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Why We Under-Prepare for Hazards

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Abstract
Upon many witnessing the immense destruction caused by Hurricane Katrina in August 2005, feelings of sympathy were coupled with those of puzzlement: how could so much carnage be caused by a hazard that was so predictable? In 2004 the region had the benefit of a full dress rehearsal for Katrina when Hurricane Ivan—another category 5 storm while in the Gulf—triggered full-scale evacuations of the same areas, revealing many of the same weaknesses of preparedness procedures that were observed during Katrina. In addition, just weeks before the storm planners in New Orleans engaged in a training exercise that simulated the impact of a hypothetical hurrican—Pam&mdash:that breached the levees of New Orleans, submerging 87% of the city. Finally, the warnings of impending catastrophe could not have been stronger or more accurate in the days and hours leading up to the storm's landfall. Substantial numbers of residents nevertheless failed to heed urgent warnings to leave, few organized efforts were made to assist those who lacked the means to do so, and governments failed to have sufficient resources in place to deal with the disaster when it was realized.

Disciplines
Business | Emergency and Disaster Management | Marketing | Organizational Behavior and Theory | Public Administration | Public Policy | Risk Analysis

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Upon many witnessing the immense destruction caused by Hurricane Katrina in August 2005, feelings of sympathy were coupled with those of puzzlement: how could so much carnage be caused by a hazard that was so predictable? In 2004 the region had the benefit of a full dress rehearsal for Katrina when Hurricane Ivan—another category 5 storm while in the Gulf—triggered full-scale evacuations of the same areas, revealing many of the same weaknesses of preparedness procedures that were observed during Katrina. In addition, just weeks before the storm planners in New Orleans engaged in a training exercise that simulated the impact of a hypothetical hurricane—Pam—that breached the levees of New Orleans, submerging 87% of the city. Finally, the warnings of impending catastrophe could not have been stronger or more accurate in the days and hours leading up the storm's landfall. Substantial numbers of residents nevertheless failed to heed urgent warnings to leave, few organized efforts were made to assist those who lacked the means to do so, and governments failed to have sufficient resources in place to deal with the disaster when it was realized.

What went wrong? Lost in the debate over affixing blame is the fact that the human errors that amplified the tragedy were, in many cases, no less predictable than the storm itself. Over the past four decades a sizable academic literature has emerged warning of the inherent weakness that exist when individuals—both planners and residents—are faced with making decisions about protection from low-probability, high-consequence events. In many ways, Hurricane Katrina was a case study of these weaknesses: opportunities to learn from experience went unexploited, mitigation measures with long-run benefits were under-funded, and the principals emerged as both overconfident before the event and overmatched afterward. Indeed, one might argue that as Hurricane Katrina bore down on Louisiana on the evening of August 28th, the residents of Louisiana and Mississippi faced what was, in fact, a greater risk than they

knew—one born in the failure of advance planning to anticipate the frailties of likely limitations of human responses to the storm.

The purpose of this essay is to review some of what we know about biases that arise when individuals and planners try to make decisions about investing in mitigation against low-probability, high-consequence events, and steps that can be taken to mollify them. I argue that the quality of investment decisions is often degraded by three deep-rooted biases in how we learn and process information:

1. A tendency to learn by focusing on short-term feedback
2. A tendency to see the future as a simple extrapolation of the present
3. A tendency to overly discount the value of ambiguous future rewards compared to short-term costs.

Taken together, these biases not only produced many of the decision errors that were made in the days (and years) leading up to Katrina, but also carry a warning: unless we become better students of our own psychologies, we have little long-term hope of insuring that tragedies like Katrina do not occur again.

Learning Biases: Why Experience Is Not Always the Best Teacher

On Tuesday, September 14, 2004, the *USA Today* ran the following article that described the problems the Mayor of New Orleans was facing complying with a mandatory evacuation order in advance of Hurricane Ivan—at the time a category-5 hurricane near the western tip of Cuba:

> Mayor Nagin said he would "aggressively recommend" people evacuate, but that it would be difficult to order them to, because at least 100,000 in the city rely on public transportation and have no way to leave. "They say evacuate, but they don't say how I'm supposed to do that," said Latonya Hill, 57, who lives on a disability check and money she picks up cleaning houses or baby sitting. Despite the potential need for emergency housing, no shelters had been opened in the city as of Tuesday night. Nagin said the city was working on setting up a shelter of "last resort" and added that the Superdome might be used, but a spokesman for the stadium said earlier Tuesday that it was not equipped as a shelter (USA Today On Line, September 14, 2004, 5:28PM).

Less than a year later as an even stronger Hurricane Katrina approached the dilemma faced by emergency planners in New Orleans was essentially unchanged. Again 100,000 of the city's poorest had little means of complying with evacuation calls, and the Superdome was no better equipped to serve as a long-run shelter.

The city seemed to learn so little from the false alarm of Ivan, in part, because of an all-too-familiar bias in how we naturally learn: by and large, we are much better at learning from the mistakes we actually make than

those we *almost* make. History is replete with apparent examples; In the domain of natural hazards, Brown and Hoyt (2000) offer evidence that a significant predictor of individuals' decisions to purchase federal flood insurance is simply whether flood losses are incurred in the previous year—an effect observed after controlling for such factors as price, income, and whether the homeowner had engages in other kinds of mitigation.

Human cognitive evolution is one reason for why we are prone to learn this way. Through time we have developed strong instincts to learn things by trial and error, avoiding actions (or inactions) that yield bad outcomes and repeating those that yield good ones. It is, after all, how we learn to walk, acquire food preferences, and develop video-game skills. The problem comes when this—otherwise efficient—approach to learning is applied to settings where replications are few and the feedback we receive is noisy—the very features that define low-probability, high-consequence events. In such environments, learning by trial and error can be frustratingly slow, marked by tendencies to draw the wrong associations between actions and outcomes, and a cyclical recurrence of under-investment errors.

The Paradox of Feedback

In late October of 2005 hurricane warnings were issued for South Florida in advance of Hurricane Wilma. A general evacuation was ordered for the Keys, and residents throughout the region were urged to begin taking preparations such as securing supplies of bottled water and batteries and filling the cars with gas. To South Floridians these actions would have been all-too familiar; it was the fourth time that year that hurricane warnings had been issued for the region, and the seventh time in the past two years. Yet, after Wilma had departed there was widespread evidence of under-preparation, particularly in highly-populated cities of Miami and Ft. Lauderdale: people stood in hours-long lines awaiting supplies of bottled water after a boil-water order was issued, and gas lines stretched, in some cases, for miles. Florida Governor Jeb Bush expressed the frustration felt by many planners when seeing the lines: "People had ample time to prepare. It isn't that hard to get 72 hours worth of food and water" (October 26, 2005).

One explanation for this outcome is that while residents had extensive experience in *preparing* for storms, far fewer had direct experience *recovering* from them: almost all of the previous hurricane warnings had proven to be false alarms. As trial-and-error learners, what people in southeast Florida were instinctively learning was *not* that preparation actions were essential, but rather that hurricane hazards can be survived without them.

Kahn and Luce (2005) discuss this same effect in the context of false-security effects in decisions about personal safety, such as failures to wear bike helmets). Although all knew, abstractly, the damage and chaos that hurricanes can cause (from Andrew in 1992 and Katrina earlier in the year), this knowledge did little to motivate personal action; direct experience trumped abstract notions of what *might* have happened.

An example of problems caused by sparse feedback is the often-heard critique of warning systems: while they are essential in the prevention of losses of lives and property, they may also act to discourage marginal propensities to comply when warnings are issued. The problem is that because warning zones are invariably much larger than impact zones, for most people warnings prove to be false alarms. The effect of such repeated exposure to false alarms is that it both diminishes overt beliefs in reliability of warnings, as well as the perceived relationship between mitigation acts and safety. While emergency management planners might try to offset this by repeatedly reminding residents of what would have happened had the hazard struck and they were not prepared, such calls are often lost in the sea of more tangible real evidence that protective actions were taken that were unneeded.

When Correct Outcomes Teach Us the Wrong Thing

A perhaps even more disturbing feature of trial-and-error learning is that even the absence of false alarms is no guarantee that it will lead to optimal mitigation decisions. In fact, in some cases successful learning will be self-defeating: the more one invests in mitigation against hazards, the less one is likely to receive feedback that encourages additional investments; that is, the experience of losses. This censoring bias is difficult to overcome: because the decision maker cannot observe the counter-factual of what would have happened had a mitigation investment *not* been made, he or she will be unsure whether to attribute the lack of damage to the mitigation investment or the docility of the hazard itself. That is, it is quite possible that no losses would have been incurred even if no investment had been made in mitigation. Given such a feedback structure, a trial-and-error learner would have a tough time making progress; the more he or she invested in protection, the more ambiguous the feedback that would be received about its benefits. One might thus see evolutionary convergence to a world of limited remedies; damage caused by hazards induces an initial round of investments in protection, but the very success of these investments then limits the motivation to make further investments (Meyer and Kunreuther 2005).

A case example of such a truncated learning process might be found in the repeated decisions by state and federal governments to under-fund

flood control projects in greater New Orleans prior to Hurricane Katrina. After the floods of Hurricane Betsy in 1965 the federal government authorized funding to bolster the levee system around the city—the Lake Ponchartrain and Vicinity Hurricane Protection Project. Although the project was not expected to be completed until 1978, by 1969 the early stages of investment had already paid off: the city was spared flooding when Hurricane Camille—a much stronger storm than Betsy—passed just to the east. But, ironically, this success—combined with the lack of storms in the years that followed—seemed to deflate rather than spur interest in completing the project. Reduced funding (combined with cost overruns) forced planned dates of completion to be postponed—first to 1991, then 2008. In addition, recommendations made in 1982 to upgrade the original plan for the height of the levees around New Orleans was never funded (U.S. General Accounting Office, 1982). The longer New Orleans went without a flood, the harder it was to make a politically expedient case for a multi-billion-dollar investment in additional protection.

The presence of ambiguous feedback can also produce an opposite—and more perverse—consequence: the perpetuation of superstitious beliefs about protection. The flip side of the tendency for ambiguous feedback to preclude people from fully investing in mitigation when it is truly effective is that it can also fail to extinguish tendencies to invest in mitigation measures that are, in fact *in*effective. As an example, for years it had been a time-honored belief throughout the Midwest that the best way of insuring that one's house did not blow apart during a tornado was to open its windows in advance of the storm. The logic was that open windows would act to equalize the pressure between the inside and outside of the house as the funnel passed, reducing the tendency for houses to "explode." It was not until the early 1980s that it was conclusively shown that this is not why houses fell apart during tornados—open windows and doors were, in fact, the *cause* of collapse, not the remedy. Winds coming in through open windows and doors tended to destabilize roofs which, in turn, tended to destabilize walls.

The myth of open windows proves so persistent, in part, because of spurious reinforcement. If people lost their houses in a twister, they would be motivated to seek remedies that would prevent the calamity from recurring in the future—in this case adopting the wisdom of opening windows in advance of the storm. The next time the home is threatened by a tornado the homeowner will thus open the windows—and likely find positive results. The reason, however, would not be because the measure was effective, but because the odds that a house will survive a brush with a tornado are far greater than being demolished by it (windows open or not). Moreover, even if the owner had the misfortune of having the house destroyed again, the outcome would more likely be attributed to the overwhelming

force of the twister rather the possibility that the homeowner's own actions contributed to the calamity.

Learning about mitigation investments is likely to be a frustratingly slow process, one that may never achieve individually (or socially) optimal levels. The advent of a disaster at one point in time triggers a rash of reactive protective actions designed to preclude a recurrence. But the most likely subsequent feedback decision makers will receive after that works to suppress, rather than enhance, subsequent investments. The fact that most encounters are false alarms provides an overtly negative association between investments and outcomes. Likewise, the very effectiveness of mitigation works to make the cues that are needed to trigger additional investments—losses—less likely to be encountered in the future. Hence, what likely emerges is a slow proves where societies learn the wisdom of mitigation only in fits and starts.

A Different Take on Decision Errors: Imperfect Calculations of Risk

While the mistakes we see in mitigation decisions might well resemble a trial-and-error learning process, few would suggest that this is the actual mechanism that produces errors. Rather, in most cases mitigation decisions involve at least an attempt to engage in a reasoned process that trades off costs with benefits (Kunreuther 2006). In this view, if a coastal resident elects not to evacuate in the face of a hurricane, it is not simply because she has been conditioned to do so, but because she consciously perceives that the benefits of leaving (such as eliminating the risk of drowning) are overshadowed by the perceived costs (such as securing lodging and making the home vulnerable to looting). The errors in mitigation decisions described above could also have origins in mistaken beliefs about either the likelihood of hazards or errors in forecasts of likely consequences.

Seeing Is Believing: Biases in Inferences About Likelihood

Another way of explaining the tendency for people to be overly swayed by the outcome of recent events when making risky decisions is that they form beliefs about the likelihood of hazards by looking at just the most recent data; that is, we underweight long-term base rates of hazards. Supportive of this, there is ample evidence that subjective perceptions of the probability of hazards often dramatically departs from actuarial values in a way that is suggestive of an excessive focus on recent (or more memorable) instances (Kahneman and Tversky 1973; Lerrner et al. 2003).

For example, Lerner, Gonzalez, Small, and Fischhoff (2003) report data

showing that when a sample of 973 Americans were asked to provide an estimate of the probability that they will be harmed by violent crime in the course of the coming year, the mean estimate was 43%—an exaggerated estimate just slightly less than the perceived likelihood of getting the flu (47%). Likewise, Burger and Palmer (1992) report evidence showing how California Bay residents' beliefs about the likelihood they would suffer personal harm from a natural disaster rose immediately after their encounter with the 1989 Loma Prieta earthquake—only to fall again a few weeks later.

All of these findings are suggestive of an availability bias—the tendency for people to construct perceptions of likelihood based on the mental availability of instances (Folkes 1988; Kahneman and Tversky 1973). People likely overestimate the likelihood of death by violent crime or gunshot accidents because examples of these things are easily brought to mind, perhaps fostered by their pervasive depiction in media. Deaths from accidental falls, on the other hand, suffer from the opposite bias: while it is easy to retrieve instances of friends and family members who survived falls from chairs and ladders, few can recall instances where such falls produced deaths. The changeable perceptions of natural-hazard risk reported by Burger and Palmer (1992) follows suit; in the days immediately following the earthquake it was likely far easier for residents to imagine future calamities than weeks later, when memories of the quake faded compared to more recent memories of life without hazards.[1]

It is important to note that too much should not be made of the fact that in these studies of subjective probability people's stated likelihoods of rare events tend to exceed their actuarial values—a finding that would seem counter to the evidence that people under-mitigate. Remember that subjective estimates of probability are simply ratings of how certain people are that some event will occur as measured on a 0-to-1 scale. Because these judgments are not mathematical probabilities, raw comparisons to actuarial likelihoods may not be particularly meaningful. What is important about these findings is that subjective estimates of risk are influenced by factors that have no normative stature—such as how easy it is to imagine harmful events—something that, in turn, could cause harmful distortions of subjective *orderings* of risk to be distorted.

Beliefs that small samples tell all. Another reason why assessments of risk may be overly influenced by the recent past—even in the absence of availability effects—is a tendency for people to believe that the statistical properties of large samples should be evident in small samples—a bias Kahneman and Tversky (1973) term the *representativeness heuristic.* To illustrate the effect, consider a person who tosses a fair coin four times. The common intuition is that the most likely outcome of this experiment will be two heads and two tails—that is, the large-sample properties of the coin

toss should be evident in the small sample. While this indeed the most likely outcome, people tend to think this outcome is far more likely than it really is (3/8ths). By reciprocal logic, the percentage mix observed in a small sample is taken to be a good estimate of the mix in the whole population. Hence, if the four coin tosses yield four heads, the instinct will be to conclude that the coin is biased—not that one is seeing a chance event consistent with a fair coin (on average such an outcome would occur once in every sixteen experiments).

In the context of hazard perception, the representative heuristic has two implications. One is that it validates the intuition that recent history is a fair guide to long-term likelihoods. If a region goes without a hurricane hit for a few years, it must be because the odds of getting hit have gone down (or were previously overestimated), not that such a run should be expected under a constant base probability.

The second is that it makes people see deeper meaning in runs of events than would normatively be justified and *fail* to see trends that are evident in long-run data. To illustrate this, between 1887 and 1969 387 hurricanes were recorded in the Atlantic basin, of which 27 directly impacted the extreme southern tip of Florida from Miami southward through the Keys—about 7 percent of all storms. But between 1970 and 1991—the year before Andrew—the same area was hit only twice (both minimal storms), including a run of 15 years when there was no hit at all. Had the region become a safer place? In a long-term sense, no. As early as the 1960s climatologists recognized that hurricane activity in the Atlantic Basin tended to run through multi-decade cycles of higher and lower activity, and that the lull in the 1970s and 80s was likely to be temporary (see, for example, Dunn, 1964). Developers and residents, however, acted as if the lull was a permanent regime. This increased sense of safety, in turn, contributed to diminished interest in the development and enforcement of building codes (heightening the damage caused by Andrew in 1992) and spurring coastal development along the Atlantic and Gulf Coasts (the source of much of the damage caused by the hurricanes of 2004 and 2005).

Optimistic biases: I'm at risk, but you're more so. A final source of bias that arises in subjective judgments of likelihood is the tendency for people to believe that hazardous events are more likely to strike others than themselves—an effect termed the *optimistic bias* (Chandler, et al. 1999; Sjoberg 2003; Weinstein 1980; 2000). The standard take on the effect is that while people might well hold a general appreciation of the risks of hazards in their environment—be they hurricanes, earthquakes, or terrorist attacks—they are more likely to impact others than ourselves. Part of this effect may be explained in terms of the availability bias noted above: for the vast majority of us what we know about the damaging effects of haz-

ards comes from witnessing their impacts on other people in other places—such as tsunamis in Asia, avalanches in the Alps, and floods in a distant part of the country. As a result, there is a tendency to uniformly see disasters as other people's problems: a very real risk from which we are likely to be spared (Weinstein 1980). As an illustration, after the 9-11 terrorist attacks Lermer et al. (2003) asked people to judge the probability that they would be hurt in a terrorist attack over the next 12 months. The data revealed a strong self-versus-others bias: people judged their own probability as being 20.5% (median 10%), while that for the "average American" as being 47.8% (median 50%).

In other cases optimistic biases come from a tendency to believe that personal risk is lower because of an ability to control it. In these cases the mechanism appears to be a tendency for people to be more prone toward image scenarios that would *not* lead to a negative outcome (for instance, braking in the nick of time) than would (Weinstein 1980).

Seeing the Future as an Extension of the Present: Biases in Forecasts of Impacts

When things go wrong after a natural hazard the first line of defense one often hears from emergency management officials is that things happened that were beyond the scope of predictability. After Hurricane Katrina, for example, FEMA officials were quick to cite the extreme nature of the storm surges experienced along the Mississippi coast (which exceeded actuarial predictions for a storm of its strength), and how the storm revealed flaws in the New Orleans levee system that were unknown prior to the event.

Even President Bush joined the fray when he told ABC news on September first, "I don't think anybody anticipated a breach in the levees." While few seemed to buy the defense in the case of Katrina, in a more general sense the logic has merit: the instant one makes a decision not to protect against all possible risks, one accepts the possibility that errors will occasionally arise—cases where one would have invested more had one the benefit of hindsight.

But the legitimacy of this analysis rests on a critical assumption that the beliefs about the likely consequences of hazards that are the basis of decisions are unbiased. That is, if it were somehow possible to reproduce the hazard a large number of times, in half of these instances we would see damage that is less severe than these expectations and half the time more severe. How can planners (or individuals) be sure that their beliefs have this property? They cannot, of course, and therein lies the problem: by definition almost all forecasts of the outcome of rare hazards are subjective conjectures about what *might* happen, conjectures that are known to

be subject to a number of systematic—and potentially quite damaging—biases.

Consider the Rachlieu Apartment tragedy that occurred during Hurricane Camille in 1969. The Rachlieu Apartments were a 2-story complex that enjoyed a prime location facing the Gulf Coast in Pass Christian, Mississippi. The complex was well-built, indeed so much so that the complex was designated as a civil defense shelter. As Hurricane Camille approached the coast with 190-mph winds a general evacuation was ordered, and most complied; 23 residents of Pass Christian, however, elected to ride out the storm in the Rachlieu complex. The reason was simple: it was hard to imagine forces of nature that could seriously damage—much less destroy—such a formidable structure. But shortly after midnight on August 17th the category-5 storm did just that: a 25-foot storm surge took the complex down to its foundation. Twenty-one people died (Pielke et al. 1999.[2]

The inability of the Rachlieu residents to imagine their complex in a vastly different state is an example of what Lowenstein, O Donoghue, and Rabin (2003) term a *projection bias*—a tendency for subjective forecasts about the future to be biased toward what is being experienced and felt in the present. At some level we all know this intuitively, such as in the age-old adage that one shouldn't go grocery shopping when hungry. The rationale is that one will end up buying a quantity and mix of goods that appeal to one in a hungry state (for example, junk food) rather than later when one is more satiated. Read and van Leewuen (1998) offer laboratory evidence showing this very effect: in an experiment where hungry and satiated subjects to choose a snack that they would consume in a week when they were in a different hunger state. Consistent with a projection bias, their choices much more closely corresponded to their current states than their future ones: hungry subjects tended to choose unhealthy snacks to eat later (when they would be satiated) while satiated subjects did the reverse.

In the context of hazard planning, the projection bias offers a natural mechanism for explaining the reluctance of many decision makers to engage in costly acts of mitigation—such as the reluctance of many in New Orleans who had the means to evacuate before Katrina to do so. The projection bias implies that a contributing factor here may have been the mere difficulty people likely had imaging an environment vastly different from the one that they were currently facing, or how they would feel when faced with such an altered environment—in this case a residential neighborhood under twenty feet of water. The more difficult this future became to imagine, the more short-term decisions would tend to be anchored toward those that make the most sense in the present—here a preference for home versus the unfamiliar confines of distant shelter.

But the projection bias also has a more positive flip side: a tendency for individuals who suffer damage from hazards to underestimate the time it will take to recover, both physically and mentally. In press briefing on September 5th after Hurricane Katrina, for example, the US Corps of Engineers estimated that ir might take "months" for floodwaters to be fully drained from city—an estimate that reflected the discouraged feelings of many that the timetable for the city's recovery might best be measured in years rather than weeks. But the reality was not quite as bad as first feared: some parts of city became accessible by natural drainage within a week of the storm, and drainage operations were completed by the beginning of October. Likewise, by early October commerce had also begun to return, with most clubs and restaurants in the French Quarter re-opening for business—albeit to few customers.

Underestimation of recovery times has other examples. Gilbert and colleagues (Gilbert et al. 1998; Wilson and Gilbert 2003) offer several lines of evidence showing that people underestimate their ability to bounce back from negative life events—such as being denied tenure or incurring a disease. By comparing forecasts that people make about how they will feel after a negative event with the expressed feelings of those who have already incurred them, the general evidence is that people tend to be too pessimistic about their ability to mentally recover—they presume that the immediate negative reactions they would have to negative events would persist in the future. In all these cases the excessive pessimism that immediately follows a negative event is the mirror image of the optimistic bias that arises before it: we simply find it difficult to imagine a negative set of circumstances (such as city under water) being made right again.

Implementation Errors: Procrastination and Preferences for the Status Quo

Not all decisions to under-invest in mitigation arise from biased beliefs about probabilities or outcomes. In some cases such errors arise from the mere fact that people are unsure what acts of mitigation to undertake, or when. There is an extensive body of research showing that when people are faced with choosing among a set of options whose merits are uncertain versus a default of doing nothing, people will often prefer the latter—an effect known as the *status-quo bias* (Samuelson and Zeckhauser 1988).

It is just such a bias, for example, that Schwitzer and Hershey (1997) argue contributes to the tendency for employees to under-contribute to flexible medical spending accounts. While many may recognize the need for a larger allocation in a coming year, uncertainty about just what amount this should be leads many to retain the previous year's default. Likewise, preferences for inaction have been found to increase with the

number of available choice options (Dhar 1997; Tversky and Shafir 1992)—in essence, the more confusing the menu, the more one is likely to order nothing from it.

It should be emphasized, of course, that initial decisions to defer actions are rarely seen as being permanent; one imagines one is merely postponing the decision to a point in the near future when, hopefully, the correct course of action will become clearer, or one has more resources to pursue action. It only becomes permanent when this cycle of procrastination becomes repetitive, or when people perpetually see a more favorable set of choices lying just around the bend.

A good example of this is the decades-long under-funding of the Lake Pomchartrain Hurricane Protection Project mentioned earlier. The policy makers who supported funding legislation that contributed to successive postponements were under no illusions about the risk the region faced from a catastrophic flood. Hurricane strikes in the region were known to be frequent, and the impacts of Hurricanes Betsy, Camille, and another flood-inducing storm in 1947 provided clear case studies for predicting impacts. Yet, due a series of cost overruns and funding cuts, the original project was never completed. Earlier we suggested that a contributing factor may have been the very success of the early stages of the project: the absence of flood events in the years that elapsed after 1965 likely diminished perceptions of the need for—or at least the urgency of—additional funding. But another explanation lies in the psychology of deferral and procrastination. Few policy makers likely saw their votes to restrict funding as expression of a desire to *withhold* protection; rather, they were merely expressions of a desire to momentarily delay protection to a time in the near future when its costs could be more reasonably affordable.

Decisions to invest in protection against low-probability events are particularly susceptible to procrastination for a straightforward reason: because the actuarial odds that a hazard will occur within any one short period of time are exceedingly small (odds heavily favor your yard *not* being stuck by lightning this afternoon), small differences in the timing of mitigation investments have little impact on overall risk exposure (one is not incurring a lot of additional risk by choosing to wait until tomorrow to buy a lightning rod). On the other hand, small differences in the timing of out-of-pocket expenditures can have a large impact—at least psychically. The psychic benefits of putting off an investing in mitigation for a day will almost always seem large relative to the psychic costs of incurring an added day of exposure to a hazard. Legislative decisions to defer funding for mitigation projects have this flavor. In 2005, given that New Orleans had gone 40 years without a major flood, odds would seem to favor that it could make it through one more—hence freeing up money

that could be used for other investments that seem more urgent (for instance, a war in Iraq).

O Donoghue and Rabin (1999; 2001) explain this effect in terms of the tendency for people to engage in *hyperbolic discounting* when considering the relative merits of current versus future events (Lowenstein and Prelec 1992). Hyperbolic discounting is a tendency we have to disproportionately value immediate versus delayed actions. The effect is intuitively illustrated by common feelings about the prospect of delays in payments: one is much more likely to be perturbed hearing that a check one expected to get in the mail today will not come until tomorrow than hearing that a check one expected to get next week will be delayed a day.

When making a choice between a current or delayed mitigation investment this contrast is particularly acute. In the context of mitigation decisions, the benefit one is receiving is, by definition, uncertain and distant. One buys storm shutters not because they will used tomorrow but because they will be useful at an uncertain future date—perhaps later that year, perhaps ten years from now. In contrast, expenditures for mitigation are tangible and immediate. Hyperbolic discounting predicts that people will see a huge—and recurring—psychic benefit to delaying the investment relative to a more ambiguous—and unchanging—psychic cost. In this way, deeply held beliefs that investments in mitigation are worthwhile can (paradoxically) co-exist with failures to invest in mitigation. Failures to invest come not from a conscious sense that such investments are not cost-effective, but rather from a recurrent series of decisions to postpone the investment one more day—with the end result being that no investment is ever made until it is too late.

This explanation for procrastination is somewhat less compelling, however, in cases where procrastination is observed in the face of an imminent hazard whose arrival time and severity is reasonably certain—such as when a coastal town has been put under a hurricane warning. In such cases all outcomes lie in the immediate future, and one might imagine that the psychic benefits of putting off the costs of mitigation for a few hours would be negligible, and offset by the psychic penalty of delaying receipt of its certain benefits—feelings of safety. Nevertheless, procrastination is often observed in such cases: people wait to the last second to evacuate (only to find they can't), and wait until a storm is upon them to secure supplies (only to find that none are available).

A somewhat different mechanism by which people may evaluate options in time that could explain explanation procrastination in such cases is Trope and Liberman's (2002) *Temporal Construal Theory*. Construal Theory is a hypothesis that people focus more on costs (or downsides) of options when considering immediate actions and benefits (or upsides) when considering delayed options. As an illustration, consider the ten-

dency we noted earlier of Floridians to under-stock supplies in advance of Hurricane Wilma in October of 2005. Residents faced the dilemma of whether to buy supplies early in advance of the storm or wait and buy them on an as-needed basis afterward. Each of these options had a clear downside: buying now presents one with the unpleasant prospect of spending money for supplies that turn out to be needed. Delaying has the downside that the supplies might not be available to buy after the storm. Construal theory would predict a preference for the latter—more risky—act. The reason is a difference in valuations: when considering the option to buy in advance there would be a tendency to focus more on the costs of the action (the chance of buying unneeded supplies) than on the benefits (reassurance), but when considering the option to delay the focus would be more on the benefits (avoiding buying unneeded supplies) than the costs (the possibility of unavailability). The consequence is a preference for procrastination: future, risky options seem more attractive than current, conservative ones (see Sangristano, Trope, and Liberman 2002).

Planning Fallacies

Few accounts of the losses of human lives during natural disasters are more tragic than that of the 260 World War I veterans who lost their lives in the Florida Keys during the great Labor Day Hurricane of 1935. The story has been often told (Drye 2002): the veterans had come to the Keys as part of a depression-era works program to build an overseas highway through the Keys, and were being housed in a camp of lightly-constructed shelters. Early on the Sunday before Labor Day of 1935 the Weather Bureau warned that a developing hurricane was moving toward the Florida Straits, and would begin affecting the Keys with gales that evening. Aware of the precariousness of the veterans' location, Federal Relief Agency officials ordered that a train be sent to the Keys to evacuate them to the mainland. But something went wrong: the agency underestimated the amount of time that would be required to assemble a train (for instance, the engine was pointed in the wrong direction), and by the time it was poised to rescue the workers the storm was already upon them. The train never made it (it was washed off the tracks), making the large loss of life inevitable.

The tragedy of the Labor Day Hurricane illustrates what is popularly known as the planning fallacy: the tendency to underestimate the amount of time (and just as often costs) it takes to complete tasks (Buehler, Griffin, and Ross 1994; Kahneman and Lovallo 1993; Roy, Christenfield, and McKenzie 2005). The bias is thought to come from a confluence of two cognitive tendencies: that of being overly optimistic when imagining future sequences of events, and having overly optimistic recollections of

past durations (Roy et al. 2005). The fallacy has several clear implications for hazard response. The most transparent is that it will cause people (and organizations) to be unable to complete planned acts of mitigation before the arrival of a hazard, such as the above example of underestimating evacuation times.

It is also an error that seems to arise even in the most well-practiced of settings. A good case in point was the massive traffic jams that arose when 1.5 million residents of Galveston and Houston, Texas were ordered to evacuate in advance of Hurricane Rita in 2005. Although emergency traffic-control plans for hurricane evacuations had long been on the books in Texas, the plans proved inadequate. Unforeseen, for example, was the fact that that many more residents would attempt to evacuate than were required to do so (2.7 million; *Austin American Statesman*, October 27, 2005) which produced traffic jams of a Herculean scale. Anecdotes included motorists taking up to 15 hours to travel 13 miles (*Houston Chronicle*, September 22), with delays being exacerbated by the fact that few motorists, for their part, had planned enough fuel, food, or water for such long waits. Tragically, the greatest loss of life during the storm occurred in the course of attempts to flee it, when 23 nursing home residents died in a bus fire during the evacuation.

The second implication is that it may contribute to underestimation of the damaging impact of hazards when they arrive—hence, in turn, underestimation in protection. The prime example is underestimation of interdependencies that exist in the production of physical damage (Kunreuther and Heal 2003). During hurricanes, for example, it is quite likely that if one's home is damaged by a flying object, that object likely came from a neighbor's yard (or house), not one's own. Such interdependencies are another source of future contingency that may overlooked when considering a hazard's likely impact. After Hurricane Wilma struck South Florida in October 2005, for example, structural engineers were "dumbfounded" by the extensive damage done to windows in high-rise structures in the downtown areas of Miami and Ft. Lauderdale—in many cases in buildings built to conform to stronger codes set for the region after Hurricane Andrew in 1992 (*Miami Herald*, October 26). The explanation for the unforeseen damage was that it was a compounding effect of flying debris from damage elsewhere—such as broken glass and pebbles—effects that were, apparently, under-predicted in the course of structural design.

Errors in Planning for Others

A final class of errors that we consider are those that arise when mitigation decisions are not made by an individual directly, but are rather overseen

by a central planning agent. Most real-world mitigation scenarios, of course, involve at least some of this element; county emergency planning officials are charged with the responsibility of ordering evacuations, central governments oversee decisions about the overall level of investment in mitigation as well as where these investments will be targeted. In such cases errors made by policy-makers are subject to many of the same sources of bias discussed above, and also two more: an inability to accurately anticipate the preferences and actions of those who will be directly affected by the hazard, and a tendency to underestimate the time and costs associated with implementing plans.

Why we can't make decisions for others: Empathy Gaps. People have a hard time putting themselves in the shoes of others. This effect, which has been referred to as both the empathy gap (Van Boven, Dunning, and Loewenstein 2000) and the false-consensus effect (Hoch 1988; Marks and Muller 1987; Ross, Greene, and House 1977) is an extension of the projection bias in personal forecasting discussed earlier; in the same way that people have a hard time decoupling current emotions and preferences from forecasts of future preferences, people also have a hard time imagining the preferences they would have were they in someone else's shoes. In such cases, forecasts tend to be biased toward their own (Hoch 1988; Holmes 1968). This limitation in perspective-taking has been used, for example, to explain why buyers and sellers often have a difficult time reaching agreements: buyers have a hard time fully appreciating the aversion for loss that causes sellers to (often) overvalue their possessions (the endowment effect), while sellers have an equally hard time viewing their possessions from the perspective of a buyer who is spared this bias (Van Boven, Dunning, and Loewenstein 2000).

In the context of policy-making for hazard mitigation such biases are, of course, potentially lethal in their consequences. Policies for mitigation, by definition, are formulated in environments that are physically and emotionally remote from those that will exist at the time of the hazard, and rarely by the same people who will be the targets of the hazard. As such, planners face the prospect of succumbing to errors in both faulty projection—such as underestimating the likelihood of panic—and temporal construal—such as implementing plans that presume a willingness to adopt formidable levels of risk (Sangristano, Trope, and Liberman 2002).

Conclusions: Can Anything Be Done?

While there may be many flaws in how we go about making decisions, second-guessing does not appear to be one of them. After disasters we are astute judges of what *should* have been done to better prepare for them.

Yet, this skill does not seem to translate to increased abilities to take effective preventive action beforehand. The key lesson of this essay is that in many cases these failings simply accrue to our own psychological make-up; as human decision makers we are not well equipped to make effective decisions in settings where feedback is rare, ambiguous in its meaning, and where optimal decisions require astute skills in foresight. In particular, we are overly prone to succumb to three classes of decision bias: an excessive tendency to learn by focusing on recent outcomes, a tendency to see the future as a simple extrapolation of the present, and an inability to see the value of long-term benefits when compared to short-term costs.

I argue, however, that these limitations need not have been fatal. If a criticism is to be leveled at past governmental policies (both local and national) on mitigation it is that they have tended to look far more to economics for guidance than psychology. Yet, it is the latter that will ultimately determine the effectiveness of policies. Developing programs that offer individuals economic incentives to engage in mitigation is but a first step. Policies are also needed to assist people in overcoming the psychological barriers to adopting those measures.

In this same spirit, policy makers need to be made aware that they are no less subject to decision biases than their constituents. In fact, a case can be made that most tragedies are not the result of an aggregation of a large number of errors made by individuals, but rather by a single error made by a policy maker that impacts a whole population. While it is hoped, for example, that the individual victims of Hurricane Katrina will learn from the experience, it is clearly more critical that governments learn.

Enhancing What We Learn from Experience

To illustrate this point, the natural urge that governments have to learn as much as possible from a disaster to insure that it does not happen again often competes with a conflicting need to return to a normal way of life, that is, make the event a thing of the past. For example, consider Pielke et al.'s (1999) description of the reconstruction that took place along the Mississppi Gulf coast after hurricane Camille in 1969:

> A massive rebuilding effort took place in the months and years following the hurricane. Ironically, hurricane mitigation was not a key thought to those rebuilding immediately after Camille. A need for structures to live and work out of led to a rapid rebuilding effort. The same characteristics which led to absolute destruction of homes and businesses were repeated in the months immediately following the hurricane (Pielke et al. 1999).

While new building codes were indeed developed and suggestions for systematic redevelopment were proposed, the former were spottily enforced

and the latter set aside in the understandable urge for people to get their lives back on course. But as we discovered in the summer of 2005, this haste has a real cost; most of what was rebuilt during Camille was destroyed again during Katrina.

A major challenge to both policy makers and individuals is thus to design recovery efforts that manage to achieve two seemingly conflicting goals: righting communities as quickly as possible while rebuilding in a way that maximally learns from past mistakes. The only way it can effectively happen, of course, is if such recovery planning is done *ex ante* in the form of long-term contingent reconstruction and recovery plans. One of the major critiques of hurricane planning in New Orleans was that policies in place dealt only with the earliest stages of a flood disaster—how to get people to survive the initial impact of the event. Shockingly absent was careful foresight into the longer-term problems of recovery that would obviously follow, such as transportation and housing of those in temporary shelters and the treatment of displaced businesses. Likewise, the Mississippi Gulf coast now faces the same set of challenges it did after Camille: there is a widespread appreciation for the need for rebuilding to be done carefully and safely, but such time-consuming planning processes are fighting a losing battle of time against the greater need to provide homes and places of employment for residents.

While the virtue of advance recovery planning might seem transparent, the greatest obstacle in many cases may be a psychic one. It requires individuals and communities to think the unthinkable—the real possibility that they may be confronted with a disaster that destroys their way of life. But as painful as such a planning exercise may be, the costs of engaging in it as a hypothetical event are small relative to those of engaging in the process after a disaster has impacted.

Aiding Foresight: Tools to Increase Compliance with Mitigation Advice

The reluctance of both individuals and communities to engage in advance contingent planning accrues, at its core, to one of the fundamental classes of biases that we discussed earlier: the inability of people to have clear insights into how they would respond to future life events. Not only does limited foresight impair abilities to set long-term plans, but also manifested in highly short-term aversions of mitigation, such as failing to see the values of mitigation.

In recent years a large body of work has developed seeking to find the best means of overcoming short-term thinking biases in a number of domains of personal safety. For example, consider the problem of how one might overcome misperceptions of the likelihood that one will be

harmed by a hazard. Two closely related correction mechanisms have explored such cases, both with some success. One involves facilitating the mental generation of risk-consistent instances—such as helping people imagine the different ways that an area protected by levees might find itself inundated (Raghubir and Menon 1998). Earlier we noted that overly optimistic beliefs about hazards sometimes arise from proportional availability biases—the harder it is to think of ways that a hazard could occur relative to *not* occur, the less likely the hazard is perceived to be (Schwartz et al. 1991). In a series of studies designed to explore the effectiveness of advertisements aimed at increasing protective behavior with respect to the spread of the hepatitis C and AIDS viruses, Menon, Block, and Ramanathan (2002) and Raghubir and Menon (1998) find that personal-optimism biases can be over come by designing messages that either facilitate visualization of the mechanics by which the virus can be transmitted (such as through unprotected sex; Raghubir and Menon 1998) or by including examples of transmission methods that people recognize as occurring comparatively often (for example, contracting hepatitis C by from a shared toothbrush).

Closely related is the approach of tailoring persuasions to unique circumstances of the decision maker. When governments offer advice to residents about how to protect against hazards it usually takes the form of generic catch-all lists where only a subset of precautions would be seen as relevant to any one decision maker. For example, a recent preparedness guide for hurricanes prepared by the NOAA and the Red Cross (U.S. Department of Commerce 2001) included a lengthy list of preparations designed to encompass most possible circumstances—such as reminders to be sure to bring baby food and diapers if one is going to a shelter with small children, the need to identify a safe room within every home, and make conditional plans to insure the safety of pets.

The downside of such communications is as above; the more personally relevant cues are lost among a myriad of less relevant ones, the less persuasive becomes the overall message. Consistent with this idea, Kreuter and Strecher (1995) report evidence that personal estimates of risk are improved in programs that customize communications to conform to the lifestyle characteristics of decision makers. An extension of this idea to hazard settings would seem natural; in many cases what people look for is advice about how, for example, someone living in an inland condominium should prepare—not a generic list from which they must make their own judgments about personal relevance.

In contrast to this work, research that has attempted to enhance compliance with mitigation by encouraging people to anticipate their future *emotional* responses to hazards—such as fear or dread—has proven less successful (Weinstein 1995). There are a couple of impeding factors. The

first is that emotions are difficult to vicariously reproduce. In the same way that it is impossible for people to accurately recall past sensations of pain or pleasure (Read and Loewenstein 2001), the emotions triggered by communications that encourage people to *imagine* future floods will likely pale relative to those likely to felt given its actual realization

The second is that when communications *are* effective in triggering strong emotional responses—such by showing people vivid depictions of corpses—these emotions have the unintended by-product of suppressing processing of the message itself. This explains, for example, why extreme fear appeals have repeatedly been found to be ineffective in inducing behavioral change (Block and Williams 2002; Krisher, Darley, and Darley 1973). The reason is simple: our natural response to a threatening stimulus is to flee from it. Hence, when we are exposed to a communication that triggers feelings of fear a common response is *not* to pay closer attention to the content of the message (for example, wear seat belts) but rather to turn away from it. Hence, intuitions that the best way to encourage compliance is to show vivid depictions of the consequences of *non*-compliance is often misplaced; the greater effect is decreased message comprehension rather than increased hazard avoidance.

On the other hand, there is some developing evidence that appeals that tap into other emotional responses to hazards—most notably regret—*can* be effective in creasing compliance. In a recent paper Passyn, Luce, and Kahn (2005) offer showing that undergraduates were more likely to adopt proactive condoms after viewing communications designed to trigger regret emotions compared to communications that carried a fear appeal and one that carried factual risk information. The regret appeal seemed to work in this context because it heightened senses of personal responsibility for preventive action while at the same time being unthreatening—hence allowing the content of the message to be processed.

Overcoming Temporal Planning Biases

The final courses of remedy are those aimed at aiding errors that accrue to poor inter-temporal judgments about the optimal timing of mitigation. A couple of solutions come to mind. One is a familiar timing aid used in retailing: create perceptions of rigid time limits. In some hazards settings this is done already; NOAA, for example, annually has a "hurricane preparedness week" at the start of each hurricane season designed to both heighten awareness and consolidate decision making. Likewise, governments could publicize mitigation calendars that organize "to do" lists around fixed completion dates.

Biases due to a reluctance to incur out-of-pocket expenses are, clearly, far harder to remedy by persuasion alone. In such cases government inter-

vention would seem required—such as Florida's pilot program to provide no pay-back loans for the purchase of storm shutters. Unfortunately, even those remedies may be limited in their effectiveness, as the loans themselves might be seen as costly to secure (in time and hassle), and they do little, of course, to compensate the non-monetary costs of the mitigation.

Postscript: The Role of Governments Versus Individuals

The fact that human decision makers are limited by cognitive biases is sometimes taken to imply that the best remedy lies in placing restrictions on the freedom of decisions; that is, improved benevolent central planning that either legislates action by individuals (for instance, imposes more rigid rules on evacuation behavior), or channels public funds to provide financial incentives for specific actions. The central limitation of such an argument, however, is that it has legitimacy only to the degree that benevolent central planning is free of the decision biases that it is meant to cure. Such an assertion could not be further than the truth; in most cases the most far-reaching decision errors we illustrated were those being made by policy makers charged with responsibility of building safer societies. In our view, if a resource emphasis should be placed, it is to develop policies that encourage individuals to improve the quality of decisions they make for themselves, not cede these choices to agents.

Notes

The author thanks Edward J. Blum, Baruch Fischhoff, and Don Kettle for comments on an earlier draft of this manuscript.

1. The mere passage of time. however, does not always induce a decrease in beliefs about the likelihood of certain hazards. In a follow-up to the Lerner, et al. (2003) study of public concerns about terrorism measured immediately after the 9-11 attacks, Fischhoff, et al. (2005) found that personal estimates of the likelihood of harm from terrorism among the same participants in the 2001 survey were only slightly lower measured 3 years later. The immense and unrelenting media attention given to terrorism as well as attacks elsewhere likely contributed to the persistence.

2. In 1995 the lot where the Rachlieu apartments once stood was redeveloped as a shopping center. When Hurricane Katrina hit in 2005, the new structure was again demolished to its foundation.

On Risk and Disaster

Lessons from Hurricane Katrina

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