Understanding Perceived Risk: 1978–2015

by Paul Slovic

Tim O'Riordan made it sound easy when he convinced me to write a brief perspective on hazard management almost four decades after the publication of three seminal articles in *Environment* on that topic. I agreed, not realizing the breadth of those articles and the relatively narrow focus of my own work and knowledge. Moreover, much has happened in the world of risk since the fall of 1978. Fortunately, Baruch Fischhoff and Howard Kunreuther agreed to join me in reflecting on these developments.

I focus this commentary on the second article, "Handling Hazards: Can Hazard Management be Improved?" by Fischhoff, Hohenemser, Kasperson, and Kates.[1] This important article, which can be viewed online at *www.environmentmagazine.org*, presented a framework of hazard causation pointing to opportunities for management interventions. Concepts such as risk perception, acceptable risk, and value trade-offs were introduced, along with institutional failures in properly attending to the most serious hazards.

The article by Fischhoff et al. was insightful in its treatment of risk perception, noting that the way we think about and respond to hazards shapes the agendas of public interest groups and politicians, as well as the attempts of laypeople to manage the hazards of their daily lives. The importance of perceived benefits and value trade-offs was also stressed along with the observation that reducing a hazard might conflict directly with other widely held values or political goals. Also noted was the fact that our tolerance of risk varies widely among activities and technologies, and this inconsistency of public values greatly complicates hazard management.

This article was soon followed by another article in *Environment*, "Rating the Risks," in which my colleagues and I described early attempts to quantify perceptions of risk and document their implications for hazard management.[2] Revisiting this article, I am struck by how harshly we came down on the public. Risk was characterized narrowly in terms of annual fatality rates, and serious public misjudgments of these rates were attributed to lack of knowledge compounded by biases linked to the imaginability and memorability of the hazard. Although the possibility was raised that experts, too, often rely on judgments that might sometimes be biased, we concluded that the public needed to be better informed, to rely less on unexamined judgments, to be aware of the qualitative aspects of hazards that could bias its judgments (e.g., involuntary exposure, emotions), and to be open to new evidence that might alter its risk perceptions. Despite the inaccuracy of public perceptions, we noted that removing the public from the hazard-management process was not feasible in a democratic society.

Almost four decades later, many of the same issues still challenge risk management, though our understanding of them has greatly increased and a more balanced appreciation of the strength and weaknesses of both expert risk assessments and public perceptions has evolved.[3] The method of using numerical rating scales to measure risk perceptions was later named "the psychometric paradigm" and was extended to characterize and assess perceptions in many different ways. Perceived risk and acceptable risk were found to be systematic and predictable. Psychometric techniques seemed well suited for identifying similarities and differences among groups with regard to risk perceptions and attitudes. This research showed that the concept of "risk" meant different things to different people. The public was found to have a broad conception of risk, qualitative and complex, that incorporates considerations such as uncertainty, dread, catastrophic potential, controllability, equity, risk to future generations, and so forth, into the risk equation. In contrast, experts' perceptions of risk are not closely related to these characteristics. Rather, studies found that experts tend to see riskiness as synonymous with probability of harm or expected mortality. As a result of these different perspectives, conflicts often resulted from experts and laypeople having different definitions of the concept "risk." In this light, it is not surprising that expert recitations of "risk statistics" often did little to change people's attitudes and perceptions.

Over time, it was recognized that there are legitimate, value-laden issues underlying the multiple dimensions of public risk perceptions, and these values need to be considered in risk-management decisions.[4] For example, is risk from cancer (a dreaded disease) worse than risk from auto accidents (not dreaded)? Is a risk imposed on a child more serious than a known risk accepted voluntarily by an adult? Are the deaths of 50 passengers in separate automobile accidents equivalent to the deaths of 50 passengers in one airplane crash? Is the risk from a polluted Superfund site worse if the site is located in a neighborhood that has a number of other hazardous facilities nearby? Quantitative risk assessments cannot answer such questions.

At much the same time, the technical foundations of scientific risk assessment also came under scrutiny, perhaps because of sharp discrepancies with public perceptions and the frequent conflicts and controversies centered around these differences. Social research challenged the traditional view that dangers result from physical and natural processes in

Table 1. Some Ways of Expressing Mortality Risks
Deaths per million people in the population
Deaths per million people within *x* miles of the source of exposure
Deaths per unit of concentration
Deaths per facility
Deaths per ton of air toxic released
Deaths per ton of air toxic absorbed by people
Deaths per ton of chemical produced
Deaths per million dollars of product produced
Loss of life expectancy associated with exposure to the hazard
Source: Slovic (1997).[4]

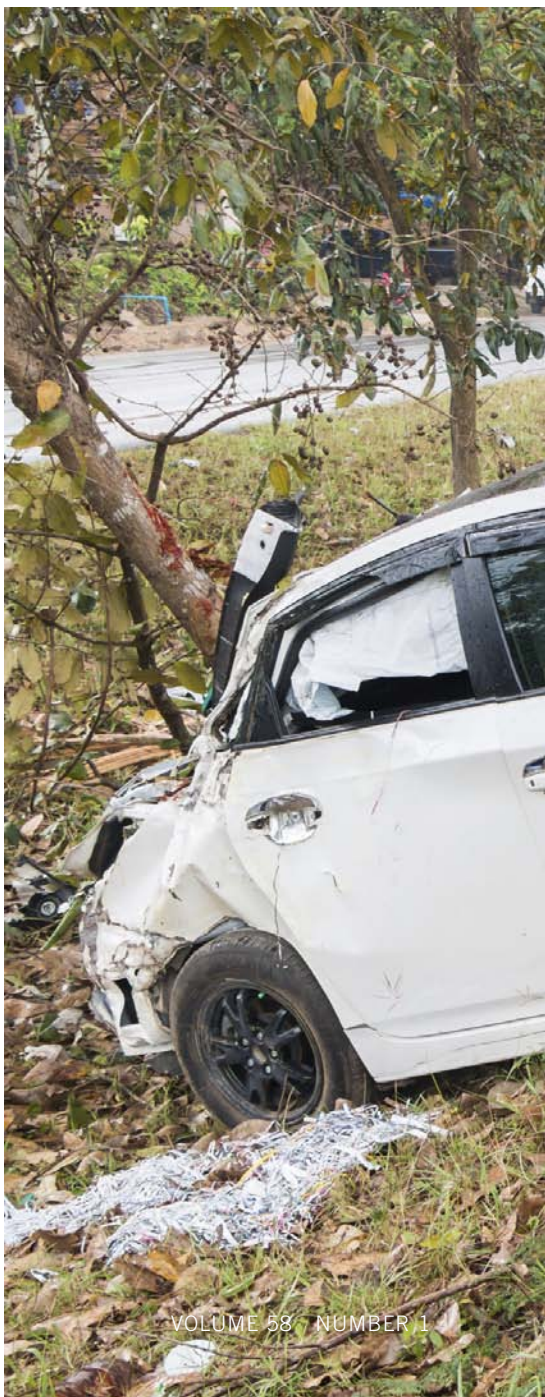
ways that can be objectively quantified by risk assessment. Social scientists argued instead that the measurement of risk is inherently subjective. For example, the nuclear engineer's probabilistic risk estimate for a nuclear accident and the toxicologist's quantitative estimate of a chemical's carcinogenic risk are both based on theoretical models, whose structure is subjective and assumption-laden, and whose inputs are dependent on judgment at every stage of the assessment process, from the initial structuring of a risk problem to deciding which endpoints or consequences to include in the analysis, identifying and estimating exposures, choosing dose-response relationships, and so on. For example, even the apparently simple task of choosing a risk measure for a well-defined endpoint such as human fatalities is surprisingly complex and judgmental. Table 1 shows a few of the many different ways that fatality risks can be measured. How should we decide which measure to use when planning a risk assessment, recognizing that the choice is likely to make a big difference in how the risk is perceived and evaluated?

The influence of social values on risk perception can also be seen in studies by Kahan and colleagues examining the impact of worldviews and general attitudes toward society and its organization.[5] Recognition of the subjectivity and value-laden nature of both technical risk assessments and public views has highlighted the need for an approach for addressing risk controversies that focuses upon introducing public participation into both risk assessment and decision making in order to make the process more democratic, improve the relevance and quality of technical analysis, and increase the legitimacy and public acceptance of the resulting decisions. Work by scholars and practitioners in Europe and North America laid the foundations for improved methods of public participation within deliberative decision processes that include negotiation, mediation, oversight committees, and other forms of public involvement.[6]

This need for a participatory approach has been clearly recognized by high-level committees formed to examine risk-assessment practices. Notable was a report by the National Academy of Sciences, "Understanding Risk: Informing Decisions in a Democratic Society,"[7] that concluded that risk assessment should be performed as part of an iterative analytic-deliberative process designed to inform risk-management decision making. According to the report, each step of the process should have an appropriately diverse participation or representation of the spectrum of interested and affected parties, decision makers, and risk-assessment specialists.

Another direction taken by work within the psychometric paradigm was to examine the role of perceptions in determining the degree of impact resulting from an "unfortunate event" (e.g., an accident, a discovery of pollution, sabotage, product tampering).

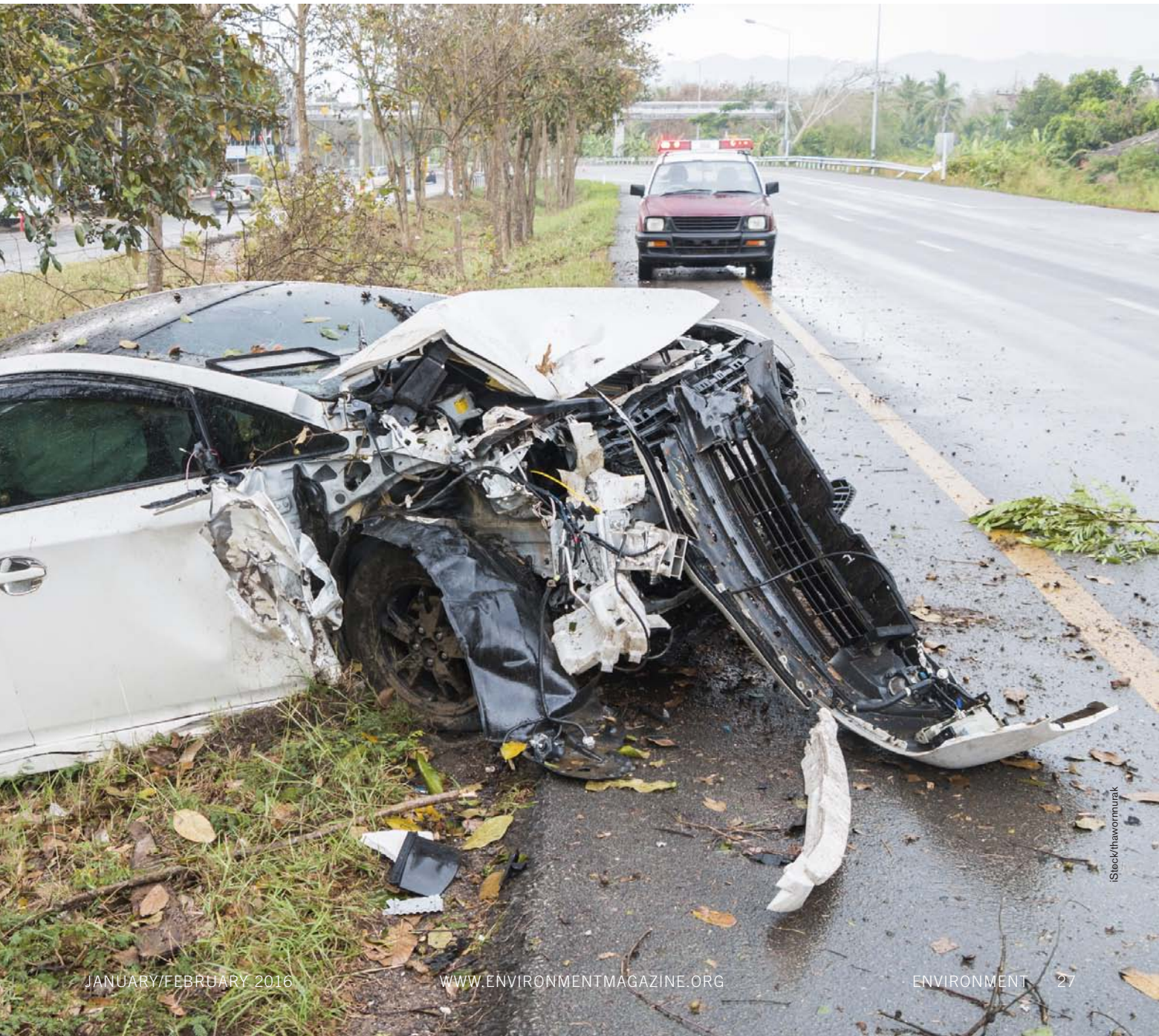
Early theories equated the magnitude of impact to the number of people killed or injured or to the amount of property damaged. However, risk-perception studies showed that there were other impacts as well, analogous to the ripples from a stone dropped into a pond. These secondary impacts could be enormous and were found to depend upon characteristics of the hazard, as well as on risk perceptions stimulated by the extensive media coverage that accompanies certain events.



A conceptual framework aimed at describing how psychological, social, cultural, and political factors interact to "amplify risk" and produce ripple effects was developed by Kasperson et al.[8] and named "the Social Amplification of Risk." An important element of this framework is the assumption that the perceived seriousness of an accident or other unfortunate event, the media coverage it gets, and the long-range costs and other higher-order impacts on the responsible company, industry, or agency are determined, in part, by what that event signals or portends. *Signal value* reflects the perception that the event provides new information about the likelihood of similar or more destructive future mishaps.[9] A few of the high-signal events whose ripple effects dwarfed their direct damages were the nuclear-power accidents at Three Mile Island, Chernobyl, and Fukushima, the 1982 poisoning of Tylenol, the chemical explosion at Bhopal, India, mad cow disease and the British beef scare, and the terrorist attack on September 11, 2001. These sorts of events stigmatize products, places, and technologies, triggering avoidance behaviors that are exceedingly costly.[10,11]

The pace of psychometric research accelerated over the years.[12] The early work was replicated and extended with diverse samples of respondents worldwide and with very different sets of hazards. The earliest psychometric studies were distinguished by their comparisons of large numbers of hazards

The aftermath of a car crash.



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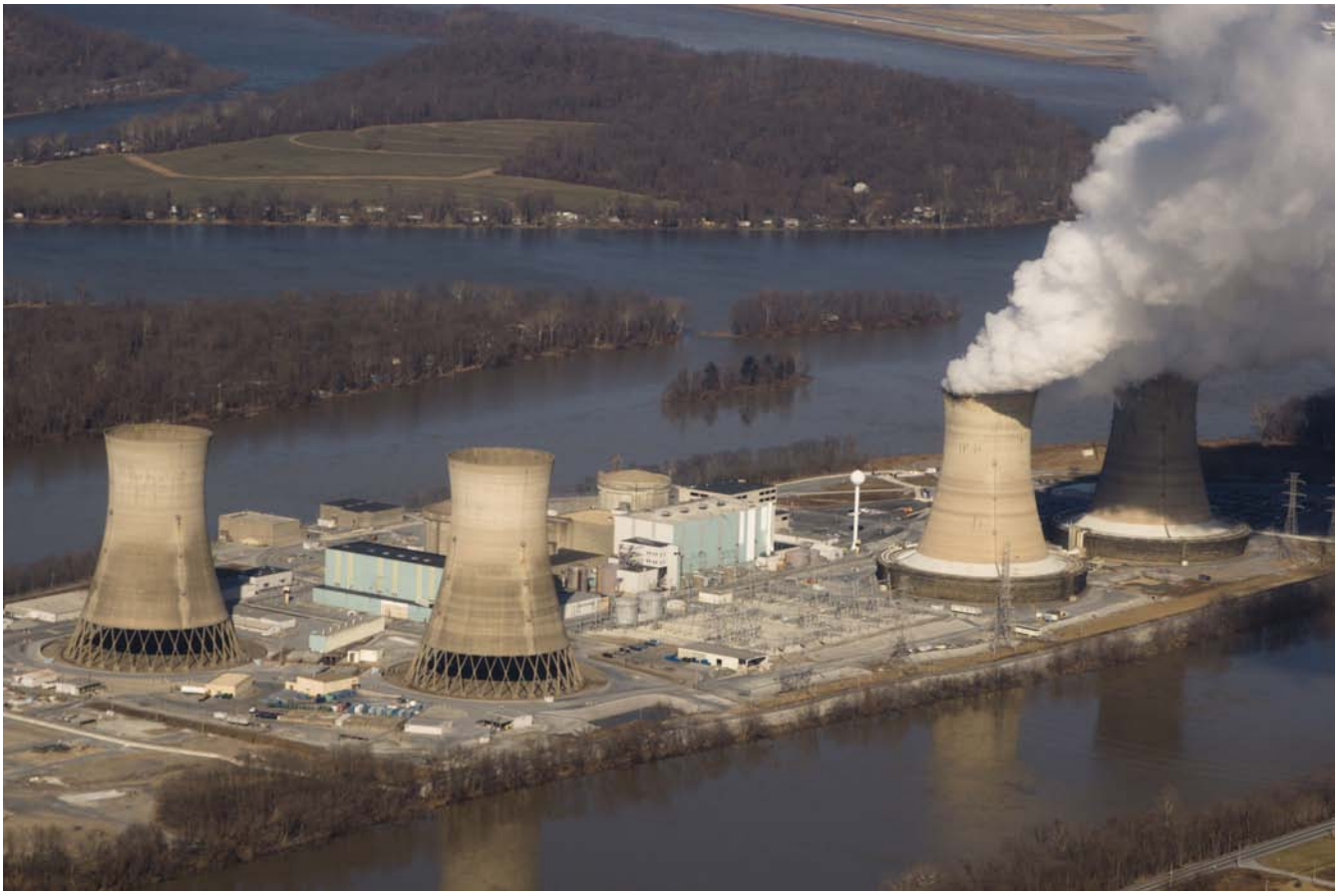
containing items as diverse as bicycles and nuclear power plants. Subsequent surveys have been dedicated to hazards within the same domain, such as natural hazards, medicines, biotechnology, terrorism, nuclear waste, and climate change. However, these quantitative studies left many important questions unanswered. For example, why wouldn't motorists wear seat belts until they were mandated by law? Why do adolescents engage in so many dangerous activities, even those that they supposedly recognize as risky (e.g., smoking cigarettes)? Why do we dread risks from chemicals (except for medicines) but not auto accidents? Why do we fear radiation exposures from nuclear wastes but not from radon in our homes? Why do we value individual lives greatly but become less motivated to protect them as the numbers of people at risk increase?

Answers to these sorts of questions require different methods of analysis—methods that may afford deeper understanding of specific issues rather than broad, but shallow, quantitative assessments. One important approach, pioneered and successfully applied by researchers at Carnegie-Mellon University, has used extensive open-ended interviews to construct influence diagrams and "mental models" depicting people's knowledge, attitudes, beliefs, values, perceptions, and inference mechanisms with regard to specific hazards such as radon and global climate change.[13-15]

This method of questioning was employed to describe and compare the mental models of experts and laypersons regarding the effects of chemicals on human health.[16] This research examined the cognitive models, assumptions, and inference methods that comprise laypeople's "intuitive toxicological theories" and compared these theories with the models underlying scientific toxicology and risk assessment. Toxicologists give great importance to considerations of exposure and dose when evaluating chemical risks, whereas laypeople were found to believe that any exposure to a toxic substance or carcinogen, no matter how small, is likely to prove harmful. Another important finding was the divergence of opinion among toxicologists on questions pertaining to the reliability and validity of animal tests for assessing the risks that chemicals pose to humans. The research also documented a strong "affiliation bias" indicating that toxicologists who worked for industry saw chemicals as more benign than did their counterparts in academia and government. In sum, the knowledge gained from these studies of intuitive toxicology appears to provide a valuable starting point around which to structure discussion, education, and communication about assessing and managing risks from chemicals.

Two important findings from the earliest psychometric studies were not

Three Mile Island power plant.



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adequately appreciated and lay somewhat dormant for two decades, until additional findings led them to be recognized as key links in a theory about the role of affective processes in judgment, decision making, and risk perception. Fischhoff et al.[17] noted in passing that, across different hazards, perceived risk declined as perceived benefit increased. They also found that the characteristic most highly correlated with perceived risk was the degree to which a hazard evoked feelings of dread.

A significant step toward understanding the importance of these findings was taken by Alhakami and Slovic,[18] who observed that the inverse relationship between perceived risk and perceived benefit was linked to an individual's general positive and negative feelings about a hazard. For example, technologies we like (e.g., x-rays and medicines) are judged high in benefit and low in risk. Technologies that carry negative feelings (e.g., nuclear power and pesticides) are judged low in benefit and high in risk. Reliance on feelings as a guide to risk perception and, more generally, all manner of judgments and decisions was named the *affect heuristic*.[19,20]

Although it is tempting to conclude that these studies demonstrate that laypeople's perceptions of risk are derived from emotion rather than reason, and hence should not be respected, such a conclusion is incorrect. Research shows that affective and emotional processes interact with reason-based analysis in all normal thinking and, indeed, are essential to rationality.[21] Reliance on "the feeling of risk" was essential to human survival in the course of evolution, and even today, feelings serve as a compass that guides most of our daily decisions. Although analytic thinking is certainly important for decisions involving risk, reliance on affect is a quicker, easier, and efficient way to navigate in a complex, uncertain, and sometimes dangerous world.

This is not to say, however, that our feelings might not, in some cases, mislead us. For example, a rare event will seem much more likely when we are told it will occur to one out of 100 of people like us than when we are told we have a 1% chance of experiencing it. The "1%" likely makes us think of a small number. "One out of 100" creates images in our mind of "the one" with corresponding positive or negative feelings that amplify the feeling of benefit or risk.[22] Another foible is that envisioning a scary consequence may feel as frightening when its probability is low as when it is high, leading to what some have called *probability neglect*.[23]

Perhaps the most serious shortcoming of unanalyzed feelings is that they don't respond adequately to consequences large in scale, described by numbers or statistics.[23] We will spare no effort to protect or rescue one identified individual, but that same life loses its value when others are also at risk. We will not feel or respond differently learning that 88 persons are in danger rather than 87. The feeling system loses sensitivity and responsiveness when the scale of a problem increases, a phenomenon known as "psychic numbing." This insensitivity contributes significantly to societal underreaction to mass threats from problems such as climate change, poverty, famine, disease, and genocide that are communicated to us through statistics. We need faces, and stories, and careful deliberation to comprehend the realities underlying these statistics and to motivate the creation of analytic procedures, laws, and institutions that can counter the destructive anaesthetizing illusions brought about by psychic numbing, much in the spirit of Howard Kunreuther's essay in this issue.

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