Recollection Bias and Its Underpinnings: Lessons from Terrorism-Risk Assessments

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by

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Abstract

Recollection bias is the phenomenon whereby people, after observing a highly unexpected event, hold current risk beliefs about a similar event that are no higher than their recollection of their prior beliefs. This article explores recollection bias in relation to individuals' perceptions of the risks of terrorism attacks. Over 60% of respondents in a national U.S. sample of over 900 adults believe that the risks of a future terrorist attack by either an airplane or in a public setting are no higher than they believed respectively before the 9/11 attack and the Boston Marathon bombing. Only one-fifth of respondents are free of any type of recollection bias. Recollection bias is negatively correlated with absolute levels of risk belief. Recollection bias—basically the belief that perceived risks have not increased—dampens support for a variety of anti-terrorism measures, controlling for the level of risk beliefs and demographic factors. Public attitudes influence policy. Thus, educating the public about risk is critical.

Keywords: Recollection bias, hindsight bias, terrorism, risk perception, catastrophe

1. INTRODUCTION

Catastrophic events that result from deliberate action pose well-established challenges for individuals' risk beliefs. Fortunately, such major catastrophes, which impose sudden harm on large numbers of victims, are rare events in our society. The downside of this infrequency is that most Americans have little experience to draw on in forming risk beliefs regarding the potentially huge losses attendant on purposeful catastrophic events. This factor alone implies that there is the considerable likelihood that risk judgments will be seriously flawed. That in turn will affect the public pressures for policies arrayed against terrorism, a critical class of such events.

Decisions in general become more challenging as we move from certainty to uncertainty. For example, probabilities must be assessed and then updated. Not surprisingly, most of the prominent behavioral biases arise under uncertainty. Small probabilities often promote dramatic departures from rational decision; witness the vertical leap of the probability weighting function of prospect theory (Kahneman and Tversky[1]) at the bottom of the probability scale. Understandably, most decision experiments in the laboratory involve mechanical devices, such as pulling balls from urns. Though very small probabilities can be produced with such devices, those probabilities are much more easily comprehended than equivalent-sized probabilities associated with natural disasters. And even with natural disasters, such as hurricanes, we have a reference class.

Terrorist events present grave challenges for decision making. They involve very small probabilities. They tend to be *sui generis*, defeating efforts to identify a reference class. And the fact that they are purposeful events makes them much harder to assess than even natural

disasters. We should anticipate that significant behavioral biases will intrude when humans assess and seek to respond to terrorist events.

In assessing a significant past event, it is often important to try to reconstruct one's expectations about the event before it occurred. This is particularly true when formulating policy for the future, when one has to estimate the probability that a similar event will occur. Was the past event a bolt from the blue, i.e., something impossible to anticipate, or was it the type of happening a prudent person would have anticipated? The answer will help us estimate probabilities of similar events, and/or prepare as best possible for events that are not on our radar screen.

Can individuals effectively assess how they viewed a significant event before it happened? We address that question, focusing on events with negative high consequences that public information reveals were either completely unanticipated, ignored, or assigned a very low probability before they occurred. Prime examples would be 9/11, the unanticipated rise of ISIS, and the 2008 financial meltdown. If people are poor at recalling to what extent they foresaw the possibility or likelihood of such events, that bias will have profound implications for our ability to anticipate major events in the future.

The focus of this article is on two catastrophic attacks against the United States: the September 11, 2001, attack on four planes, the World Trade Center, and the Pentagon that killed 2,977 victims and shook the nation, and the April 15, 2013, bombing at the Boston Marathon that caused 3 deaths and 264 injuries. Prior to 9/11, there were previous airplane hijackings. By September 10, 2001, however, airport screening mechanisms were in place, and hijackings or attempted hijackings of planes from the U.S. were extremely rare. Moreover, hijacked planes had never been used as weapons to target populated areas. In the three years before the 9/11

attack, the total annual number of deaths of U.S. citizens from anti-U.S. attacks by terrorists had ranged from 6 to 23, while the two years after 9/11 similarly claimed 27 and 35 Americans each (National Safety Council[2]). These statistics include attacks outside the U.S. as well, so they overstate the domestic risks assessed in our survey.

Given that 9/11 had already occurred, and that the Boston Marathon bombing was a less distinctive phenomenon, it should have been much less surprising that 9/11. Nevertheless, terrorist attacks in public places in the U.S. had been rare. The Oklahoma City bombing in 1995 had killed 168 people, but this was a domestic act unrelated to international conflicts. Thus, one would expect each of these unanticipated, shocking catastrophes to cause Americans to significantly update their risk beliefs regarding future catastrophes due to internationally inspired terrorism, with 9/11 leading to massive updates. We examine whether they in fact do update in this way.

2. RECOLLECTION BIAS AND ITS UNDERPINNINGS

The particular phenomenon that we focus on in this article is what Viscusi and Zeckhauser[3] termed *recollection bias*. This term means that after the experience of a highly surprising adverse event, people recollect their risk beliefs prior to the event to have been no lower than what they currently believe about future risk levels.

2.1 Relationship of Recollection Bias to Hindsight Bias

Recollection bias is closely related to but substantially different from *hindsight bias*. Hindsight bias (Fischhoff[4]) has widespread implications for daily life. It promotes Monday morning quarterbacking on business and life decisions: "She shouldn't have made that investment; he shouldn't have married that woman." Hindsight bias has been studied in detail in relation to juror behavior in liability cases. See Rachlinski[5]; Hastie, Schkade, and Payne[6];

Viscusi[7]; and Sunstein et al.[8] Kelman, Fallas, and Folger[9] examine different experimental reference points for hindsight bias and refer to after-the-fact judgments by external observers, such as jurors, as "third-party hindsight bias."

Both hindsight bias and recollection bias compare two assessments of the likelihood of a significant event from the past. They both ask current individuals to report what they believed about the likelihood of the event before it occurred. Call this the *retrospective assessment*. However, the two concepts differ completely in what they employ as the comparator for the retrospective assessment. Hindsight bias compares it to *prospective assessments* that were made before the event. Recollection bias compares the retrospective assessment to the current individual's *prospective assessment* of a similar event looking forward.

Whereas hindsight bias can be studied either within or across subjects, recollection bias is intrinsically a within-subject phenomenon. Thus, hindsight bias usually compares prospective assessments by one group of subjects before an event with retrospective assessments by either the same or a different group of similar subjects after the event. Recollection bias, by contrast, makes all assessments after an event, and asks each individual to make two assessments, what she believed before the event and what she believes now. If anything, the restriction to a within-subjects should make it less likely to find recollection bias, since an individual in theory could compare her own two assessments, and recognize that the information provided by the past event should increase her probability estimate for a future event.

The presence of hindsight bias implies that, after a particular event, people will overestimate the extent to which the event had been predictable. In its extreme form, hindsight bias is reflected in the statement: "I knew it all along." In a more moderate version, it would be: "I always knew it was a real possibility." Thus, with hindsight bias, neither 9/11 nor the Boston

Marathon bombing would be thought afterwards to have been a substantial surprise. Not infrequently, hindsight bias is exhibited by a third party who blames a decision maker for not taking adequate precautions. "Monday morning quarterbacking," where a sports fan explains why a player or manager made a different decision, is an exemplar of hindsight bias combined with blaming.

2.2 Fundamentals of Bayesian Learning about Terrorism Risks

To examine how a rational learning process works, consider the following stylized example involving drawing balls from a Bernoulli urn consisting of red and white balls. Let the matter of concern be the probability of drawing a red ball. The prior assessed probability is given by a beta distribution with parameters b and c, whereby the prior belief is equivalent to having drawn b red balls and c white balls. The initial perceived probability of drawing a red ball is b/(b+c). If the person draws a ball from the urn and sees that it is red, the probability is updated to (b+1)/(b+c+1), but if the persons draws a white ball, the assessed probability declines to b/(b+c+1). In each instance, the extent of the change in risk beliefs decreases as the value of (b+c) increases. In short, the less information the person has initially, the more the draw of a single ball from the urn should change risk beliefs. Thus, a terrorist attack or other unanticipated event will have a greater effect on prior beliefs when those beliefs started with more limited information content.

To illustrate, to deal with a highly unlikely situation where a single occurrence would lead the posterior probability to be massively greater than the prior probability, we might have b = 0.01 and c = 10, hence a prior probability of 1/1,001 = 0.001. A single trial would consist of a year with or without an event. If the event did occur, the probability would jump to 1.01/11.01 = 0.092, or by a multiple of more than 90.

The amount of information being conveyed also may vary with the extremity of the adverse event. That will be the case when the probability and magnitude of an adverse event are positively correlated. Here are three examples where a positive correlation would seem plausible. There is an extreme outbreak in a region of a mosquito-carried disease. Knowing nothing more, this would lead you to believe that infected mosquitoes are more prevalent in that region, hence the probability of any size outbreak is greater. You do not know how stable or unstable is a securities market. You learn that it dropped 5% in a day last week. That suggests that it is more unstable than you thought, and should lead you to increase the likelihood of a 2% drop. In November 2015, ISIS launched a terrorist attack in Paris that killed 130 people. This suggests that ISIS has greater capability to launch attacks in Europe than would have an ISIS-directed attack that killed 4 people. The likelihood of a successful future ISIS-directed attack in Europe is higher than would be the case after a hypothetical four-death attack.

2.3 Risk, Uncertainty, Ambiguity, and Ignorance

For low initial probabilities for an event coupled with loose prior beliefs, the greater should be the multiple of its likelihood should it occur. In a rational Bayesian framework, low likelihood by itself is not sufficient. The variability in the prior estimate of the probability—its uncertainty or ambiguity[1]—is also a key driver. Thus, in the beta distribution example above, for low values of b and c in which the low levels of prior beliefs are loosely held, the effect of a terrorist attack event on risk beliefs should be substantial.

[1] Knight[(10)] distinguished between risk, where probabilities are known, and uncertainty, where they are unknown. Decision theorists, including your authors, usually treat uncertainty by positing a prior probability distribution, often subjectively determined, on the underlying probability. Ellsberg[(11)] employed the term ambiguity to apply to uncertainty situations. His presentation where an urn has an unknown mixture of two different colors makes it clear that there is no objective way to determine that prior probability distribution.

The metaphor of drawing balls from an urn, when those balls are known to be red or white, dramatically underestimates the impact of the monumental surprise associated with some terrorist attacks, such as 9/11. A more appropriate analogy might be drawing a ball from an urn when the composition of their colors is completely unknown. The ball turns out to be checked with colors of chartreuse and magenta. Posit that one had been asked in advance about the likelihood of getting such a marble on a single draw when asked along with a vast number of other possibilities. The response might have been 1 in 100,000.[2] However, having drawn one such ball, a rational Bayesian assessor might assign the likelihood 1 in 20 that the next ball would also be checked chartreuse and magenta. Note the synergy between the low likelihood and the massive ambiguity that enters once marbles need not be a solid single color.[3]

Very low probabilities allow for extremely differential likelihood ratios, hence massive updates in probabilities. With our checked chartreuse magenta example, a single ball draw made the outcome 5,000 times more likely.[4] By contrast, if one's prior probability estimate for an event is say 2%, its posterior likelihood can't possibly multiply by a factor greater than 50.

A homeland attack of the level and character of the 9/11 event was unforeseen by the general public and many risk experts. It differed in damage by many orders of magnitude and in fatalities by an order of magnitude from any prior terrorist incident on American soil. It also had many more perpetrators than and prior incident, and used a weapon—an airplane as a bomb—hardly contemplated by authorities. And the attackers came from overseas. Outliers of course are possible. One estimate is that the probability of observing a terrorist event of 9/11-sized or

[2] Of course, asking about a specific pattern and color combination would lead the subject to raise that probability. That is why it is important to ask about a "vast number of other possibilities."
[3] This example adds layers of ambiguity above the one described by Ellsberg(11), since the possible colors are not known, there is the possibility of mixed colors, and the colors can be in varying patterns, or indeed non-patterns.
[4] This would be consistent with a beta prior with b representing a checked chartreuse magenta marble, and c all other color marbles. Here, b would be 0.0002 and c would be 20. Technically, the posterior would really be 1.0002/21.0002, or slightly above 1/21.

larger somewhere in the world over the 45-year period 1968–2013 was 11–35% (Clauset and Woodard[12]). However, the U.S. vulnerability was presumably less, both because the U.S. has less than 5 percent of the world population and the widespread belief before 9/11 that the U.S. was less vulnerable than, for example, targets in the Middle East or even Europe. And that estimate stretched over four and a half decades, whereas the implicit (sometimes explicit) time period for our questions was just a year. Risk projections for the U.S. surely should have shifted after 9/11, as the novel mode of the attack undermines such models' premise of a stationary event generation process.

Given that 9/11 had already happened, the Boston Marathon bombing was much less startling, particularly given its much less monumental consequences and more conventional mode of attack. Nevertheless, both events represented instances of uncertainty, not risk, one where probabilities were both unknown and highly ambiguous. More appropriately, we believe that they should be thought of as situations of ignorance, where even the possible states of the world are not known (Roy and Zeckhauser[13]). Indeed, these events reflect a deeper level of ignorance than simply having imprecise priors. People may not have even contemplated the possibility of such attacks. At the 2013 Boston Marathon, for example, security was slight.

This raises the question as to what events should be classified together. For example, 9/11 dramatically raised the likelihood for the use of airplanes as weapons, but its occurrence also increases the likelihood of another major terrorist event inspired by Islamic extremism. In the latter category, it should alert us that our enemies are more willing to attack us and that their capabilities are greater than we expected.

The marathon bombing, and the recent San Bernadino massacre, are better characterized as lone-wolf attacks. Leaving aside any copycat effects, it is tempting to conclude that since we

have seen a number of such events, one more should not be a surprise. However, even if we think of such events as coming from a Poisson distribution, given that the numbers are small, one more attack should notably increase our assessment of the mean λ of that distribution. Furthermore, if we allow for a trend in the mean, e.g., terrorist events may be becoming more common, the occurrence of an event would also require updating the estimate of the slope of the trend.

Note that terrorist attacks can differ greatly in their motivation, locale, mode of attack, and the organization involved, suggesting that they are much more differentiated than say are floods or hurricanes. They fit less well into a single reference class. Thus, there should be more updating when two young men educated in an American high school get radicalized and use a crude bomb to kill three and injure 250+ others than when there is a major flood or category 5 hurricane. Major lone-wolf, jihadi terrorist attacks have been revealed to be much more of a threat.

2.4 The Better Protection Rationale

Before proceeding, we should mention one conceivable rationale for why individuals' assessments after a severe adverse event might dampen the updated probability, indeed possibly make it lower than the prior probability: Protective measures could be taken. Thus, burglar alarms are installed after one's home is robbed. After 9/11, al Qaeda leaders and adherents are killed, and airline security is tightened substantially.

No 9/11-type incident has occurred over many intervening years. Does that imply that protection is now better? Unfortunately, a very low probability updates massively and quickly when it occurs, but slowly when it does not (Pratt and Zeckhauser[14]). Suppose that after the 9/11 attack, the person's risk beliefs for subsequent annual attack were characterized by a beta

distribution where b=10 and c=90. Thus, the person believes that the annual risk of attack is b/(b+c)=0.10. After 15 years with no incident, the value of the denominator rises to 115 while the numerator remains the same, so that the assessed probability is 10/(115)=0.087. That represents substantial updating, but hardly to the extent of what should have happened in the opposite direction from pre-9/11 to immediate post-9/11.

We do not believe that increased protective measures, plus the deterrence to perpetrators they promoted, or other recent developments have been nearly sufficient to swamp the sizeable updating in probability that should have accompanied the 9/11 or Boston Marathon attacks.

2.5 Weak Updating

Posit that individuals' recall their assessed probability of a salient low-probability event before it happened as being too large relative to their current assessment of the risk, as judged from the standpoint of rational decision theory. Such a bias could arise from weak updating, meaning that they updated too little from their prior to their posterior probability. This might happen, for example, because they *anchored* (Tversky and Kahneman[15]) too heavily on their initial probability, the likelihood ratio they employed for updating was too low, or because they did not employ the tools of decision theory, even informally, to update their probability.

2.6 Retrospective Adjustment of Prior Probabilities (RAPP)

The retrospective adjustment of prior probabilities (RAPP) phenomenon arises because present beliefs affect what we recall ourselves believing in the past, a form of backward anchoring. At a deep level, we believe that the RAPP phenomenon is related to cognitive dissonance: "It is hard for me to believe now that such a consequential phenomenon that I now fear greatly was of so little concern to me before its first occurrence." In fact, we believe that few citizens consciously contemplated any probabilistic possibility for something like 9/11 or the

Boston Marathon bombing before it occurred. Thus, their actual probability estimate went from "not on the radar screen" to "strongly on the radar screen" at whatever is their current probability estimate.

Our surveys made no attempt to parse the relative contributions of weak updating, leading to too low a posterior, and RAPP, promoting too high a prior.

2.7 The Basic Question

The prime issue being addressed here is not whether individuals' risk beliefs have in fact increased or decreased, and if so, moved too much or too little. The survey questions with respect to the 9/11 attack and the Boston Marathon bombing are explicitly *not* longitudinal in nature. Thus, they do not track the level of people's actual previous risk assessments and compare them to their current risk beliefs. Neither do we do a between-subjects analysis of beliefs expressed by one group before the event and by another group after.

Rather, the question being investigated is whether the respondents believe that the risks going forward are higher, lower, or the same as their current recollection of what their own risk beliefs were before the attack. This comparison may or may not reflect how beliefs have actually shifted. Rather, the focus is on whether respondents, recollecting what they believed before, perceive that risks have increased.

Given the analysis above, if no increase in an individual's risk beliefs is assessed, or worse, an individual recalls higher beliefs before the attack, a strong recollection bias must be at play. Interestingly, the policy implications of recollection bias might be viewed as having an impact that is the opposite of the influence of the availability heuristic. Whereas the availability heuristic phenomenon gives rise to exaggerated responses to risk (Sunstein[16]), recollection bias may cause people to be insufficiently attuned to a significant increase in risk.

A world of biases is a world of the second best. Once you suffer one bias, say availability bias, you might be better not worse off from suffering another, say recollection bias, if the two to some extent counterbalance.

2.8 Updating by Experts Versus Updating by the Public[5]

Experts may update much more effectively than the public for two reasons: First, they have much more data to employ in formulating judgments. They would be better equipped to know the frequency or infrequency of similar or relevant events in the past, and to determining whether there have been trends if underlying forces have changed the likelihood of events. Trends in terrorist events could emerge from the rise and fall of overseas groups; trends in weather-related catastrophes could be the product of climate change. Second, experts are familiar with Bayesian methods. Thus, they intuitively understand concepts such as likelihood ratios, and the updating of priors to posteriors based on the information seen. A major finding of the behavioral decision movement is that even when dealing with mechanical processes, such as drawing marbles from an urn, members of the general public have an imperfect grasp of Bayesian methods. Most relevant to this analysis, as pointed out above, they anchor on their original probability estimates too strongly: they update too little on the basis of new information.

When bolts-from-the-blue arrive, how should updating ideally be done? To answer that question is beyond the scope of this analysis, but we will make four observations. First, it is not obvious that even experts are skilled in such processes. Therefore, the study should have a strong empirical component, to see what likelihood ratios were assigned in various cases, and whether posteriors were updated appropriately, too little, or too much. With feedback, experts might improve their performance significantly. Second, the study should try to define reference classes

[5] We are indebted to Warner North, the Area Editor, and a referee for encouraging us to include much more information on how updating should be conducted.

in advance in a sufficiently broad manner to incorporate almost any occurrence. Thus, when considering terrorism, the classification might merely depend on the number of deaths and magnitudes of morbidity. Note, such a classification allows for terrorist attacks that cause illness or otherwise harm human health, not merely bombs or bullets. (Nevertheless, that classification would miss a cyber-attack that merely severely inconvenienced American society and dragged down its economy.) Third, given that the analysis is dealing with low probability events, no class of outcomes, such as terrorist events or weather events, will provide sufficient data in a reasonable timeframe. Thus, an aggregate analysis looking across different type of outcomes would be required to see how effective we are in formulating likelihood ratios and thus moving from priors to posteriors. Fourth, the study proposed above would take years to complete. In the interim, attention to the methods that experts currently employ would be valuable.

None of this should suggest that expert assessment should trump public opinion in defining policy, and even less that it could do so. A critical question then becomes: How can the public best be involved in assessing the risks that effective policies are expected to confront? A 2008 National Academy of Sciences study (National Research Council[17]) addressed this question for environmental problems dealt with by federal agencies. It concluded that appropriately elicited public input not only aided legitimacy, but increased the quality of decisions. This makes it all the more import to find ways to confront the biases members of the public suffer when they assess low probability risks. Public perceptions generate political pressures that in turn influence policies. Effective education about societal risks to overcome perceptional biases is critical.

3. RISK BELIEFS: SURVEY DESIGN AND SAMPLE DESCRIPTION

3.1 The Risk Belief Survey Questions

The empirical approach to assessing whether respondents are subject to recollection bias utilized the following questions for the 9/11 attack and the Boston Marathon bombing:

"Take yourself back to the World Trade Center disaster. Do you believe that the risk of a terrorist attack is higher or lower than what you thought it was before the September 11 disaster? Higher_____, The Same_____, Lower_____."

"Take yourself back to the Boston Marathon bombing. Do you believe that the risk of a terrorist attack is higher or lower than you thought it was before the Boston Marathon bombing? Higher_____, The Same_____, Lower_____."

The first of these questions follows the wording used in the surveys reported in Viscusi and Zeckhauser[3]. The Boston Marathon question employs a broadly-based public-event risk context for the assessment. As stressed above, rational decision makers would significantly raise their risk beliefs after they have experienced a totally unanticipated adverse event. Even if they had never heard of Bayesian analysis, they should do so. For any given event, the extent of the revision should be greater when the prior beliefs were held less strongly. Similarly, for any given set of prior risk beliefs, events conveying more information, such as attacks leading to large numbers of casualties, should boost risk beliefs to a greater extent than would smaller-scale attacks. For an equivalent example, you just moved to a new southern locale and encountered a hail storm in summer, something you never anticipated. You would assign greater probability to another hail storm if the hail stones were a half-inch in diameter than if they were 1/16 inch in diameter. Sunstein[18] finds that people tend to have "excessive reactions" to terrorist events

because they respond more to the "badness of events" than to their probabilities. We are only seeking "appropriate responses" to the badness of events.

In addition to examining the presence of recollection bias, it is also instructive to ascertain the level of respondents' risk beliefs. Are these risk beliefs related to the presence of recollection bias and, controlling for the presence of recollection bias, do risk beliefs influence attitudes toward anti-terrorism policies? To explore the range of uncertainty reflected in respondents' beliefs, the survey elicited information on the overall level and the distribution of the respondents' current risk beliefs. In particular, the survey asked people for the 5^{th} percentile, the 95^{th} percentile, and their best estimate of the number of American terrorism deaths due to attacks on airplanes over the next 12 months. The survey question read as follows:

"Based on some estimates, the September 11, 2001, disaster led to 266 deaths in the planes and 2,717 deaths at the World Trade Center. The total number of deaths was consequently 2,983, or about 3,000. Below is a series of questions about the number of people who you believe will be killed in the next 12 months because of attacks by foreign terrorists on airplanes:

(a) Think of the best-case outcome in which the number of terrorism deaths could be low. Suppose there is only one chance in 20 that the number of terrorism deaths could be at this low level or below. What is your estimate of this low-end death toll? _____

(b) Now think of the worst-case outcome. Suppose there is only one chance in 20 that the number of terrorism deaths could be this high. What is your estimate of this high-end death toll? _____

(c) Your best estimate of the actual death toll will be somewhere between your estimate of the low-end death toll and your estimate of the high-end death toll. What is your

best estimate of the expected number of terrorism deaths in the next 12 months? _____"

The survey also included a series of questions directed at policies that might be affected by risk beliefs regarding terrorist attacks. Recollection bias takes on potentially powerful policy importance if it is changes in self-perceived risk level that drive behavior more than the perceived absolute level. An overreaction to the risk change may result if people who believe that the risk has escalated differentially favor aggressive policy.

One possibility is that recollection bias and risk beliefs may alter the tradeoff people are willing to make between terrorism risk reduction through airport screening and civil liberties. The survey question directed at this tradeoff read as follows: "One way of reducing terrorism risks to plane flights is better screening of passengers. The FBI has developed a profile of the chances that a passenger is a terrorist, taking into account the person's age, race, gender, national origin, appearance, and baggage. Airlines either could screen all passengers, leading to additional delays in line, or they could screen passengers based on the terrorist risk profiling. Targeted screening that would reduce the terrorist risk by as much as random searches would involve lesser time delays for passengers…Would you favor terrorist risk profiling if the alternative was for you to wait in line an extra 30 minutes so that all passengers could be screened randomly? Yes _____ No _____"

The survey included two types of questions regarding surveillance cameras: (1) Is installing surveillance cameras in public places a good idea (good idea, no opinion, bad idea)? (2) How many surveillance cameras should there be in public places (we need more, current amount is just right, we need fewer)? We tallied responses to these two questions coding positive support as 1, neutrality as zero, and opposition as -1.

3.2 Sample Description

Viscusi and Zeckhauser[19,3] relied solely on several student samples. We expand on that analysis with a survey of a national sample of adults undertaken in the autumn of 2013, after the Boston Marathon bombing. That survey was able to examine perceptual shifts associated with both airplane attacks and public-event attacks.

Our adult sample comprised 910 members of Vanderbilt University's e-Lab panel. The respondents completed the survey in the autumn of 2013. Appendix Table A1 summarizes the sample characteristics. The sample is 37% male, 11% nonwhite, 27% Republican, 38% Democrat and has an average of 15 years of education, a mean age of 51, and a mean household income of $67,000 (with a median value of $52,500, which is 1% higher than the 2013 U.S. national median of $51,939).

The empirical analysis below employs a detailed set of demographic variables as controls. These variables are often of independent interest, as risk beliefs and preferences with respect to anti-terrorism policies vary with personal characteristics. Previous studies have found that support for anti-terrorism policies is greater among Republicans, the better educated, and those with higher risk beliefs, as found in Viscusi[20]. Here we couple this analysis with an exploration of the effect of demographic characteristics on recollection bias, risk beliefs, and policy preferences.

4. DATA ANALYSIS

4.1 Summary of Risk Belief Responses

The first two columns of Table I summarize the risk belief responses to the airplane risk and public-event risk questions. For comparison, the third column provides results from Viscusi and Zeckhauser[3]. Individuals whose current risk estimates are the same or lower than their

recalled estimates before the terrorist event suffer recollection bias. More than three-fifths of the sample exhibited recollection bias, 68% for the airplane risk and 61% for the public-event risk, slightly greater percentages than the 57% reported in Viscusi and Zeckhauser[3]. The distribution of public-event risk responses were more concentrated in the middle category, with only 8% who believed that their previous risk assessments were lower. The cross tabulations in Table II show a strong concentration of responses on the diagonal; thus, large numbers of respondents indicated that both risks are below or the same as they recall that they believed before. The strongest persistent relationship is for those who believe that the public-event risks are lower than before, as 82% of this group also believes that the airplane risks are also lower. The empirical analysis below distinguishes three different recollection bias measures: airplane bias, public-event risk bias, and double bias for individuals who consider both risks to be the same or lower than before. Only 21.5%, i.e. 196/910, of individuals avoid both types of biases. Consistent updating merely in a rational direction is the exception.

Table III summarizes the patterns of risks assessments for the expected number of U.S. terrorism-related deaths both for the current sample as well as previous estimates from 2003–2004. The analysis of these risk assessments excluded four outliers who believed the death toll would exceed 1 million. The mean and median values of the best estimate for the 2013 sample are respectively 1,383 and 100 deaths. The median of the lower- and upper-bound values are 15 and 600, respectively. Given the highly skewed nature of the risk-belief responses, the empirical analysis will focus on the log of the best estimate, which has a mean of 4.5.

Individuals' characteristics, such as age or political affiliation, may influence their risk beliefs. For example, Republicans might believe risks to be higher, or more likely to have increased, conceivably with causality flowing in either or both directions. Table IV employs

probit regression analyses to examine the factors related to our three recollection biases. The two most consistent and significant findings are that older respondents and those with higher incomes are less subject to bias. Republicans are also less subject to bias, though not significantly so for airplane bias. Males are more prone to airplane bias (0.05 level) and event bias (0.10 level). The result for males echoes previous findings by Mumpower et al.[21] that white males have lower risk beliefs regarding terrorist attacks on airplanes. It would not be surprising if respondents' risk-assessment levels related to recollection bias. That would be expected if weak updating were the prime source of the bias.

4.2 Factors Affecting Best Estimates

Table V presents double-bounded Tobit regressions assessing how the log value of the level of individuals' best estimates of the number of terrorism deaths relate to their demographic characteristics and any recollection biases they suffer. Because we are taking log values, we assign a value of 1 to predictions of zero terrorism deaths. The distribution of log responses is censored from below at zero and above as well, since outliers exceeding one million expected deaths were excluded.

All three recollection bias measures have negative and statistically significant coefficients. Thus, in addition to possible direct effects of recollection bias on policy preferences, there will also be an indirect effect through the lower absolute level of risk beliefs. Males and individuals who are better educated or have higher levels of income have systematically lower risk beliefs. The most puzzling result is that city dwellers have lower risk beliefs compared to the omitted category of rural respondents. The surprising puzzle arises because the two most prominent attacks involved major urban areas, and previous research found that proximity to the 9/11 attack related positively to risk beliefs (Fischhoff et al.[22]).

4.3 Policy Preferences

We now turn to examine how recollection bias affects preferences for policies in dealing with terrorism. Recollection bias represents an amalgam of a change in perceptions of risk and of the current level of beliefs. If the change in perceptions is influential along with current beliefs in affecting preferences, recollection bias would have a powerful effect. Changes in perceptions often are important. For example, an incumbent president might have a greater chance of being reelected if unemployment went from 5.5% to 5.25% in the election year than if it increased from 4.5% to 4.75%. Similarly, an individual might be more likely to go to the doctor if pain went from mild to moderate, but not if it went from severe to strong. Such behavior could be completely rational given a variety of underlying models for causality. However, behavioral factors could also play a crucial role. In accord with Prospect Theory[(1)], humans are attuned to noticing changes from a reference point. The potential for a strong response is what one might expect given the results in Gigerenzer[(23)], who found that the alarmist private behavioral responses to terrorism risks on balance was counterproductive.

The policies considered in the survey include profiling of airline passengers, use of more cameras in public places, and surveillance of mail, emails, and phones. Presumably, these results for policy preferences would carry over to decisions about insuring against terror (Smetters[(24)]), or going against its sources overseas (Keohane and Zeckhauser[(25)]). The explanatory variables in the regressions include one of the three recollection bias measures indicated by the column heading, the absolute-risk estimate as reflected in the log of the best estimate of the number of deaths, and a series of demographic variables. The best estimate value in turn is lower for those exhibiting recollection bias. Thus, the potential role of recollection bias includes both its direct negative effect on support for anti-terrorism policies and its indirect effect linked to lower values

of the best estimates of the risk. Respondents' attitudes toward different anti-terrorism policies relate strongly to their risk beliefs for all policies except risk profiling.

The policy analyzed in Table VI reports the probit regression results for the 0-1 responses for whether subjects were willing to support racial and demographic profiling of passengers if the alternative was to wait in line for an extra 30 minutes.

The strongest negative effect of recollection bias is for those exhibiting the double bias; they have a 0.1 lower probability of supporting profiling, an effect that is strongly significant at the 0.01 level. Older respondents and Republicans exhibit consistent positive support for demographic profiling; better-educated respondents are less supportive, consistent with the finding by Mumpower et al.[21] that better educated respondents have lower willingness to pay to prevent attacks on airplanes.

Table VII reports the ordered probit results for whether respondents support surveillance cameras in public places using each of the three recollection bias variables indicated by the column headings, and Table VIII reports analogous results for whether respondents support more surveillance cameras in public places. The coefficient for each recollection bias variable is negative and significant, indicating a dampening effect for both questions. When risks are perceived not to be increasing, support for expensive and intrusive protective measures falls.

Older respondents support cameras more; better-educated respondents support them less, though the effect is weaker in Table VII than for the enhanced surveillance policies in Table VIII. It is intriguing that both Democrats and Republicans strongly support these surveillance measures; the omitted category of respondents in groups such as Independents and Libertarians is less supportive.

Attitudes toward surveillance of mail, e-mails, and phones in Table IX are much less strongly linked to recollection bias. Recollection bias has a negative coefficient, but it is only marginally significant at the 0.10 level for the combined-bias variable. As expected, the presence of higher risk beliefs does increase support for these efforts, so there continues to be a plausible relation to individual beliefs. Support for surveillance of mail, e-mail, and phones increases with the level of risk beliefs, age, and income; there is a weaker negative relation to education.

5. CONCLUSION

Recollection bias proved to be widespread in a survey of 933 individuals asked to compare their risks assessments before the 9/11 and Boston Marathon attacks with their current assessments. Overall, 68% of the 9/11 risk beliefs and 61% of the public attack risk beliefs fell prey to the bias. This bias runs contrary to the implications of the availability bias, which would predict a significant increase in risk assessment after a dramatic, highly memorably event. Two possible explanations for recollection bias are that individuals anchored much too strongly on their original risk estimate, or that individuals "upgraded" their recollected prior estimate to accord with their current estimate, a phenomenon related to cognitive dissonance.

Recollection bias is of importance, beyond its scientific interest, because it influences policy preferences. The public's attitude toward different anti-terrorism policies is related to people's overall terrorism risk beliefs, as one might hope. However, even taking the level of risk beliefs and an extensive set of demographic characteristics into account, there is also a profound influence of recollection bias on policy perspectives. Recollection bias in turn is also negatively related to the level of risk beliefs, reinforcing the effect of recollection bias on respondents' lack

of support for anti-terrorism measures. The effects are strongest for those who exhibit recollection bias for both airplane risks and public-event risks.

These results surely have implications that extend beyond the particular risk context. People suffering recollection bias believe that their prospective risk levels are not higher than they recollect their previous risk beliefs to have been before a strongly surprising negative event. In many policy contexts, it is the change in the risk situation that promotes support of new initiatives rather than the risk level alone. Individuals with risk beliefs recollected as stable or possibly declining, even in the wake of a strongly adverse information event, are poorly suited to adapt to changes in the decision environment. As a result, their well-being suffers, and their policy preferences are poorly informed.

Given that the beliefs and preferences of the public also affect policy decisions taken by government officials, recollection bias will also influence policy. Better education of the public about the assessment of risk could thus improve both its welfare and public policies.

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Table I. Current Risks Assessments Relative to Recollected Assessments Before Disasters

Risk Relative to Before	2013 Sample		2002–2004 Samples
Disaster/Bombing	Airplane Risk	Public Event Risk	Airplane Risk
Higher	33	39	43
Same	40	53	26
Lower	28	8	31
Recollection Bias	68	61	57

Note: The 2002–2004 sample is 333, reported in Viscusi and Zeckhauser[3], Table I. N = 910 for the 2013 sample.

Table II. Number of Respondents in Risk Belief Categories

		Airplane Risk Rating			
		Higher	Same	Lower	Total
Public-Event Risk Rating	Higher	196	87	73	356
	Same	95	265	122	482
	Lower	5	8	59	72
	Total	296	360	254	910

Note: Statistics indicate the number of respondents with current risk beliefs for airplane risks and public event risks relative to their pre-attack values.

Table III. Terrorism Risk Estimates of Fatalities for the Next 12 Months

2013 Sample	Median	Mean	Std. Error of Mean
Lower Bound (5th percentile)	15	203.15	56.79
Best Estimate (50th percentile)	100	1382.77	572.11
Upper Bound (95th percentile)	600	8977.04	2,252.80
2003–2004 Sample			
Lower Bound (5th percentile)	1.5	95.95	33.71
Best Estimate (50th percentile)	100	451.59	99.98
Upper Bound (95th percentile)	2000	23,768.35	12,658.61

Note: The 2003–2004 sample estimates are from Viscusi and Zeckhauser[3], Table II. Reported statistics for both surveys omit estimates of over one million deaths, leading to 8 observations being dropped for the 2003–2004 sample and 4 observations being dropped for the 2013 sample.

Table IV. Probit Regressions for Different Forms of Recollection Bias

Variable	Airplane Bias	Public-Event Bias	Double Bias
Age	-0.003**	-0.005***	-0.004***
	(0.001)	(0.001)	(0.001)
Male	0.084**	0.064*	0.047
	(0.032)	(0.034)	(0.036)
Education	-0.005	1.8E-4	-0.002
	(0.007)	(78.9E-4)	(0.008)
Income/1,000	-0.795E-3**	-0.642E-3*	-0.911E-3**
	(0.345E-3)	(0.366E-3)	(0.381E-3)
Republican	-0.063	-0.104**	-0.093**
	(0.042)	(0.044)	(0.044)
City	-0.034	-0.011	-0.052
	(0.052)	(0.054)	(0.056)
Pseudo R^2	0.02	0.04	0.03

Note: N = 910. Other variables included in the regressions are nonwhite, suburb, small town, west, midwest, south, New York City, missing income, and Democrat. All coefficients have been transformed to correspond to marginal effects. Significance levels: *0.10, **0.05, and ***0.01.

Table V. Tobit Regressions for Log Best Estimate of Terrorism Deaths in the Next 12 Months

	Airplane Bias	Public-Event Bias	Double Bias
Recollection Bias	-0.643***	-0.747***	-0.585***
	(0.177)	(0.171)	(0.166)
Age	0.011*	0.009	0.010*
	(0.006)	(0.006)	(0.006)
Male	-0.309*	-0.315*	-0.333*
	(0.174)	(0.173)	(0.174)
Education	-0.070*	-0.066*	-0.067*
	(0.039)	(0.039)	(0.039)
Income/1,000	-0.004**	-0.004*	-0.004*
	(0.002)	(0.002)	(0.002)
Republican	0.302	0.267	0.289
	(0.214)	(0.214)	(0.215)
City	-0.630**	-0.614**	-0.644**
	(0.269)	(0.268)	(0.269)
Pseudo R^2	0.01	0.01	0.01

Note: N = 906. Respondents indicating an upper bound on terrorism deaths in excess of one million are excluded. Other variables included in the regression are nonwhite, suburb, small town, west, midwest, south, missing income, and Democrat. Significance levels: *0.10, **0.05, and ***0.01.

Table VI. Probit Regressions for Support of Profiling if a 30-Minute Waiting Time

	Airplane Bias	Public-Event Bias	Double Bias
Recollection Bias	-0.046	-0.060*	-0.096***
	(0.036)	(0.035)	(0.034)
Log Best Estimate	0.012*	0.012	0.011
	(0.007)	(0.007)	(0.007)
Age	0.006***	0.006***	0.006***
	(0.001)	(0.001)	(0.001)
Male	0.004	0.003	0.004
	(0.036)	(0.036)	(0.036)
Education	-0.019**	-0.019**	-0.019**
	(0.008)	(0.008)	(0.008)
Income/1,000	0.227E-3	0.231E-3	0.184E-3
	(0.378E-3)	(0.377E-3)	(0.378E-3)
Missing Income	0.183**	0.185**	0.182**
	(0.071)	(0.071)	(0.071)
Republican	0.123***	0.119***	0.117***
	(0.042)	(0.042)	(0.043)
City	-0.012	-0.011	-0.016
	(0.056)	(0.056)	(0.056)
West	-0.132***	-0.132***	-0.129***
	(0.048)	(0.048)	(0.048)
Midwest	-0.116**	-0.120**	-0.116**
	(0.051)	(0.051)	(0.051)
Pseudo R^2	0.06	0.06	0.06

Note: N = 906. Respondents indicating an upper bound on terrorism deaths in excess of one million are excluded. Other variables included in the regression are nonwhite, suburb, small town, missing income, and Democrat. Significance levels: *0.10, **0.05, and *** 0.01.

Table VII. Ordered Probit Regressions for Support of Surveillance Cameras in Public Places

	Airplane Bias	Public-Event Bias	Double Bias
Recollection Bias	-0.343***	-0.197*	-0.315***
	(0.109)	(0.102)	(0.096)
Log Best Estimate	0.045**	0.045**	0.044**
	(0.020)	(0.020)	(0.020)
Age	0.019***	0.019***	0.019***
	(0.004)	(0.004)	(0.004)
Male	-0.192**	-0.205**	-0.208**
	(0.098)	(0.098)	(0.098)
Education	-0.042*	-0.040*	-0.041*
	(0.022)	(0.022)	(0.022)
Income/1,000	1.118E-3	1.252E-3	1.109E-3
	(1.093E-3)	(1.088E-3)	(1.094E-3)
Republican	0.450***	0.452***	0.445***
	(0.125)	(0.125)	(0.125)
Democrat	0.450***	0.446***	0.448***
	(0.111)	(0.110)	(0.111)
City	0.191	0.198	0.193
	(0.155)	(0.155)	(0.155)
West	-0.251*	-0.255**	-0.245*
	(0.130)	(0.130)	(0.130)
Pseudo R^2	0.08	0.07	0.08

Note: N = 906. Respondents indicating an upper bound on terrorism deaths in excess of one million are excluded. Other variables included in the regression are nonwhite, suburb, small town, midwest, south, and missing income. Significance levels: *0.10, **0.05, and *** 0.01.

Table VIII. Ordered Probit for Support of More Surveillance Cameras in Public Places

	Airplane Bias	Public-Event Bias	Double Bias
Recollection Bias	-0.207**	-0.199**	-0.204**
	(0.086)	(0.084)	(0.080)
Log Best Estimate	0.044**	0.043**	0.044**
	(0.017)	(0.017)	(0.017)
Age	0.016***	0.015***	0.016***
	(0.003)	(0.003)	(0.003)
Male	-0.077	-0.082	-0.084
	(0.083)	(0.083)	(0.083)
Education	-0.055***	-0.054***	-0.055***
	(0.019)	(0.019)	(0.019)
Income/1,000	1.435E-3	1.498E-3*	1.430E-3
	(0.892E-3)	(0.890E-3)	(0.892E-3)
Republican	0.195*	0.188*	0.189*
	(0.102)	(0.102)	(0.102)
Democrat	0.365***	0.363***	0.361***
	(0.095)	(0.095)	(0.094)
City	0.046	0.052	0.045
	(0.130)	(0.130)	(0.130)
West	-0.198*	-0.198*	-0.195
	(0.110)	(0.110)	(0.110)*
Pseudo R^2	0.05	0.05	0.05

Note: N = 906. Respondents indicating an upper bound on terrorism deaths in excess of one million are excluded. Other variables included in the regression are nonwhite, suburb, small town, midwest, south, and missing income. Significance levels: *0.10, **0.05, and *** 0.01.

Table IX. Probit Regressions for Support of Surveillance of Mail, E-mails, and Phones

	Airplane Bias	Public-Event Bias	Double Bias
Recollection Bias	-0.057	-0.035	-0.058*
	(0.037)	(0.035)	(0.034)
Log Best Estimate	0.026***	0.026***	0.025***
	(0.007)	(0.007)	(0.007)
Age	0.007***	0.007***	0.007***
	(0.001)	(0.001)	(0.001)
Male	-0.022	-0.025	-0.024
	(0.036)	(0.036)	(0.036)
Education	-0.015*	-0.015*	-0.015*
	(0.008)	(0.008)	(0.008)
Income/1,000	0.755E-3**	0.790E-3**	0.757E-3**
	(0.376E-3)	(0.375E-3)	(0.375E-3)
Missing Income	-0.161*	-0.159*	-0.160*
	(0.075)	(0.075)	(0.075)
Republican	0.029	0.029	0.027
	(0.044)	(0.044)	(0.044)
City	0.086	0.087	0.084
	(0.056)	(0.056)	(0.056)
Midwest	-0.088*	-0.092*	-0.089*
	(0.048)	(0.048)	(0.048)
South	-0.079*	-0.079*	-0.077*
	(0.042)	(0.042)	(0.042)
Pseudo R^2	0.06	0.06	0.06

Note: N = 906. Respondents indicating an upper bound on terrorism deaths in excess of one million are excluded. Other variables included in the regression are nonwhite, suburb, small town, west, and Democrat. Significance levels: *0.10, **0.05, and *** 0.01.

APPENDIX A: SAMPLE CHARACTERISTICS

Table AI. Summary Statistics for All Variables

	Mean	Standard Deviation
Recollection Bias – Plane	0.675	0.469
Recollection Bias – Public	0.609	0.488
Recollection Bias – Both	0.499	0.500
Best Guess of Terror Fatalities	1382.77	17220.43
Log Best Guess of Terror Fatalities	4.521	2.333
Age	50.755	13.574
Male	0.368	0.483
Nonwhite	0.105	0.307
Education	14.875	2.336
Income/1,000	67.253	48.800
Missing Income	0.043	0.203
Republican	0.269	0.444
Democrat	0.378	0.485
New York City	0.030	0.170
City	0.280	0.449
Suburb	0.387	0.487
Small Town	0.179	0.384
West	0.213	0.410
Midwest	0.231	0.422
South	0.397	0.489

Note: N = 910. For Best Guess and Log Best Guess, N = 906; respondents indicating an upper bound on terrorism deaths in excess of one million are excluded.