizing how people decide to respond to hazards, past research (Gonzalez and Wu 1999, Tversky and Fox 1995) has shown that the model components (including the likelihood estimates for probability, (un)attractiveness estimates for outcomes, and the ways in which these can be combined into an evaluation of risk) can vary based on characteristics of the situation such as whether the likelihood estimates are very large, moderate, or very small (Tversky and Fox 1995). More importantly for the present work, Gonzalez and Wu (1999) demonstrated that SEU can vary both between and *within* individuals (i.e., the same person may be risk averse in one situation and risk seeking in another) because the components are all sensitive to the domain knowledge people use when evaluating the risky event.

We argue that near misses change the domain knowledge (or cognitive category) that people use in their assessment of the SEU components, and thus can bias the judgments people make about risky situations. For example, people may learn that a hurricane has a 50% chance of striking their town and causing major flooding and wind damage. This information provides input to assessing probabilities and outcomes, but it also cues the retrieval of other information that will be used to refine these estimates and their relationship to each other. Krizan and Windschitl (2007) provide a useful conceptualization of this knowledge retrieval process: given a situation involving risk, people must assess what this information means in light of what they already know. "What they already know" is the domain knowledge Gonzalez and Wu (1999) spoke of as modifying assessments of probabilities and outcomes and their combination. To select which domain of knowledge to use, people can use the cognitive category to which a hazard event belongs (Kahneman and Miller 1986). "Hurricane" represents a category of events that guides the retrieval of relevant knowledge from memory. So although an avalanche is also a hazard, knowledge about avalanches would not be retrieved based on the hurricane category (although knowledge of flooding, which is related to hurricanes, might).

Near misses come into play in that they can modify the hazard category, because prior experiences with an event can alter the cognitive category for that event (Kahneman and Miller 1986). Thus, after a near miss, the knowledge people will use in assessing SEU components for a future hazard will change. This explains why prior outcomes can strongly influence future decisions and realized outcomes tend to be seen as deterministic (Hastie and Dawes 2001).

The chain of events we posit is as follows: (1) upon encountering a hazard, people retrieve relevant knowledge from memory about that hazard, a process that is largely implicit (Anderson 1983, 1993; Kahneman and Miller 1986) but results in assessments of probabilities, outcomes, and how they will be combined; (2) an explicit evaluation of the risk of the hazard is made largely using an SEU framework; and (3) once the risk is evaluated, people must explicitly choose what behavior to engage. In the next section, we hypothesize how near misses influence this chain of events.

Hypotheses

Dillon and Tinsley (2008) found that near misses in completing a space project encouraged people to choose a riskier strategy when faced with a future hazard threat to the mission. Although highly contextualized and specific, their research showed that near misses are events that alter evaluations of risk, and thus a near-miss bias should generalize to many kinds of hazards and be relevant to a large array of natural and man-made hazard environments. Near-miss events in the hazard context often highlight resiliency because people escape harm. For example, imagine that a hurricane is being tracked in the Caribbean and

is a concern to two neighborhoods, *A* and *B*. People in both neighborhoods rely on existing domain knowledge to direct their thinking about the risk of this situation and whether or not to take protective action. Assume that as the storm grows nearer, it becomes clear that the hurricane will miss neighborhood *A*, but neighborhood *B* is still in danger, and they create a sandbag levee around the main city buildings. Fortunately, when the hurricane makes landfall, the storm surge subsides before overtopping *B*'s makeshift levee, and the town suffers no damage. In this illustration, neighborhood *A* did not experience a near miss because there was no expectation of harm. Neighborhood *B* experiences a near miss because there was a nontrivial expectation that the flooding could occur, but for good fortune (i.e., chance storm characteristics) it did not. We argue that the near-miss event experienced by people of neighborhood *B* will change the hurricane category knowledge in a way that when facing a new hazard warning, the domain knowledge retrieved will make the hazard seems less threatening, leading to complacency. Thus, near misses that emphasize resiliency will lead to riskier behavior.

Hypothesis 1 (H1). *People with near-miss information that highlights how a disaster did not happen will be less likely to take mitigating action for an impending hazard than people without this information.*

The process we have described for how near misses work (change to the category knowledge) does not restrict the direction in which the category may be modified. Near-miss experiences do have some plasticity in their interpretation. For example, in their discussion of aviation near misses, March et al. (1991, p. 10) essentially argue that near collisions can produce two different types of salient associations. They describe:

> Every time a pilot avoids a collision, the event provides evidence both for the threat [of a collision] and for its irrelevance. It is not clear whether the . . . organization came [close] to a disaster . . . or that the disaster was avoided.

If people experience the near miss as a disaster that *almost happened* rather than a disaster that was avoided, then their hazard category should be associated with vulnerability. We distinguish these "vulnerable" near misses (wherein a disaster almost happened and results in the perceived vulnerability of the system) from "resilient" near misses (wherein a disaster could have but did not happen and results in the perceived resilience of the system).[2] Returning to our scenario, imagine there is another neighborhood *C* next to neighborhood *B* who also experienced the hurricane. Because neighborhood *C* was closer to the center of the storm, neighborhood *C* was hit with a stronger force, and their sandbag levees collapsed, resulting in significant flooding. For the people of neighborhood *B*, seeing damage to neighborhood *C* further modifies the basic near-miss information ("we were ok, but look what happened to them") to alter the hurricane category away from resilience. With the stimulus of damage to a neighboring town, they may encode that the disaster *almost caused harm*, and that they were vulnerable to possible damage.

If the near-miss effect operates through mostly implicit processes, then we expect that counteracting the near-miss effect will require further modification of the hazard category (Kahneman and Miller 1986). When the near-miss experience also highlights the harm the event could have caused, it adds information to counteract the basic resilient near-miss effect; that is, the near miss (no harm done) can alter the category to make the hazard seem less threatening, but new harm information counteracts this with associations of vulnerability. In our illustration, the people from neighborhood *B* would now encode information about both resilience (from the absence of damage) and potential harm (a neighboring town was severely flooded). When facing a warning about a future impending hurricane, people from neighborhood *B* should now be less swayed by the fact that they escaped harm.

Hypothesis 2 (H2). *People with vulnerable near-miss information* (*that highlights how an event almost caused harm*) *will be more likely to take mitigating action for an impending hazard than people with resilient near-miss information.*

How the new hazard is evaluated will depend on the category knowledge retrieved, which in turn is dependent on how the prior near miss modified the hazard category. Moreover, this modification could produce different assessments of probabilities (*P*), outcomes (*O*), or risk (*R*) because the information about the particular hazard that is embedded in the warning will be integrated with domain knowledge about the hazard category, thereby influencing some part of the SEU model (*P*, *O*, and/or *R*).

We predict that near misses change the negativity associated with a bad event rather than changing probability assessments. This is consistent with Windschitl and Chambers' (2004) finding that people are more likely to change their feelings about a choice than their explicit beliefs about the probabilities. Furthermore, in the domain of near misses, Dillon and Tinsley (2008) showed that people changed their perceptions of risk without changing their probabilities.

[2] See also Kahneman and Varey (1990) for arguments on the critical distinction between an event that did not occur and an event that did not but almost occurred.

Depending on the type of near miss (resilient or vulnerable), the valence of the information retrieved should change, influencing risk estimates. As the risk estimates change, so should the resulting judgments about what to do for an impending hazard.

Hypothesis 3 (H3). *Resilient near misses will decrease one's feelings of risk more than vulnerable near misses without changing perceived probabilities, and these feelings of risk will mediate the corresponding behavioral response.*

Overview of Studies

Our hypotheses were tested across multiple studies, where we sought different types of respondents and used different threats and contexts to demonstrate that our effects are robust across various populations and decisions. Study 1 looked for evidence of the near-miss effect using a field survey of households in coastal counties of Louisiana and Texas who experienced Hurricane Lili.[3] We examined how previous storm experience as well as prior near-miss experiences (in the form of unnecessary evacuations) influenced whether or not the individuals surveyed evacuated for Hurricane Lili. Studies 2–6 used the laboratory to discover how the near-miss phenomenon operates. Study 2 examined how encoding near misses as resilient or vulnerable led to different evacuation rates for a hypothetical hurricane and demonstrated that the addition of vulnerability information to the near-miss stimulus can counteract the complacency effect. Study 3 examined the components of people's SEU assessments. It probed people's assessments of probabilities (P), outcome attractiveness (O), and their ultimate judgments of risk versus safety (R) to test our hypothesized mediation. Study 4 generalizes our basic finding by changing the context from a house to a cruise ship; in doing so we address a concern that participants may be updating their calculations of the risk after a resilient near miss. Additionally, in Study 4, we examine the role counterfactuals have in the risky decision. Study 5 offered evidence that near misses do in fact change the hazard category, and hence the knowledge associated with a hazard, by examining what participants' thought about a hazardous situation. This study removed the need to make a decision, thereby (a) providing evidence for the first (implicit) step in our sequence of how near misses affect cognitive processes and (b) discounting a concern that people first chose what to do and then, when forced to answer questions, generate assessments of probabilities, outcomes, and risk to justify their choice (i.e., reverse causality). Study 6 corroborated the findings of Studies 2–5 with actual behavior by having participants' decisions regarding a risky situation have financial consequences for their compensation.

Study 1

This study provides evidence of the near-miss effect in actual hazard situations. It is well established that people's mitigation decisions, evacuation in the case of hurricanes, are influenced by what relevant others do (Tierney et al. 2001). We tested whether or not prior near-miss experiences reduce evacuation behavior beyond what is due to social cues and a household's specific geographic location (proximity to coast and waterways). This speaks to the importance of the effect (i.e., it is not overwhelmed by people's inclination to do what their neighbors do), and why it warrants further study.

Participants and Procedure. In the spring of 2003, six months after Hurricane Lili hit the Louisiana coastline, 1,000 households from five affected areas (200 each area: Vermilion and Cameron Parishes in Louisiana and Orange, Jefferson, and Chambers counties in Texas) were randomly selected and mailed a survey by the Hazard Reduction and Recovery Center at Texas A&M asking whether they had evacuated. For the storm, the National Hurricane Center had issued a hurricane warning, and local officials had issued an early evacuation advisory in these five areas. A total of 507 usable surveys were returned for a response rate of 50.7%, which exceeds similar hurricane studies (Prater et al. 2000, Lindell et al. 2001).[4] To obtain this response rate, nonresponsive households were sent a follow-up survey every three weeks (until a total of three surveys had been sent).

Variables. Respondents were asked (on a 1–5 scale, where 1 equaled "not at all" and 5 equaled "very great extent") whether or not they had "previous experience with an unnecessary evacuation." This was our proxy for a resilient near miss (i.e., where a disaster did not happen), which was treated as the independent variable. For the dependent variable, respondents were asked whether or not they evacuated. For control variables, respondents were asked (on a 1–5 scale, where 1 equaled "not at all" and 5 equaled "very great extent") about individual geographic proximity including how close they lived to the coast and how close they lived to inland water such as bays, bayous, or rivers. Also on the same 1–5 scale, respondents were asked about social cues including whether they saw businesses closing; saw

[3] The survey was conducted six months after Hurricane Lili by the Hazard Reduction and Recovery Center at Texas A&M. Hurricane Lili was the deadliest and costliest hurricane of the 2002 Atlantic hurricane season.

[4] See Lindell et al. (2005) for more details of the original survey collection.

friends, relatives, neighbors, or coworkers evacuating; heard announcement of a hurricane warning; and heard local authorities issue a recommendation to evacuate. They were also asked whether or not they saw storm conditions such as high wind, rain, or flooding, and whether they had personal experience with hurricane storm conditions.

Analysis and Results. Factor analysis revealed that some control variables could be averaged into scales. We created the "individual geographic proximity" (alpha = 0.74) scale by averaging the first two control variables and the "social cue" (alpha = 0.81) scale by averaging the next four control variables.

Binary logistic regression was used to test H1, with evacuation (yes/no) as the dependent variable. Four control variables were entered in the first step (*geographic proximity*, *social cues*, *see storm conditions*, and *prior hurricane experience*); our independent variable (*prior unnecessary evacuation*) was entered in the second step. Regression results, displayed in Table 1, show that geographic proximity, social cues, and seeing storm conditions all have a positive influence on evacuation behavior, whereas prior unnecessary evacuations has a negative influence. Thus, controlling for geographic proximity, social cues, and seeing storm conditions, prior near-miss experiences in the sense of having evacuated when later deemed unnecessary lead to less protective action in the form of evacuation in the face of an impending hurricane, supporting H1.

Discussion. This study shows that prior near-miss experiences influence the behavior of people facing similar subsequent threats, even amid all the concurrent forces that affect such behavior. Those with resilient near-miss experiences were significantly less likely to evacuate than those without this experience, supporting H1. We recognize that an unnecessary evacuation is an imperfect proxy for a resilient near-miss experience, although we think there is correspondence because unnecessary evacuations imply that a disaster did not happen. However, the point of this study was to provide empirical evidence beyond the post hoc evaluations of highly visible disasters like Katrina that the near-miss effect happens and merits further study. To understand the mechanics of the near-miss phenomena in detail, we examine it using a series of laboratory studies.

Table 1 Study 1—Logistic Regression Results for Evacuation from Hurricane Lili by Near Miss

	Model 1 Odds ratio
Control variables	
geographic proximity	1.38**
social cues	2.22***
see storm conditions	0.80*
prior hurricane experience	1.00
Independent variable	
prior unnecessary evacuation (near miss)	0.85*
Nagelkerke R^2	0.23**

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Study 2

We argue that near-miss information encourages riskier behavior (H1), but that this effect can be counteracted when the near miss includes information that highlights vulnerability (H2). We tested for the difference between a resilient near miss and a vulnerable near miss by giving participants information about an impending hurricane and asking them whether or not they would evacuate. We have also said that this process operates automatically, and that such automaticity makes the effect robust even in the face of experience. In this study, we verify our basic hypotheses and test the robustness of the effect across populations with varying levels of experience and expertise.

Participants. For Study 2, we collected data from four different samples. Participants were (1) 352 undergraduate and 47 graduate business students from a large, private university in the eastern United States who completed a number of exercises, including ours, in return for class participation points; (2) 82 upperclass undergraduate students at Tulane University in New Orleans (two-thirds of whom evacuated for Hurricane Katrina) who completed the short exercise at the end of a regularly scheduled lecture session; (3) 187 undergraduate business students from the same university as sample 1 who completed a number of exercises online, of which ours was one, in return for class participation points; and (4) 102 emergency managers who averaged 13.6 years of experience with natural disasters, whose participation was solicited though email lists and newsletters associated with the Natural Hazard Center in Colorado, and who participated in exchange for entrance in a lottery to win sweatshirts.

Procedure. Participants read that they lived in an area subject to hurricanes and that the National Weather Service was tracking a hurricane that had a 30% chance of hitting their community with moderate force within 36 hours. They were also told that they lived alone, had no pets, and that evacuation would incur a sure loss of $2,000. However, if they stayed and the hurricane hit, the collateral damage (above and beyond damage to house, such as damage to one's car, self, portable personal belongings, etc.) would add up to $10,000 (see Appendix A for the full text). After reading the vignette, they answered whether or not they would evacuate. For the New Orleans sample, participants were also asked whether

or not they had evacuated for Hurricane Katrina, and two-thirds reported that they had.[5]

Variables. We had three conditions: whether participants had resilient or vulnerable near-miss information or no near-miss information (control). Participants in the no near-miss information (control) condition read, "You have no specific data regarding past hurricane impacts to your property." Participants in the resilient near-miss condition read, "You have lived in this house through three prior storms similar to that forecasted, and you and your neighbors have never had any property damage." Participants in the vulnerable near-miss condition for Collections 1 and 2 read the resilient near-miss condition plus "In the last storm, however, a tree fell on your neighbor's house, completely destroying the second story. If anyone had been inside, they would have been seriously hurt."

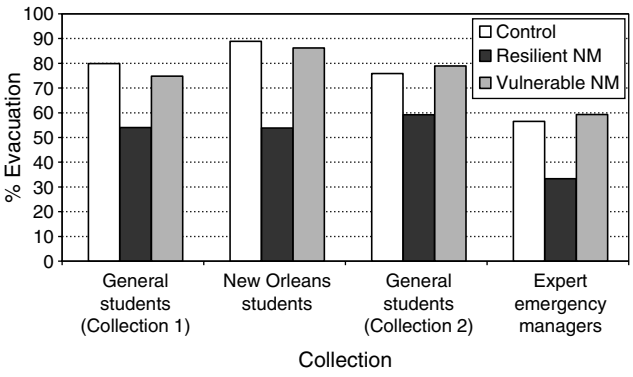
Participants in the vulnerable near-miss condition for Collections 3 and 4 read the resilient near-miss condition plus "In the last storm, however, a tree fell on your neighbor's car and completely destroyed it."[6]

The dependent variable was whether or not participants would evacuate.

Analysis and Results. Figure 1 shows the percentage of participants in each condition for each collection who chose to evacuate. For all four samples, participants with resilient near-miss information chose to evacuate significantly less than those with no near-miss information, supporting H1, and participants with vulnerable near-miss information chose to evacuate more than those with resilient near-miss information, supporting H2 (see Table 2 for χ^2 tests).

Discussion. Study 2 found that people with resilient near-miss information that highlights how a disaster did not happen were less likely to evacuate for an impending hurricane than people without near-miss information (supporting H1). On the other hand, people with vulnerable near-miss information that highlights how a disaster almost happened were more likely to evacuate than people with resilient near-miss information (supporting H2). And these results were robust across participants representative of the general population (Collections 1 and 3), those who live in a culture highly sensitive to hurricanes (i.e., New Orleans), many of whom had prior evacuation experience (Collection 2), and emergency management practitioners (Collection 4). Although this study and the previous field study show the near-miss effect, neither provides evidence of the mechanism by which near-misses operate. The next study examines whether people's evaluations of the nature of the hazard mediate their decision to evacuate.

Figure 1 **Study 2—Evacuation Rate by Condition for Different Sample Collections (See Table 2 for χ^2 Test Results)**



Note. NM, near miss.

Study 3

This study looked into the hypothesized mechanisms through which near-miss information works. If different types of near misses cause changes to the hazard category, then we would expect the different types of near misses to change the assessments of risk (R) but not the assessments of probability (P). Moreover, assessments of R should mediate observed mitigation choices (H3).

Participants and Procedure. Participants in Study 3 were 236 undergraduate and graduate business students who completed a number of exercises online, of which ours was one, in return for class participation points. Participants read the same story as in Study 2, about living in a hurricane area, yet this time they answered questions about the thoughts and feelings associated with the impending hazard.

Table 2 **χ^2 Results for Study 2**

Data collection	χ^2 (1): Control vs. resilient near miss (Hypothesis 1)	χ^2 (1): Resilient vs. vulnerable near miss (Hypothesis 2)
1 = General population students	$\chi^2(1) = 20.63$, $p < 0.001$	$\chi^2(1) = 11.98$, $p < 0.001$
2 = Tulane students (experienced)	$\chi^2(1) = 8.02$, $p < 0.01$	$\chi^2(1) = 6.96$, $p < 0.01$
3 = General population students	$\chi^2(1) = 3.31$, $p < 0.05$	$\chi^2(1) = 10.86$, $p < 0.01$
4 = Emergency managers (experts)	$(\chi^2(1) = 2.85$, $p < 0.05$	$\chi^2(1) = 6.68$, $p < 0.01$

[5] Note that given the timing of the data collection, these students would still have been in high school during Hurricane Katrina and not matriculated students at Tulane.

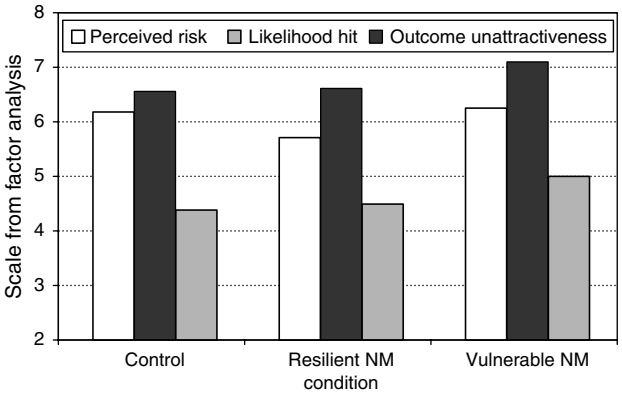
[6] We altered the wording for Studies 3 and 4 to test whether the effect was robust to different types of harm information—bodily injury versus harm to property—which it was. We thank Howard Kunreuther for this suggestion.

Variables. We used the same three conditions from Study 2 for the independent variables: control, resilient near miss, and vulnerable near miss (with the wording from Collections 3 and 4). For dependent variables, participants answered on a 10 point scale (1 equaled "not at all" and 10 equaled "extremely"), about the extent to which they felt worried, anxious, vulnerable, distressed, dread, safe, and protected, and whether the situation before evacuating was risky. They also answered on a 10 point scale (1 equaled "not at all" and 10 equaled "very much") how much they agreed with the following statements: the damage will be bad, I could experience much harm, the damage will not be a big deal, my chances of being hit are good, and I will likely suffer damage. Finally, they were asked whether or not they would evacuate.

Analysis and Results. We used a factor analysis with varimax rotation to examine the associations people had with the hurricane warning and found three factors: (1) estimations of probability (of being hit, chances of being hit are good and I will likely suffer damage; alpha = 0.81); (2) estimations of outcome (un)attractiveness (damage will be bad, harm will be incurred, and damage will be no big deal (reverse coded); alpha = 0.86); and (3) perceptions of risk versus safety (worried, anxious, vulnerable, distressed, dread, risky, safe (reverse coded), and protected (reverse coded); alpha = 0.93). Three scales (probability of hit, outcome unattractiveness, and perceived risk) were created for each factor averaging the above described items, and were subject to a multivariate analysis of variance (MANOVA) with condition (control, resilient near miss, and vulnerable near miss) as the independent variable.

The multivariate F was significant (Wilks Lambda $F_{(6,462)} = 2.23$, $p < 0.05$), as were the univariate F values for perceived risk ($F_{(1,233)} = 3.56$, $p = 0.03$) and outcome unattractiveness ($F_{(1,233)} = 3.04$, $p = 0.05$). The means for the three scales by condition are plotted in Figure 2. Planned contrasts (using Tukey's honest significant difference) showed that for perceived risk, the significant difference across conditions was driven by the resilient near-miss condition being significantly lower than the vulnerable near-miss condition ($p < 0.05$), and marginally lower than the control ($p = 0.1$). For outcome unattractiveness, the significant difference across conditions was again driven by the resilient near-miss condition being significantly lower than the vulnerable near-miss condition ($p < 0.05$). Probability of hit was not significantly different across conditions. To test for mediation we used binary logistic regression on whether or not people chose to evacuate. Dummy variables were created for the resilient near-miss and vulnerable near-miss conditions, using control as the referent category.

Figure 2 Study 3—Risk Judgments by Condition



Following James and Brett (1984), we assessed (1) whether the mediators are a probabilistic function of the independent variables, (2) whether the dependent variable is a probabilistic function of the independent variable, (3) whether the dependent variable is a probabilistic function of the mediators, and (4) how the addition of the independent variable to step 3 changes the variance explained in the dependent variables. Full mediation occurs when the addition of the independent variables does not explain any additional variance in the dependent variables beyond what the mediators explained (i.e., the change in R^2 from step 3 to step 4 is not significant). If the change in R^2 from step 3 to 4 is significant, then partial mediation is a possibility.

Step 1 was accomplished with the MANOVA detailed above (again see Figure 2). For step 2, binary logistic regression showed that evacuation decisions were significantly influenced by resilient near-miss experiences (Table 3, model 1). For step 3, binary logistic regression showed that evacuation decisions were significantly influenced by perceived risk and outcome unattractiveness (Table 3, model 2). For

Table 3 Study 3—Binary Logistic Regressions on Evacuation Behavior

	Model 1 Odds ratio	Model 2 Odds ratio	Model 3 Odds ratio
Independent variable[a]			
Dummy *resilient near miss*	0.56*		0.65
Dummy *vulnerable near miss*	0.67		0.55
Mediators			
perceived risk (*R*)		1.28**	1.27**
outcome unattractiveness (*O*)		1.13+	1.14+
probability of hit (*P*)		1.01	1.03
Nagelkerke R^2	0.02*	0.12**	0.13**
Change in R^2 (from models 2 to 3)			0.01

[a]For the condition variable, the control was chosen as the reference category; thus the regression weights for the first row, for example, show the effect for having resilient near-miss information.

$^+p < 0.07$; $^*p < 0.05$; $^{**}p < 0.01$.

step 4, when the condition variables were added to model 2 as additional explanatory variables, these condition variables did not contribute any unique additional explanatory power (Table 3, model 3). The nonsignificant betas in model 3 for the condition variables and lack of any measurable change in R^2 suggest full mediation. Near-miss information influences perceptions about risk and consequences, which influence whether or not participants evacuated in the face of a hurricane warning.

Discussion. Study 3 found that near-miss information influenced the associations people had with the hazard, which mediated people's subsequent mitigation behavior. The resilient near miss tends to be associated with lower risk, which explains the consistent lack of protective action by these participants compared to those in the other conditions. The vulnerable near misses (highlighting danger albeit to someone else) tend to counteract these reassurances. Study 3 supports our theoretical model, that near misses are stimuli that influence the general hazard category (Kahneman and Miller 1986) so that assessments of risk are either raised or lowered (depending on type of near miss) to influence behavior. However, there are still several alternative explanations for our findings that need to be examined, such as near misses encouraging counterfactual thought or prompting legitimate Bayesian updating. Our next studies test these alternatives, and in doing so demonstrate that our behavioral results generalize more broadly.

Study 4

An alternative to our proposed mechanism (that near misses implicitly influences the knowledge associated with the hazard category) is that near misses prompt counterfactual thoughts. A counterfactual is an alternative to reality. Thus, a counterfactual thought is thinking explicitly about what could, should, or might have been (Kahneman and Tversky 1982). Upward counterfactuals are thoughts about how an alternative could be better than the realized outcome; downward counterfactuals are thoughts about how an alternative could be worse than the realized outcome (Roese and Olson 1995). Counterfactual thought is more likely to occur when people encounter a surprise outcome than when they encounter a routine outcome (Kahneman and Miller 1986, Miller et al. 1989), or when activated by a problem that needs to be addressed (such as a bad outcome that someone wishes to avoid) (Epstude and Roese 2008). Thus, if near misses either surprise participants (as in the resilient near miss, that danger was avoided) or are represented as a problem (as in the vulnerable near miss, that danger almost happened), one could argue that they evoke counterfactual thinking, and that this guides the mitigation behavior. For example, vulnerable near misses might produce more downward counterfactuals than resilient near misses, which might impel the protective action we see participants take in this condition. This might be particularly true if the severity of the negative consequences in the near-miss information is high (that someone could have been severely injured or even killed) rather than low (that someone could have been inconvenienced). Thus, we test for counterfactual thinking in this study, and we vary the severity of the negative consequences (high versus low).

Another limitation of Studies 2 and 3 is that people may be legitimately updating their beliefs about the resilience of their house using Bayesian logic; that is, perhaps people are processing the near-miss experience as data to recalculate the likelihood of hurricane damage to their particular house, thereby reducing it from the stated 30%. Moreover, given that their house is stationary, each hurricane threat is not truly an independent event, and participants could reasonably infer that their particular house is at less risk than what was previously calculated.

In Study 4, we asked the person to decide whether or not to go on a Caribbean cruise that is threatened to be interrupted by a hurricane. The survival of a prior cruise ship during a Caribbean hurricane is completely independent from the chances of survival of their current Caribbean cruise ship given the constantly changing ship location. We nonetheless tested for likelihood updating by asking participants what they believe to be the percentage chance of being hit by a storm. We also vary the severity descriptions of the possible consequences from high (warning of severe injury or even death) to low (inconvenience) and explore the role of counterfactuals in their decision process.

Participants and Procedure. For Study 4, we collected data from 299 undergraduate business students who completed a number of exercises online, of which ours was one, in return for class participation points. Participants read that they had nonrefundable tickets for a Caribbean cruise that is leaving the next day, but the National Weather Service is currently tracking a hurricane in the Caribbean that they estimate has a 30% chance of impacting the cruise. They were also provided costs associated with not going on the trip and with going on the trip if a hurricane diverts the ship. The participant then decided whether or not to go on the trip. For the full text of the exercise, see Appendix B.

Variables. Five conditions made up the independent variables: control and resilient near miss versus vulnerable near miss crossed by strong versus weak prime (see Appendix B for specific wording). To briefly summarize, in the control condition, participants were told that cruises can be diverted because of hurricanes but receive no information about prior

cruises being impacted by hurricanes. In the resilient conditions, participants read that cruises can be diverted by hurricanes but that they have been on three prior cruises and never experienced any problems. In the vulnerable conditions, participants read that cruises can be diverted by hurricanes but that they have been on three prior cruises and never experienced any problems; however, they know someone else who has. In the weak conditions, participants were reminded that hurricane diversions can cause delay and cost money, and in the strong conditions participants were reminded that in addition to delays and costs, people can be injured or even killed.

For the dependent variables, participants answered whether or not they would go on the trip. Then, participants were asked: "Please answer the following statements as thoroughly as possible. 'In making this decision, I thought about if . . . ,' 'I also thought about if . . . ,' and 'I also thought about if. . . .' " Participants then rated their belief that a hurricane would impact their ship (from 0%–100%).

The open-ended responses were coded by two research assistants blind to conditions and hypotheses. They coded whether the statement contained an upward counterfactual (e.g., "If I go, I will have the time of my life"), a downward counterfactual (e.g., "If I were to get diverted on the cruise, I would miss work"), a neutral counterfactual (e.g., "If I could sell the cruise tickets to another party"), or no counterfactual (e.g., "$2,000 is a sunk cost and I should not make my decision based on it") (Nasco and Marsh 1999).

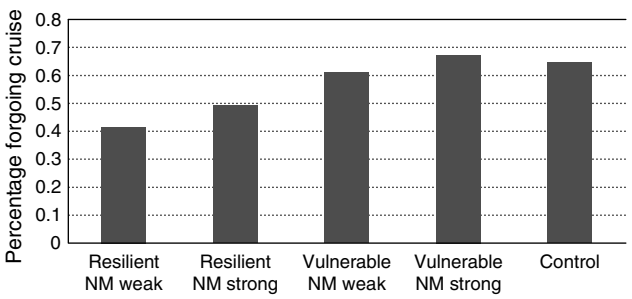
Analysis and Results. Results for participants' decisions (to forgo the trip or not) are shown in Figure 3. To test H1, we collapsed the two resilient near-miss conditions and compared them to the no near-miss experience (control). Significantly fewer people with resilient near-miss information were willing to forgo the cruise than people without near-miss information ($\chi^2(1) = 5.99,\ p < 0.05$) supporting H1. To test H2, we collapsed the two vulnerable near-miss conditions and compared these to the resilient near-miss conditions. Significantly more people with vulnerable near-miss information were willing to forgo the cruise than people with resilient near-miss information ($\chi^2(1) = 8.14,\ p < 0.01$), supporting H2.

To test whether severity of consequences had any influence on people's travel decisions, we compared the weak versus strong severity within each type of near miss. Although participants whose near-miss experiences included severe (strong) consequences were slightly less likely to go on the cruise than participants whose near-miss experiences included weak consequences (50.8% versus 58.5% in the resilient near-miss condition; 32.8% versus 39.0% in the vulnerable near-miss condition), neither of these differences were statistically significant (resilient, $\chi^2(1) = 0.67,\ p > 0.1$; vulnerable, $\chi^2(1) = 0.50,\ p > 0.1$). Thus, for the following analyses, we collapse data across the severity conditions.

To test whether people with near misses are updating their calculation of the likelihood of harm, we ran an ANOVA on participants' belief that a hurricane would impact their ship (from 0%–100%). Across all conditions, participants slightly inflated their belief that a hurricane would impact their ship from the given 30% (control mean, 35%; s.d., 18; resilient mean, 33%; s.d., 17; vulnerable mean, 35%; s.d., 17), but there were no significant differences across the conditions ($F_{(2,\ 289)} = 0.32,\ p > 0.1$).

To test whether near misses prompt counterfactual thoughts, we looked at whether different near-miss experiences produce different types of counterfactual thoughts. Figure 4 shows the percentage of participants' counterfactual thoughts by condition. Most of participants' responses contained a downward counterfactual thought, followed by no counterfactual thought. Importantly, however, there were no systematic differences in types of thought across conditions ($\chi^2(6) = 6.45,\ p > 0.1$). Thus, the explanation that near misses evoke a particular counterfactual thought to explain the observed differences in mitigation behavior fails the first test requirement to demonstrate mediation (James and Brett 1984).

Figure 3 **Study 4—Percentage of Participants Forgoing the Cruise, by Condition**



Note. NM, near miss.

Figure 4 **Study 4—Percentage of Participants' Counterfactual (CF) Thoughts, by Condition**

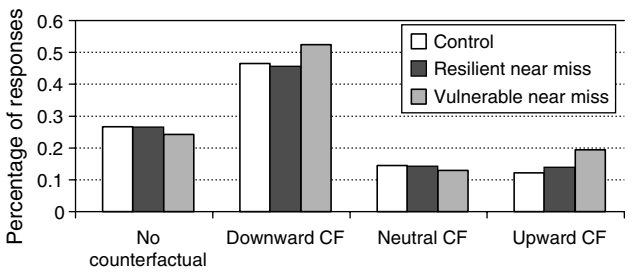
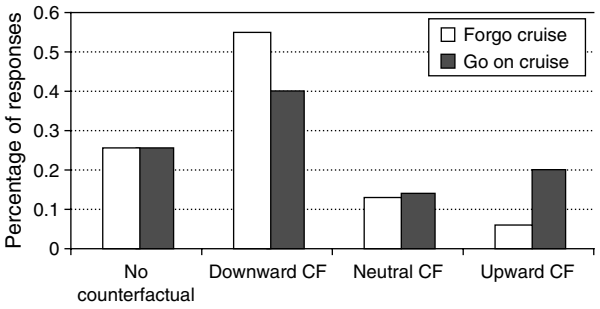


Figure 5 Study 4—Percentage of Counterfactual (CF) Thoughts, by Cruise Decision



To discount the possibility that we miscoded the various types of counterfactual thoughts, we tested whether the different counterfactual thoughts as coded were associated with different mitigation behaviors in reasonable ways and found that they were. Figure 5 graphs the percentages of participants' counterfactual thoughts by cruise decision and shows that counterfactual thoughts do influence the decision. As would be expected, decisions to go on the cruise were associated with more upward counterfactual thoughts (upward counterfactuals versus other counterfactuals, $\chi^2(1) = 27.0$, $p < 0.001$), whereas decisions to forgo the cruise were associated with downward counterfactual thoughts (downward counterfactuals versus other counterfactuals, $\chi^2(1) = 8.9$, $p < 0.01$). In sum, counterfactual thoughts, once evoked, can produce systematic differences in mitigation behavior, yet near misses do not systematically activate any particular type of counterfactual thought. Therefore, counterfactual thoughts do not provide a compelling explanation for why near misses influence mitigation decisions.

Discussion. We showed that even when the situation does not support updating one's beliefs (because the interaction of hurricanes and Caribbean cruises are independent events), the near-miss effect still operates. People who experience resilient near misses are more likely to ignore a hurricane warning and go on the cruise, whereas people who experience vulnerable near misses are more likely to choose the mitigation behavior, forgoing the cruise. We also showed that people with near-miss information are not revising their calculations of the likelihood of the hazard in ways that might explain either their decision to go on or to forgo the cruise. Finally, we showed that while counterfactuals are related to the ultimate choice people make, counterfactual thinking is not predicted by a near-miss experience.

Study 5

A potential concern with the meditational analysis of Study 3 is that peoples' decisions and their survey responses (the mediators) occurred in the same experimental period. Thus, there is the possibility that there is some reverse causality operating between how the hazard is described and the person's decision; that is, one could decide to engage in a behavior and then use that decision to shape how they characterize the situation, or these could coevolve. To discount this alternative, we examined the thoughts people had about a hazardous situation (encoded under our different conditions of near-miss information) absent any decision about what to do. By removing the need to make a choice, we removed any potential that the assessment of the situation was based on the desire to justify a particular decision. This task has the additional benefit of providing evidence that the biasing effect of near misses *precedes* the construction of an SEU evaluation (something assumed via our theory but not tested in our context). We have argued that near-miss information changes the valence of the knowledge associated with a type of hazard; if that is so, then we should expect to see different kinds of thoughts retrieved depending on type of near miss presented.

In Study 5, we gave participants a fictitious newspaper article to read about cruises during hurricane season and then asked them to describe thoughts and feelings associated with the general category "cruises during hurricane season." The task resembles Study 4, except that we removed the decision. We expected resilient near misses to be associated with more positively valenced thoughts, and vulnerable near misses to be associated with more negatively valenced thoughts. We did not make predictions about specific feelings (like harm, because the person reading a newspaper article has no reason to feel any danger) or beliefs (e.g., hurricanes will cause damage), but rather tested changes in the overall evaluations of the situation (which should be guided by the information associated with the hurricane category).

Participants and Procedure. For Study 5, we collected data from 229 undergraduate business students who completed a number of exercises online, of which ours was one, in return for class participation points. Participants read a news story about how Caribbean cruises are deeply discounted in October and November because of hurricane season. The story closes by stating that the national weather service is tracking a hurricane that could impact the ship that a fictitious Bill Thompson is currently boarding. For the full text of the exercise, see Appendix C.

Variables. For the independent variable, we used same five conditions for this study as for Study 4: control, resilient near miss (strong), resilient near miss (weak), vulnerable near miss (strong), and vulnerable near miss (weak). See Appendix C for the specific wording. After reading the news article, participants wrote their general thoughts about whether or not

they thought fall cruises were a good idea. Participants also gave two ratings on a 1–5 scale: (1) their general impression of cruises and (2) whether or not they thought that Bill Thompson (who loves cruising during hurricane season) has the correct attitude.

Written responses were unitized into thoughts (subject–verb–object). Thus, a thought could be a sentence (e.g., "Hurricanes are a big scare" has one unit). There could also be multiple units in a sentence (e.g., "You save money and have fun" has the two objects and verbs with the same subject). These thoughts were content coded by a research assistant blind to the hypotheses based on issues people seemed to think about when deciding about the cruise in the prior counterfactual study. The five basic issues are *fun* (thoughts about how enjoyable or not the experience would be; e.g., "it is not as crowded"), *harm* (thoughts about safety and getting hurt personally; e.g., "there is little risk of injury"), *monetary value* (thoughts about the cost/benefit ratio of the cruise; e.g., "it's a good value"), *the likelihood of problems* (thoughts about probability with respect to adverse events; e.g., "something could always go wrong"), and *risk acceptance* (thoughts about whether, in general, the risk/reward trade-off makes sense; e.g., "why put yourself at risk?"). Thoughts were also coded for whether it was attitudinally positive or negative; thus, in the same category of thought about the likelihood of problems, a statement could be for (e.g., "I don't mind the risk") or against (e.g., "I would not want to take the risk") a cruise in hurricane season.

Analysis and Results. We first looked to see how our 10 codes (five topics by two valences) differed across conditions. As in Study 4, severity of consequences had little effect. Only one of the 10 codes (specifically, monetary value negatively valenced) reached significance, in that participants who read about a strong consequence (people could have died) were more likely to generate negative monetary value thoughts (e.g., this cruise would not be a good value) than participants who read about a weak consequence (people could be inconvenienced or injured; $p < 0.01$). Given the general similarities in people's thought patterns across strong versus weak consequences, we collapsed across these conditions and looked at the influence of near-miss type (resilient versus vulnerable versus control).

Table 4 shows the raw counts of each thought type based on topic, valence, and near-miss condition. The overall $\chi^2(2)$ for the table was significant at 7.69 ($p = 0.02$), and this significance was primarily driven by different valence of thought across the near-miss conditions. Participants generated significantly more negative-fun-related thoughts in the vulnerable near-miss condition than in the resilient near-miss condition ($\chi^2(1) = 6.24$, $p < 0.05$). They also generated marginally significantly more negative-value-related thoughts in the vulnerable near-miss condition than in the resilient near-miss condition ($\chi^2(1) = 2.65$, $p < 0.1$, one tailed). Finally, they generated more negative- risk-related thoughts in the vulnerable near-miss condition than in the resilient near-miss condition, although these differences were not significant.

Table 4 Counts of Each Thought Type Based on Topic, Valence, and Near-Miss Condition

Thought type		Near-miss type: No near miss	Resilient	Vulnerable
Fun	Valence			
	Negative			
	Count	11	17	30
	% within near miss	44.0	37.8	63.8
	Positive			
	Count	14	28	17
	% within near miss	56.0	62.2	36.2
Safety	Valence			
	Negative			
	Count	7	13	23
	% within near miss	77.8	76.5	76.7
	Positive			
	Count	2	4	7
	% within near miss	22.2	23.5	23.3
Value	Valence			
	Negative			
	Count	6	10	15
	% within near miss	30.0	22.2	38.5
	Positive			
	Count	14	35	24
	% within near miss	70.0	77.8	61.5
Probability	Valence			
	Negative			
	Count	4	3	2
	% within near miss	100.0	20.0	14.3
	Positive			
	Count	0	12	12
	% within near miss	0.0	80.0	85.7
Risk	Valence			
	Negative			
	Count	15	24	20
	% within near miss	68.2	70.6	83.3
	Positive			
	Count	7	10	4
	% within near miss	31.8	29.4	16.7
	Total			
	Count	80	156	154
	% within near miss	100.0	100.0	100.0

We further tested whether near-miss information and severity affected the thoughts people had by running a logistic regression using contrast coding for conditions (Judd and McClelland 1989). As Table 5 shows, the type of near miss affects the valence of the thoughts associated with cruises; resilient near misses decrease the number of negative thoughts about cruises, as well as increasing the ratio of positive

Table 5 Positive vs. Negative Thoughts Across Manipulations

	Coded thoughts			Numerical ratings	
Contrast	Negative thoughts	Positive thoughts	Percentage of thoughts that are positive	Overall attitude	Thoughts of other's attitude
Control vs. others	0.01	−0.01	0.00	0.06	0.05
Resilient vs. vulnerable	−0.16*	0.08	0.15*	0.16*	0.16*
Strong vs. weak	0.04	0.01	0.01	0.04	−0.02

Note. Numbers given are standardized beta weights.
*$p < 0.05$.

to negative thoughts. Near misses do not change the number of positive thoughts. Severity of consequences has no significant impact on number of negative versus positive thoughts generated. Likewise, near-miss type but not severity affected peoples overall ratings of cruises in general and Bill Thompson's attitudes toward them.

Discussion. Study 5 verified that near-miss information changes the thoughts associated with a category of hazard independently of any decision. Vulnerable near-miss information makes people retrieve more negative thoughts (less fun, less value) than resilient near-miss information. As in Study 4, the strength of the modifier (strong versus weak consequences) did not have a significant effect, whereas type of near miss did significantly change the thoughts people generated about the hazard.

Study 6

Although participants in our laboratory studies received class participation credit, there was no relationship between their decisions and their reward (i.e., whether or not they received participation credit). In this study, we used an oil-drilling task that had gravity (at the time of this experiment, the BP oil-spill was still recent) and paid participants depending on their performance.

Participants and Procedure. Participants were 134 undergraduate students at the same university as previous studies. The experiment was constructed to be interactive in Excel using the Visual Basic for Applications programming language, and students completed the experiment in a computer lab supervised by the researchers. They were asked to imagine that they were the operations manager for a deep-sea drilling platform currently drilling a deep-water oil well in the Gulf of Mexico. Each simulated "morning," participants were given a 95% accurate weather forecast and had to decide whether to continue drilling for the day or to stop and protect the rig if a severe storm is forecasted. Students were compensated differentially based on the decisions that they made. Specifically, they were told that the operation started 5 days ago, and the total drilling time required to put the well in place was 10 days; therefore, they had 5 drilling days to go. They were also told that the drilling rig was leased for 13 days, so they had 8 days left on the lease, but for each day they finished early, they would be paid a \$5 bonus (on top of the \$5 for participating), unless they drilled during the storm and had a catastrophic failure, in which case they would create a massive oil spill that would need to be cleaned up, and they would lose any bonus. They were also told to assume that weather conditions were independent from one day to the next.

They were provided the following information about failure: "The engineers estimate that when drilling in a severe storm, catastrophic damage will occur 40% of the time. This is a robust estimate based on 30 previous drilling experiences."

Variables. There were three conditions: control, resilient near miss, and vulnerable near miss. In the control condition, participants were told: "Based on weather data available for the last 14 days, there have been three severe storms. These storms occurred in the days prior to the beginning of operations. There have been no storms since drilling started on this well (i.e., the first 5 days of the operation)."

In the resilient near-miss condition, participants were told: "Based on weather data available for the last 14 days, there have been three severe storms. There were no storms in the days prior to the beginning of operations. There were three severe storms since drilling started on this well, on Days 1, 2, and 4 of the operation. Drilling of the well continued through these severe storms, the well sustained no damage, and operations continued as normal."

In the vulnerable near-miss condition, participants were told: "Based on weather data available for the last 14 days, there have been three severe storms. There were no storms in the days prior to the beginning of operations. There were three severe storms since drilling started on this well, on Days 1, 2, and 4 of the operation. Drilling of the well continued through these severe storms and although the well sustained no damage, there were concerns. There were multiple times when pressure in the well rose to a critical level, but by sheer luck, engineers were able to get the pressure under control before any well blowouts."

All participants faced a severe storm forecast for Day 6, and were asked whether or not they would

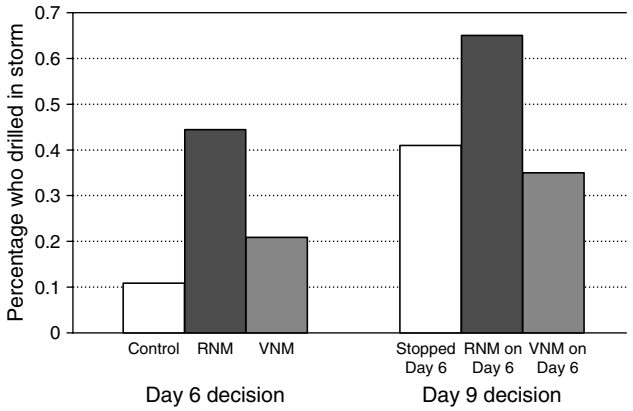
drill for that day. If participants chose to drill on Day 6, half of those experienced a "resilient" near miss and half experienced a "vulnerable" near miss. In the resilient outcome condition, participants were told: "On Day 6, the weather was bad. Fortunately, the well sustained no damage and you have progressed one day closer to the goal." In the vulnerable outcome condition, participants were told: "On Day 6, the weather was bad. Fortunately, the well sustained no damage during the storm but it was nerve-wracking to watch the pressure in the well build several times to critical levels before subsiding, and there were a number of times you were sure the pipe would break." The participants who had stopped drilling for the day were told: "On Day 6, the weather was bad. Since you were stopped, you sustained no damage. Your engineers question whether you would have sustained damage had you continued drilling, but there is no way to tell."

The focal dependent variable was whether or not participants selected to drill on Day 6 in the face of a severe storm warning. A second dependent variable looked at whether or not participants drilled on Day 9 in the face of a second severe storm warning.

After they made their decisions on Day 6, and before they learned of their outcome, we asked participants to rate the degree to which they thought about their bonus, running out of time, the risk of drilling during a storm, the likelihood of damage if they drilled, whether they thought they could manage any problem that came up if they drilled, whether they could handle any situation that arose if they drilled, and whether a problem during drilling would be a big deal. These questions mirrored the factors we found to mediate in Study 3 (risk and consequences) and also included questions about the new financial incentives participants faced in this task.

Analysis and Results. Figure 6 shows the percentage of participants in each condition drilling despite a poor weather forecast. Participants with resilient near-miss information are drilling on Day 6 significantly more than those with no near-miss information ($\chi^2(1) = 12.87$, $p < 0.001$), supporting H1, and significantly more than those with vulnerable near-miss information ($\chi^2(1) = 5.50$, $p < 0.05$), supporting H2. Across all conditions, 34 participants choose to drill in the storm on Day 6. For those 34 participants who drilled on Day 6, 17 read about a resilient near miss on that day and 17 read about a vulnerable near miss. Of those in this new Day 6 resilient near-miss condition, 11 (65%) drilled on Day 9, whereas of those in the new Day 6 vulnerable near-miss condition, only 6 (35%) drilled on Day 9. These differences are marginally significant ($\chi^2(1) = 3.0$, $p = 0.08$, one tailed), lending some support to H2 when participants experience their own near misses rather than only reading about past events. Unfortunately, our sample size to examine for Day 9 was small because of the percentage of participants who stopped on Day 6.

Figure 6 Study 6—Percentage of Participants Drilling Despite Severe Storm Warning



Note. RNM, resilient near miss; VNM, vulnerable near miss.

As we did in Study 4 to test whether people with near misses are updating their calculation of the likelihood of damage, we ran an ANOVA on participants' beliefs that there would be catastrophic damage if they drilled in a storm (from 0%–100%). Across all conditions, participants slightly inflated their belief for damage from the given 40% (control mean, 48%; s.d., 17; resilient mean, 48%; s.d., 20; vulnerable mean, 46%; s.d., 19), but there were no significant differences across the conditions ($F_{(2, 130)} < 1.0$).

We constructed three factors to mirror the mediators of Study 3: (1) perceived risk (risk of drilling during a storm and concern about the risk of damage; $\alpha = 0.58$), (2) the outcome attractiveness (outcome would not be a big deal, can manage the problem, and can manage the situation; $\alpha = 0.75$), and (3) probability (likely future storms and likely damage in future storms; $\alpha < 0.2$). We focused only on the Day 6 decision for the mediation analysis because a significant number of our sample stopped on Day 6. To test whether or not these thoughts mediated participants drilling decisions (on Day 6), we again used the four-step method advocated by James and Brett (1984).

For step 1, we used regression with the three factors as the dependent variables and dummy variables for resilient and vulnerable near misses as the independent variables. Resilient near-miss information predicted perceived risk attitude (standard Beta $= -0.49$, $p < 0.001$), whereas vulnerable near-miss information did not (standard Beta $= -0.09$, $p = 0.31$). The reverse was true for outcome attractiveness: resilient near-miss information was not predictive (standard Beta $=$ 0.05, $p = 0.58$), whereas vulnerable near-miss information was (standard Beta $= 0.22$, $p = 0.025$). For probability, neither type of near miss was predictive (resilient near miss, standard Beta $= -0.04$, $p = 0.66$;

Table 6 Logistic Regression Results for Drilling by Condition and Risk Assessments

	Model 1 Odds ratio	Model 2 Odds ratio	Model 3 Odds ratio
Independent variable[a]			
Dummy *resilient near miss*	6.56***		1.22
Dummy *vulnerable near miss*	2.17		0.89
Mediators			
Perceived risk		0.11***	0.12***
Outcome attractiveness		2.24**	2.33**
Nagelkerke R^2	0.15***	0.71***	0.71**
Change in R^2 (from models 2 to 3)			0.00

[a]For the condition variable, control was chosen as the reference category; thus the regression weights for the first row, for example, show the effect for having resilient near-miss information.

**$p < 0.01$; ***$p < 0.001$.

vulnerable near miss, standard Beta = 0.07, $p = 0.46$). Because the type of near miss was not predictive of probability, and the alpha was very low for the probability scale, we focus on the contribution of the other two factors in the remaining analysis. Note that adding *probability* to the analysis does not change the results, which parallels the findings of Study 3. For step 2, binary logistic regression showed that drilling decisions were significantly influenced by resilient near-miss experiences (Table 6, model 1). For step 3, binary logistic regression showed that evacuation decisions were significantly influenced by both perceived risk and outcome attractiveness (Table 6, model 2). For step 4, when the condition variables were added to model 2 as additional explanatory variables, these condition variables did not contribute any unique additional explanatory power (Table 6, model 3). The nonsignificant betas in model 3 for the condition variables and lack of any measurable change in R^2 suggest full mediation. These results are consistent with those of Study 3; near-miss stimuli influence how people estimate outcome attractiveness (O) and perceived risk (R), which in turn drive their choices (here, to drill or not).

Discussion. This study further supports our theory that near misses shape the judgment about the riskiness of the hazard to influence their mitigation responses. As in the prior experiments, resilient near misses make the situation seem less risky, vulnerable near misses counteract the effect, and the feelings about the negativity of the situation (riskiness) mediate any mitigation behavior. Thus, the near-miss effect is robust to rewards. An odd finding was that vulnerable near misses had higher outcome attractiveness values than the other conditions, but this may have been an artifact of how we measured it. Unlike in Study 3, the measures here focused more on feelings of containing any bad outcome rather than the actual damage that would be incurred. Future research could more directly examine how different types of near misses influence feelings of control.

General Discussion

We found robust evidence that resilient near misses, those with no salient information about potential harm, decrease mitigation behavior. These types of near misses have been the focus of prior research (Dillon and Tinsley 2008). Yet we document another type of near miss—a vulnerable near miss, which highlights damage information that elicits associations that inspired mitigation action. Delineating this distinction is critical because the different experiences of the hazard impel opposite behavior. Moreover, the behavioral responses to different near-miss information are robust in the face of actual hurricanes (Study 1), prior experience and expertise (Study 2), and problem context (Studies 4–6).

Implications for Theory

The idea that people make sense of situations based on the information that is currently active in their minds is well established (Hershey and Schoemaker 1980). Our contribution is in showing how near-miss experiences influence which subset of information is activated. Also consistent with prior research, our results suggest people are heavily influenced by prior outcomes (Baron and Hershey 1988, Mazzocco et al. 2004, McKillip and Posavac 1975). Our contribution here is in understanding why and how outcomes influence future situational assessments. Prior near-miss experiences shape the domain knowledge associated with the hazard. This implicit change to the hazard category influences SEU assessments to shape how people explicitly judge risk and decide on a behavior. Our study also discounts the counterfactual explanation for variance in mitigation behavior following near misses and the explanation that our results are due to calculative (in a Bayesian sense) updating of people's probability estimations. Rather, consistent with prior research (Dillon and Tinsley 2008), likelihood estimates do not change, even though discrete behavioral choices (go or not) do. We believe the mechanism driving people's behavioral choice is their perception of their danger, which stems directly from the near-miss influence on the hazard category in memory.

Additionally, our results suggest that this change in the hazard category seems to influence estimates of outcome attractiveness and overall risk, rather than assessments of probability. This is consistent with forecasting research that shows likelihood estimates are less subject to distortion than discrete choices (such as a go/no-go decision) (Krizan and Windschill 2007). Yet, this may be an artifact of the general subadditivity of probability judgments that are far from

the reference points of 0 and 1 (Tversky and Fox 1995). It is possible that we could see changes in probabilities at very low (5%) or very high (95%) values, but Dillon et al. (2011a) showed near-miss effects for hurricanes when the probabilities ranged from 10% to 70%. More research may be needed to test near-miss effects at extremely high or extremely low values. Finally, prior research has shown that people's mitigation activity depends, in part, on what their neighbors decide to do (Fitzpatrick and Mileti 1991). Study 1 showed that social cues (seeing neighbors evacuating, businesses boarding up) influence evacuation behavior. Research that considers how near-misses influence group decision making is a logical next step. Additionally, because many decisions made when a natural disaster is imminent, such as mandatory evacuation orders, are made by groups in organizations, the organizational decision-making context is also important. If some decision makers experienced resilient near misses and others experienced vulnerable near misses, which one dominates when these experiences are shared? This research question could be explored in future research.

Implications for Practice

Understanding how near misses impact behavior is vital to organizations responsible for informing the public about hazards. For example, those who educate the public about natural disasters may assume that people will respond uniformly to facts about the costs and probability of future disasters. Our results suggest otherwise. Specifically, the same objective facts about the costs and statistically calculated risk of an impending hazard will be evaluated differently by people, depending on their own prior near-miss experiences. Thus, such facts (calculated costs and probabilities) may be insufficient for producing action. Rather, the narrative that accompanies these facts (including vulnerable or resilient near-miss information) can impact reactions to hazards. Supplementing people's own resilient near-miss experiences with salient harm information will likely enhance decision making around hazards.

Similar conditions commonly exist for man-made disasters in organizational contexts. For example, data have emerged that show people at British Petroleum ignored many resilient near misses on the Deepwater Horizon rig prior to the April 2010 accident (Mufson 2010). In particular, this rig had experienced several "kicks" (mini blowouts) prior to being sealed, which suggests leakage of methane gas (Gold and Casselman 2010). Research in organizational learning shows that failures challenge the status quo because organizations are forced to recognize that existing practices are inadequate. This causes decision makers to engage in mindful reflection and put processes in place to improve safety in the future (Morris and Moore 2000, Weick and Roberts 1993, Haunschild and Sullivan 2002, Madsen 2009, Madsen and Desai 2010). Yet, given that failures constitute lessons "learned in blood" (Madsen and Desai 2010), many consider near-miss identification to be one of the most promising avenues for reducing accident rates and improving safety without the costs associated with large accidents (Reason 1997, Rerup 2009). Near misses are typically generated by the same preconditions that produce catastrophic failures, but they occur much more frequently and without the detrimental after effects. Therefore, being able to identify near-miss events provides numerous low-cost opportunities for organizations to recognize and correct hazardous conditions before a failure occurs (Carroll 1998, Phimister et al. 2003, Rerup 2009). However, our research suggests that associating resilient near misses with failure will not be so easy, because resilient near misses actually change people's hazard category knowledge in the opposite direction. This may be why many scholars argue that near misses in virtually all industries remain vastly underreported (Pidgeon and O'Leary 2000, Reason 1997, Tamuz 2001, Jones et al. 1999). Future research may need to teach people how to associate resilient near misses with alternative associations (of vulnerability). For example, Dillon et al. (2011b) show that resilient near misses are associated with evaluations of project success, unless people are primed to believe they are part of an organizational culture that values safety.

Conclusion

Multiple resilient near misses preceded (and foreshadowed) many significant recent disasters including the BP oil spill and Hurricane Katrina responses. These resilient near misses changed the hazard category, prompting positive associations that decreased assessments of outcome (un)attractiveness and risk, resulting in complacency. In contrast, vulnerable near misses draw the decision makers' attention to negative associations, increasing assessments of outcome (un)attractiveness and risk to promote risk mitigation activity. These results provide an explanation for when people will and will not react to hazard warnings. Although the behaviors we demonstrate regarding types of near misses are robust in the face of experience, expertise, and the decision problem, more research is needed on the mediating mechanisms (with other ways of measuring changes to the hazard category) and on how groups might respond to near-miss events.

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Appendix A. Study 2 Details

You live in an area subject to hurricanes, and the National Weather Service is currently tracking a hurricane that could hit your community within 36 hours. You need to decide whether or not to evacuate.

You live alone and have no pets. To evacuate would cost you roughly $2,000 due to the time, energy, and cost of relocation.

If you stay, and a hurricane of moderate force does hit your house, you will incur collateral costs (above any damage done to your house), such as damage to your car, other personal belongings, and personal injury. These collateral costs add up to roughly $10,000.

Data from the past 10 years of hurricanes in your area (roughly 15 hurricanes) estimate that there is a 30% chance the current hurricane will impact your neighborhood with a moderate force thus, if you stay, you have a 30% chance of incurring $10,000 worth of damage.

Collections 1 and 2

[Control]: You have no specific data regarding past hurricane impacts to your property.

[Resilient near miss]: You have lived in this house through three prior storms similar to that forecasted and you and your neighbors have never had any property damage.

[Vulnerable near miss]: You have lived in your house through three prior storms similar to that forecasted and have never had any property damage. In the last storm, however, a tree fell on your neighbor's house, completely destroying the second story. If anyone had been inside, they would have been seriously hurt.

Collections 3 and 4

[Control]: Same as above.

[Resilient near miss]: Same as above.

[Vulnerable near miss]: You have lived in your house through three prior storms similar to that forecasted and have never had any property damage. In the last storm, however, a tree fell on your neighbor's car and completely destroyed it.

Appendix B. Study 4 Details

Last April, you purchased nonrefundable 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 incur collateral costs from the diversion. Ships that are diverted because of hurricanes commonly incur significant delays, forcing you to miss classes and work, plus you will incur the extra cost of travel from the diverted area. You calculated these collateral costs to be roughly $10,000. Thus, if you go on the trip, you have a 30% chance of losing $10,000.

[Control]: 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.

[Resilient strong near miss]: You do know that cruise ships can be diverted by bad weather and passengers have been injured (or even killed) by stormy seas, but you have been on three prior cruises when there were hurricanes, and your ship has never been diverted.

[Resilient weak near miss]: You do know that cruise ships can be diverted by bad weather, but you have been on three prior cruises when there were hurricanes, and your ship has never been diverted.

[Vulnerable strong near miss]: You do know that cruise ships can be diverted by bad weather, but you have been on three prior cruises when there were hurricanes, and your ship has never been diverted. Last year, your roommate was on a ship where a passenger fell during the rough seas and died from the injuries.

[Vulnerable weak near miss]: You do know that cruise ships can be diverted by bad weather, but you have been on three prior cruises when there were hurricanes, and your ship has never been diverted. Last year, your roommate was on a ship that was diverted because of a storm and incurred $10,000 in collateral costs.

Appendix C. Study 5 Details

"Cruising the Caribbean during Fall," November 6, 2010

The island countries of the Caribbean are some of the most desirable vacation destinations on the earth. With glimmering blue waters, white sandy beaches, and warm sunny days, cruises in the Caribbean can be a relaxing escape from the rigors of daily life. Fall cruises have become increasingly popular for those with flexible vacation schedules, as they offer deep discounts to those who can travel in October or November.

Yet, hurricane season is at its highest in the Caribbean during exactly these fall months. If a hurricane crosses a cruise ship's planned route, passengers will encounter rough seas, and the ship will be diverted from its planned route. Rough seas commonly cause motion sickness but can cause significant injuries from accidents. Ships that get diverted for bad weather can cause additional delays and travel costs for the passengers.

As this story goes to print, the National Weather Service is tracking a hurricane near the island of Jamaica, posing a threat to those about to board the Caribbean Princess in Miami to begin their cruise. Yet, veteran fall Caribbean cruise enthusiast and current passenger booked on the Caribbean Princess, Bill Thompson from Greensburg, PA, is undeterred from boarding.

[Control]: He says, "I love traveling on cruises in the fall because they are less crowded so there is never a wait for any activities."

[Resilient strong near miss]: He says, "I love traveling on cruises in the fall because they are less crowded so there is never a wait for any activities. I know that cruise ships can be diverted by bad weather and that passengers have been injured (or even killed) by stormy seas, but I have been on three prior cruises when there were hurricanes, and my ships have never been diverted or had passengers injured."

[Resilient weak near miss]: He says, "I love traveling on cruises in the fall because they are less crowded so there is never a wait for any activities. I know that cruise ships can be diverted by bad weather, but I have been on three prior cruises when there were hurricanes, and my ships have never been diverted or had passengers injured."

[Vulnerable strong near miss]: He says, "I love traveling on cruises in the fall because they are less crowded so there is never a wait for any activities. I know that cruise ships can be diverted by bad weather and that passengers have been injured (or even killed) by stormy seas, but I have been on three prior cruises when there were hurricanes, and my ships have never been diverted or had passengers injured. However, my brother and his wife were on a ship where a passenger fell during the rough seas and died from the injuries."

[Vulnerable weak near miss]: He says, "I love traveling on cruises in the fall because they are less crowded so there is never a wait for any activities. I know that cruise ships can be diverted by bad weather, but I have been on three prior cruises when there were hurricanes, and my ships have never been diverted or had passengers injured. Although, my brother and his wife were on a ship that was diverted because of a storm and they incurred several thousand dollars in extra costs trying to get home."

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